SystemC Cycle Models
Version 11.0

CPAK Getting Started Guide
SystemC Cycle Models
CPAK Getting Started Guide
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Release Information

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Preface

This preface introduces the SystemC Cycle Models CPAK Getting Started Guide.

It contains the following:
• About this book on page 7.
About this book

This guide describes downloading, installing, and running SystemC-based Cycle Model Performance Analysis Kits (CPAKs).

Using this book

This book is organized into the following chapters:

**Chapter 1 Introduction to CPAKs**
This chapter introduces Arm Cycle Model Performance Analysis Kits (CPAKs).

**Chapter 2 Building and running the default CPAK**
This chapter describes downloading, compiling, and simulating the CPAK default system.

**Chapter 3 Introduction to the makefiles**
This chapter summarizes the makefiles that are included in CPAKs and describes the available targets.

**Chapter 4 Modifying CPAKs**
This chapter describes modifications you can make to SystemC CPAKs and how to rebuild the CPAK.

**Chapter 5 Troubleshooting**
This chapter provides solutions for problems that may occur when working with CPAKs.

Glossary

The Arm® Glossary is a list of terms used in Arm documentation, together with definitions for those terms. The Arm Glossary does not contain terms that are industry standard unless the Arm meaning differs from the generally accepted meaning.

See the Arm® Glossary for more information.

Typographic conventions

*italic*
Introduces special terminology, denotes cross-references, and citations.

*bold*
Highlights interface elements, such as menu names. Denotes signal names. Also used for terms in descriptive lists, where appropriate.

*monospace*
Denotes text that you can enter at the keyboard, such as commands, file and program names, and source code.

*monospace*<bold>*monospace* italic
Denotes a permitted abbreviation for a command or option. You can enter the underlined text instead of the full command or option name.

*monospace* italic
Denotes arguments to monospace text where the argument is to be replaced by a specific value.

*monospace* bold
Denotes language keywords when used outside example code.

<and>
Encloses replaceable terms for assembler syntax where they appear in code or code fragments. For example:

```
MRC p15, 0, <Rd>, <CRn>, <CRm>, <Opcode_2>
```
SMALL CAPITALS

Used in body text for a few terms that have specific technical meanings, that are defined in the
Arm® Glossary. For example, IMPLEMENTATION DEFINED, IMPLEMENTATION SPECIFIC, UNKNOWN, and
UNPREDICTABLE.

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If you have any comments or suggestions about this product, contact your supplier and give:
• The product name.
• The product revision or version.
• An explanation with as much information as you can provide. Include symptoms and diagnostic
  procedures if appropriate.

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If you have comments on content then send an e-mail to errata@arm.com. Give:
• The title SystemC Cycle Models CPAK Getting Started Guide.
• The number 101497_1100_00_en.
• If applicable, the page number(s) to which your comments refer.
• A concise explanation of your comments.

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Note

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Other information

• Arm® Developer.
• Arm® Information Center.
• Arm® Technical Support Knowledge Articles.
• Technical Support.
• Arm® Glossary.
Chapter 1
Introduction to CPAKs

This chapter introduces Arm Cycle Model Performance Analysis Kits (CPAKs).

It contains the following sections:

• 1.1 Introduction to CPAKs on page 1-10.
• 1.2 System requirements and prerequisites on page 1-11.
• 1.3 CPAK directory structure on page 1-12.
1.1 Introduction to CPAKs

CPAKs are prepackaged systems ready to simulate with a default application.

The applications and components that ship with CPAKs may differ, but all CPAKs have the same general directory structure, environment configuration, and processes for creating and executing the test bench.

After the CPAK is simulating with the default application, you can:
• Make changes to it by modifying the CPAK testbench and corresponding build system to include, instantiate, and connect new or updated models.
• Copy and migrate a SystemC Cycle Model that is part of a CPAK, and build it into your own custom system.
• Modify an Arm CPAK system by adding your own SystemC model classes to the CPAK.

For use cases and instructions, see 4.1 CPAK modification use cases on page 4-24.

Included in the package
CPAKs include:
• Model libraries for the models included in the CPAK.
• SystemC top-level system.
• Sample applications.
• Setup scripts.
• Cycle Model SystemC Runtime, which also includes:
  — The Cycle Model Studio runtime.
  — SystemC Version 2.3.1 (64-bit Linux).
  — Google Protocol Buffer.
  — The Cycle Model Configuration tool, a command-line utility that simplifies integration of Arm SystemC Cycle Models into custom systems. For usage, see the SystemC Cycle Model User Guide for the CPU in your CPAK.

Related information
• SystemC Cycle Model User Guide for the CPU in your CPAK. This guide is located in MODELS/CPU/gccversion.
• Arm® SystemC Cycle Model Runtime Installation Guide (101146).
1.2 System requirements and prerequisites

This section describes space, operating system, and software requirements for running Arm SystemC CPAKs.

Disk space

The Cycle Model SystemC Runtime requires 200 MB of disk space.

For CPAKs, additional space is required. The amount of space needed varies depending on the complexity of the CPAK.

Supported operating systems

The supported Linux operating systems are:

- Red Hat Enterprise Linux 6.6 (64-bit)
- CentOS 6.6 (64-bit)

SystemC CPAKs are not supported on Windows.

Supported GCC versions

For rebuilding SystemC CPAKs, GCC version 4.8.3 and GCC version 6.4.0 are supported.

Licensing

You must have a valid, installed license for each runtime and Cycle Model. Visit the Arm licensing portal: https://developer.arm.com/support/licensing/generate and use your serial numbers to generate the licenses. Contact Arm Technical Support (support-esl@arm.com) if you need more information.
1.3 CPAK directory structure

This section describes the directory structure that all CPAKs share.

Using a Cortex-R52 CPAK as an example, the following figure describes the general CPAK directory structure and summarizes its contents. Certain CPAKs may have additional directories.

1. CPAKs come with sample applications that execute on the processor and application build scripts; the Applications directory contains the source code, build files, and executable images for these applications.


3. The MODELS directory contains model libraries and SystemC wrapper source code for all the models used to build the system.

4. The Scripts directory contains setup scripts (setup.sh and setup.csh) used to configure environment variables. This directory may also contain scripts that the CPAK uses for application loading or compilation.

5. The Systems directory contains top-level design files used to connect models. It also includes the system_test.cpp file (where the sc_main function is located), and the makefile used to build the CPAK.

Figure 1-1 CPAK directory structure
Chapter 2
Building and running the default CPAK

This chapter describes downloading, compiling, and simulating the CPAK default system.

It contains the following sections:

• 2.1 Download a CPAK from IP Exchange on page 2-14.
• 2.2 Decompress the CPAK package file on page 2-15.
• 2.3 Build the CPAK on page 2-16.
• 2.4 Run the CPAK on page 2-17.
• 2.5 Next steps on page 2-19.
2.1 Download a CPAK from IP Exchange

Download a CPAK from IP Exchange.

**Before you begin**
- You must have a valid account on [http://armipexchange.com/cpaks](http://armipexchange.com/cpaks). Create one if necessary.

**Download**

To download a CPAK from Arm IP Exchange:

1. Visit [http://armipexchange.com/cpaks](http://armipexchange.com/cpaks) and download a SystemC CPAK. CPAKs are packaged in a .tgz file.

**Next steps**

Proceed to [2.2 Decompress the CPAK package file on page 2-15](#).
2.2 Decompress the CPAK package file

After download, decompress the CPAK package file and review the README.txt file.

Before you begin
- Review the system and licensing requirements in 1.2 System requirements and prerequisites on page 1-11.

Decompress the CPAK and review the Readme
1. Untar the CPAK .tgz file. For example:

   $ tar xzvf R52-MP2-MC2-SysC-V10.0.0-CMS10.0.0-MK2018.09.17-SOCD9.6.0.tgz

   The CPAK directory structure is created. See 1.3 CPAK directory structure on page 1-12 for an overview of the structure of the CPAK.

2. Open and review the README.txt file located at the top of the CPAK directory structure:

   $ cd R52-MP2-MC2-SysC-V10.0.0-CMS10.0.0-MK2018.09.17-SOCD9.6.0
   $ ls
   Applications  ARM  license_terms  Makefile  MODELS  Readme_Debug_Memory_notes.txt
   README.txt  Scripts    Systems
   $ less README.txt

   The README.txt file:
   - Lists environment variables that are required to be set for this CPAK.
   - Lists other requirements and dependencies specific to your CPAK.
   - For pin-based CPAKs, states the application that the CPAK runs by default. See the Applications directory to determine all of the applications your CPAK includes. See 2.4 Run the CPAK on page 2-17 for instructions on running applications.
   - Describes scripts included with your CPAK.

Next steps

Proceed to 2.3 Build the CPAK on page 2-16.

Related information
- 2.1 Download a CPAK from IP Exchange on page 2-14
- 1.3 CPAK directory structure on page 1-12
2.3 Build the CPAK

Build the CPAK executable.

Before you begin

• Decompress the CPAK package file and review the README as described in 2.2 Decompress the CPAK package file on page 2-15.

Source the setup script and set required environment variables

Note

Setup scripts for C Shell and Bash are supported. Ensure you are in the correct environment.

1. In the CPAK Scripts directory, source the setup.sh or setup.csh script. You can do this by including the source command in a makefile, or from the command line:

   ```
   $ cd Scripts/
   $ ls
   create_dat_file.sh  setup.csh  setup.sh  vars.csh  vars.sh
   $ source setup.sh
   Arm Cycle Model SystemC setup completed.
   $ setup complete.
   $
   ```

2. If you are using a version of the Cycle Model Studio runtime other than the one included in the CPAK, set CARBON_HOME. If you are using the version of the Cycle Model Studio runtime included in the CPAK, skip this step.

Build the CPAK executable

1. cd to the CPAK Systems directory.
2. Build the CPAK system executable (system_test) by entering make:

   ```
   $ cd Systems
   $ make
   .
   .
   .
   $```

Next steps

Proceed to 2.4 Run the CPAK on page 2-17.

Related information

• Chapter 5 Troubleshooting on page 5-33
2.4 Run the CPAK

Simulate with an application included with the CPAK.

Before you begin

- Build the CPAK executable as described in 2.3 Build the CPAK on page 2-16.
- Ensure that the environment variable ARMLMD_LICENSE_FILE is set to your license server; for example, `export ARMLMD_LICENSE_FILE=port@host`.

Set runtime environment variables and run the simulation

1. Source the setup script to set environment variables that are required at runtime:

   ```bash
   $ source ../Scripts/setup.sh
   Arm Cycle Model SystemC setup completed.
   Setup complete.
   $```

2. From the Systems directory, simulate the CPAK application using the system_test test bench:

   ```bash
   $ ../system_test -a ../Applications/hello_world/armcc/elf/test.elf
   Starting Simulation
   UART0: Hello World!<0a>
   UART1: Hello World!<0a>
   UART2: Hello World!<0a>
   UART3: Hello World!<0a>
   UART0: My name is Kite<0a>
   UART1: My name is Kite<0a>
   UART2: My name is Kite<0a>
   UART3: My name is Kite<0a>
   ```

- TLM-based CPAKs require you to specify the application to run using the `-a` or `--application` argument.
- For pin-based CPAKs, do not use `-a` or `--application`. Run `./system_test` to run the default application. The CPAK README.txt file lists the default application for pin-level CPAKs; see the Applications directory for additional applications provided with your CPAK.

See 4.2 Application loading on page 4-28 for more information about application loading.

Result

The test bench starts the simulation, and loads and runs the application specified by system_test.cpp. Following is sample output from a TLM-based Cortex-R52 CPAK:
UART0: I wish you a great day
UART1: I wish you a great day
UART2: I wish you a great day
UART3: I wish you a great day
UART0: ** TEST PASSED OK **
UART1: ** TEST PASSED OK **
UART2: ** TEST PASSED OK **
UART3: ** TEST PASSED OK **
UART0: <04>
UART1: <04>
.
.
.
$

The simulation results show that the Hello World application ran successfully the four Cortex-R52 cores (output is sent through the UART model attached to each CPU). Simulation results also include performance monitoring data for each CPU (not shown in the example).

Next steps
When your CPAK simulates properly, see 2.5 Next steps on page 2-19.

Related information
- Chapter 5 Troubleshooting on page 5-33
- 4.2 Application loading on page 4-28
2.5 Next steps

When your default CPAK is simulating properly, learn about and change its operation.

Review the processor model guide

The *SystemC Cycle Model User Guide* for the processor model in your CPAK describes the functionality of the model compared to the hardware.

The model guide includes instructions for viewing model parameters, enabling waveform dumping, resetting the model, and connecting to a debugger.

View the list of processor model parameters

The set of available parameters varies, depending on the type and functionality of the processor model. To list model parameters:

- Enter `./system_test --list-params`.
- View the `model_params.cfg` file located in the directory `CPAK/MODELS/CPU/gccversion/SystemC`.

Modify the CPAK

You can change the CPAK to include different or additional models, make changes to the default application, or run the CPAK with a different application. See *Chapter 4 Modifying CPAKs* on page 4-23.

Related information

- *SystemC Cycle Model User Guide* for the CPU in your CPAK. This guide is located in `MODELS/CPU/gccversion`.
Chapter 3
Introduction to the makefiles

This chapter summarizes the makefiles that are included in CPAKs and describes the available targets.

It contains the following section:
• 3.1 Makefiles included in the CPAK on page 3-21.
3.1 Makefiles included in the CPAK

This section explains what you need to know about makefiles included in the CPAK.

The CPAK directory includes the following makefiles:

/Systems makefile

The Makefile you will use most frequently when working with CPAKs is the Systems/Makefile. This is the command script for your build infrastructure. When you make a change to the CPAK, such as adding a model to your design or changing one model for another, rebuild the CPAK using this Makefile.

See 3.1.1 Make options for the CPAK makefile and Systems/makefile on page 3-21 for CPAK build, run, and simulation options.

CPAK makefile

You can use the Makefile at the top level of the CPAK to execute the Systems/Makefile. This top-level Makefile sets certain environment variables.

/MODELS makefiles

Each model in a CPAK system includes its own makefiles, located in MODELS/CPU_name/gcc_version/SystemC/makefile.

Note

Do not modify the makefiles in the MODELS directories. If you are adding or replacing a model in the CPAK, see Chapter 4 Modifying CPAKs on page 4-23.

/Applications makefile

The Applications/Makefile defines the application that is launched by default when you run the CPAK simulation. Modify this Makefile if you want to simulate using a different application. Do not modify the initialization code contained in the Applications/Makefile.

This section contains the following subsection:

• 3.1.1 Make options for the CPAK makefile and Systems/makefile on page 3-21.

3.1.1 Make options for the CPAK makefile and Systems/makefile

This section describes the available build, run, and simulation targets; targets that are available only in the top-level CPAK makefile are noted.

Use the Systems/Makefile to rebuild the reference system after making modifications. This makefile includes the following available targets:

make all
Builds the system.

make app-setup [ APP=path ]
Sets up the application that the system uses during simulation. path is the path to the compiled application (.elf) file. This option is available only in the top-level CPAK makefile, not the Systems/makefile. See 4.2 Application loading on page 4-28 for information about application loading.

make clean
Removes all the binaries and object files.

make help
Prints all available targets. This option is available only in the top-level CPAK makefile, not the Systems/makefile.
**make req**

Prints out all the components and dependencies for the CPAK.

**make run [ APP=path ] [ RUNLOG=file_name ]**

Runs the simulation. *path* is the path to the compiled application (.elf) file and *file_name* is the name of the file for log output. If *APP* is not specified, it runs the default application or the one that was last set up using app-setup.

Note

Run this command only with TLM-based CPAKs, not with pin-based CPAKs. This command uses the -a flag as a means of passing in the application, and pin-based CPAKs do not accept the -a flag. See 4.2 Application loading on page 4-28 for more information.

**make system**

Uses the CPAK test bench (system_test.cpp) and the library files to generate the system_test binary.
Chapter 4
Modifying CPAKs

This chapter describes modifications you can make to SystemC CPAKs and how to rebuild the CPAK.

It contains the following sections:
• 4.1 CPAK modification use cases on page 4-24.
• 4.2 Application loading on page 4-28.
• 4.3 CPAK test bench modifications on page 4-29.
4.1 CPAK modification use cases

This section provides use cases and instructions for CPAK modifications.

Prerequisites

- Before making changes to a CPAK, validate the operation of its default configuration as described in Chapter 2 Building and running the default CPAK on page 2-13.
- Review the Cycle Model User Guide for your IP for information about using the Cycle Models Configuration Tool. The Cycle Models Configuration Tool is a command-line utility included with the SystemC Cycle Model Runtime. This tool simplifies CPAK modifications by extracting required build and link options for models in a system, and flagging incompatibilities that may be present.

This section contains the following subsections:

- 4.1.1 Internal changes to a model in the default CPAK on page 4-24.
- 4.1.2 Changing the CPU used in the CPAK on page 4-24.
- 4.1.3 Changes to the composition of the CPAK on page 4-25.
- 4.1.4 Creating custom systems that include Arm® models on page 4-26.

4.1.1 Internal changes to a model in the default CPAK

This use case describes making a change to a model that exists in the CPAK.

You can make changes in the source files for models included in the default CPAK. For example, you might drive an additional input by commenting out a port binding in the CPAK MODELS/model/gcc_version/SystemC/modelResetImp.h file. In this case, ensure that you also drive the value of the port.

1. Make your modifications in MODELS/model/gcc_version/SystemC/modelResetImp.h.
2. Rebuild the CPAK using the Systems/makefile.

See the SystemC Cycle Model User Guide for your IP for information about binding or tying ports.

Related information

- SystemC Cycle Model User Guide for the CPU in your CPAK. This guide is located in MODELS/CPUs/gccversion

4.1.2 Changing the CPU used in the CPAK

This use case describes replacing the CPU in a CPAK.
You can replace the CPU included in the CPAK by default with:

- a CPU of the same IP type, but with a different build configuration.
- a CPU of a different IP type.

To do so:

1. Build the new or revised CPU on IP Exchange.
2. Replace the existing CPU in the CPAK MODELS directory.
3. If the new CPU is of a different IP type than the original CPU, update the system_test.cpp test bench to reference the header files, ports, and bindings of the new CPU.
4. In the Systems/makefile, update the COMP_NAMES variable and the model directory to reflect the new model. To get the exact component name, run the Cycle Models Configuration tool with the --list argument and look at the Component Type: model: section. For example, in the following output, CortexR52 is the string to use in the COMP_NAMES variable:

```
$ cm_config --list
Component Type: model:
CortexR52 mainline /home/CPAKs/R52-MP2-MC2-SysC/MODELS/
CortexR52_2CPU/gcc640/SystemC/.data/CortexR52.xml
CortexR52 mainline /home/CPAKs/R52-MP2-MC2-SysC/MODELS/
CortexR52_2CPU/gcc483/SystemC/.data/CortexR52.xml
cm_sysc_models mainline /home/CPAKs/R52-MP2-MC2-SysC/ARM/CycleModels/
Runtime/cm_sysc/mainline/etc/.data/cm_sysc_models.xml
Component Type: runtime:
...
```

For more information about the Cycle Models Configuration Tool, see the SystemC Cycle Model User Guide for the CPU model included in your CPAK.

5. Rebuild the CPAK using the Systems/makefile.

**Related information**

- [SystemC Cycle Model User Guide](#) for the CPU in your CPAK. This guide is located in MODELS/CPU/gccversion

**4.1.3 Changes to the composition of the CPAK**

This use case describes changes to the models that make up a CPAK.
This section describes adding models to, or removing models from the CPAK platform; for example, adding a flash memory to the existing system.

1. If you are adding a model to the CPAK, add its directory to the CPAK/MODELS directory.
2. If you have removed a model from the CPAK, remove its corresponding directory from CPAK/MODELS.
3. Update Systems/system_test.cpp. This file defines the models included in the CPAK and their port bindings.
4. If the name of the model directory has changed, further modifications to the Systems/Makefile are required. Update the COMP_NAMES variable to include models and directories you are adding, and exclude models and directories you are replacing. To get the exact component name, run the Cycle Models Configuration tool with the --list argument and look at the Component Type: model: section. For example, in the following output, CortexR52 is the string to use in the COMP_NAMES variable:

   $ cm_config --list
   Component Type: model:
   CortexR52                 mainline        /home/CPAKs/R52-MP2-MC2-SysC/MODELS/
   CortexR52_2CPU/gcc640/SystemC/.data/CortexR52.xml
   CortexR52                 mainline        /home/CPAKs/R52-MP2-MC2-SysC/MODELS/
   CortexR52_2CPU/gcc483/SystemC/.data/CortexR52.xml
   cm_sysc_models            mainline        /home/CPAKs/R52-MP2-MC2-SysC/ARM/CycleModels/
   Runtime/cm_sysc/mainline/etc/.data/cm_sysc_models.xml
   ...
5. Rebuild the CPAK using the Systems/makefile.

Related information
- SystemC Cycle Model User Guide for the CPU in your CPAK. This guide is located in MODELS/CPU/gccversion

4.1.4 Creating custom systems that include Arm® models

This use case describes adding an Arm model to a custom system.
You can build your own, custom SystemC platform that includes a Cycle Model downloaded from Arm IP Exchange. Use the Cycle Models Configuration Tool, included in the SystemC Cycle Models Runtime, to extract its build options. See the *SystemC Cycle Model User Guide* for your IP for more information about the Cycle Models Configuration tool.

Contact Arm Support for more information.

**Related information**

- *SystemC Cycle Model User Guide* for the CPU in your CPAK. This guide is located in `/MODELS/CPU/gccversion`
4.2 Application loading

This section describes what you need to know about loading applications for CPAK simulations.

Applications included with your CPAK are found in the CPAK Applications directory. Pin-level CPAKs and TLM-based CPAKs handle application loading differently.

**Pin-level CPAK application loading**

CPAKs implemented through pin-level connections use the memory-loading capabilities of the memory component included in the CPAK. The application to be loaded is determined by the contents of the .hex files in the CPAK Systems directory. These hex files are created using the create_dat_file.sh script located in the Scripts directory. The application is loaded into the CPAK upon initialization of the memory.

Alternate applications must be in .elf file format. To change the application used by the CPAK:

1. Run the create_dat_file.sh script on the new .elf file to create the required hex files.
2. Run system_test.

See the README.txt file for more information about the application run by default.

--- Note ---

Do not use the -a or --application command line arguments to specify applications for CPAKs with pin-level models. These arguments have no effect on pin-level CPAKs, and result in multiple warnings.

---

**TLM-based CPAK application loading**

The information in this section applies to TLM-based CPAKs that support debugging. These CPAKs use the standard SystemC framework to determine which application to load. This means that you must specify which application to load.

Specify the application on the command line using the -a or --application argument. For example:

```
$ ./system_test -a test.elf -S
```
4.3 CPAK test bench modifications

Each CPAK has its own test bench called system_test.cpp, which is located in the Systems directory.

system_test.cpp:
• Instantiates the models
• Defines the connections between models
• Initializes model parameters
• Provides simulation controls (start, stop, run, specific number of cycles, etc.)

To make changes to the CPAK system, alter the CPAK test bench. After altering the test bench, recompile the system. Models are recompiled automatically as part of the system-level recompile.

This section contains the following subsections:
• 4.3.1 Modifying the test bench for pin-level models on page 4-29.
• 4.3.2 Modifying the test bench for TLM models on page 4-31.

4.3.1 Modifying the test bench for pin-level models

This section describes the areas of the CPAK test bench you might want to change.

Note
See 4.2 Application loading on page 4-28 for information about how pin-level CPAKs handle application loading.

Required includes

The test bench contains the SystemC wrapper files for any models in the system, the corresponding reset module file for each model (for pin-level models only), and includes required by the Fast Models runtime. Ensure you add these files for any new models added to your system. Here is an example of the includes section of a CPAK test bench:

```c++
// Include the systemc wrapper files for the models
#include "libCortexR8.systemc.h"            // CortexR8 CPU
#include "libNIC400.systemc.h"              // NIC400 Interconnect
#include "libBP140.systemc.h"               // BP140 Memory
#include "libBP140_TrickBox.systemc.h"      // BP140_TrickBox UART

// Include the reset modules for the above models (pin-level models only)
#include "CortexR8ResetModule.h"
#include "NIC400ResetModule.h"
#include "BP140ResetModule.h"
#include "BP140_TrickBoxResetModule.h"
#include "../perf_common.h" #include <iostream> #include <time.h>

// These includes are need by the SCX FastModel Runtime
#include <scx/scx.h>
#include <scx/scx_signal_sizer.h>
#include <scx_simcontroller.cpp>
#include <scx_scheduler_mapping.cpp>
#include <scx_report_handler.cpp>
```

Initialization of the simulation environment and model instantiation

The sc_main() section of the test bench must first initialize the SCX simulation environment. It must state clocking specifications, then instantiate all IP and reset models (for pin-level models only) for any models included in the system. For example:

```c++
int sc_main(int argc, char *argv[]) {
    // Debug initialization
    scx::scx_initialize("R8-SysC-Debug");
    // If you want to see messages about 'port not bound' change SC_DO NOTHING to SC_DISPLAY.
```
// If you want it to abort on a 'port not bound' error comment out the line below.
sc_report_handler::set_actions(SC_ID_COMPLETE_BINDING_, SC_ERROR, SC_DO NOTHING);

// Clock Object
sc_clock clk("clk", 1, SC_NS, 0.5);

// Instantiate IP
CortexR8 core("cortexR8");
NIC400 nic400("NIC400");
BP140 bp140("BP140");
BP140_TrickBox bp140_trickbox("BP140_TrickBox");
ARM::Models::Cycle::ModelCortexR8::CortexR8ResetModule core_reset("core_reset");
ARM::Models::Cycle::ModelNIC400::NIC400ResetModule nic400_reset("nic400_reset");
ARM::Models::Cycle::ModelBP140::BP140ResetModule bp140_reset("bp140_reset");
ARM::Models::Cycle::ModelBP140_TrickBox::BP140_TrickBoxResetModule bp140_trickbox_reset("bp140_trickbox_reset");

Signal bindings
The test bench specifies all signal bindings, including those for reset modules.

• Declare bindings using an sc_signal call in the test bench file. The signal must be the same type and
  width as the two ports being connected. If the ports are the same type but different widths, use
  scx_signal_sizer instead of sc_signal. For example:

```cpp
scx::scx_signal_sizer<sc_uint<13>, sc_uint<16>> ARIDsignal1;
core.ARIDM0.bind(ARIDsignal1);
nic400.arid_s_axi_64.bind(ARIDsignal1);
```

• Signals must be bound to both ports. For example:

```cpp
sc_signal(bool) signal1;
Inst1.port1.bind(signal1);
sc_signal(bool) signal2;
Inst2.port1.bind(signal2);
```

Clock bindings
All models must be bound to the system clock; for example:

```cpp
// Bind all the models to the system (cpu) clock
core.CLKIN.bind(cpu_clk);
mem.ACLK.bind(cpu_clk);
bus.mainclk.bind(cpu_clk);
uart.ACLK.bind(cpu_clk);
core.reset.clk.bind(cpu_clk);
bic140.reset.clk.bind(cpu_clk);
bp140_trickbox_reset.clk.bind(cpu_clk);
```

Functions to generate performance data
The following example shows the use of SCX API functions to specify PMU and Tarmac output. See the
`SystemC Cycle Model User Guide` for the CPU in your CPAK for more information:

```cpp
scx::scx_set_parameter("cortexR8_core.PMU_ENABLED", true);
scx::scx_set_parameter("cortexR8_core.TARMAC_ENABLED", true);
```

Parsing of command line arguments
The test bench calls the SCX `scx_parse_and_configure()` function to parse any command line
arguments used by the SCX runtime:

```cpp
scx::scx_parse_and_configure(argc, argv);
```

Simulation call
To simulate the system, the test bench calls `sc_start()`:

```cpp
sc_start();
```

Specify all includes, initializations, bindings, functions, and command line options before `sc_start()`.  

### 4.3.2 Modifying the test bench for TLM models

The `sc_main()` function in the test bench has the same basic flow for both pin-level and TLM models. One difference is that the TLM models are connected using TLM sockets rather than pins. This section describes the TLM-specific instructions.

--- Note ---

See the file `libcomponent.tlm.h` in your installation directory for socket names.

--- Note ---

See 4.2 Application loading on page 4-28 for information about how TLM-based CPAKs handle application loading.

### Required includes

The SystemC pin-level models are wrapped with TLM functionality. The test bench includes the SystemC wrapper files for any models included in the system, and includes required by the Fast Models runtime. Ensure you add these files for any new models added to your system. Here is an example of the includes section of a CPAK test bench:

```cpp
#include "models/SimpleMem.h"
#include "models/SimpleFlash.h"
#include "models/SimpleFlashImp.h"
#include "models/RAMBlock.h"
#include "models/SimpleBus.h"
#include "models/BasicUART.h"
#include "models/ElfLoader.h"
#include "libCORTEXR8.tlm.h"                 // CPU
#include <tlm_utils/simple_initiator_socket.h>
#include <iostream>
#include <scx/scx.h>
#include <scx_simcontroller.cpp>
#include <scx_scheduler_mapping.cpp>
#include <scx_report_handler.cpp>
```

### Initialization of the simulation environment and model instantiation

The `sc_main()` section of the test bench must first initialize the SCX simulation environment. It states clocking specifications, then instantiates any models included in the system. Ensure you instantiate any new models added to your system. For example:

```cpp
int sc_main(int argc, char *argv[]) {
    // Debug initialization
    scx::scx_initialize("R8-SysC");

    // If you want to see messages about 'port not bound' change SC_DO NOTHING to SC_DISPLAY.
    // If you want it to abort on a 'port not bound' error comment out the line below.
    sc_report_handler::set_actions(SC_ID_COMPLETE_BINDING_, SC_ERROR, SC_DO NOTHING);

    // Clock Object
    sc_clock cpu_clk("clk", 1, SC_NS, 0.5);
    ARM::Models::Cycle::ModelCortexR8::CortexR8Imp core("CortexR8");

    // Main Memory
```
Port bindings

The test bench specifies all TLM port bindings. Signal bindings required for the system are also specified in this area. Specify any additional TLM port bindings and signal bindings in this area:

```cpp
// Core Main Memory Port Bindings
core.iSkt_AXI3_Master_PORT0->bind(bus.tSkt);
core.directIskt_AXI3_Master_PORT0.bind(simple_mem.directTskt);

// Core Low Latency Peripheral Port Bindings
core.iSkt_AXI3_Master_PERI->bind(uart.tSkt);
core.directIskt_AXI3_Master_PERI.bind(uart.directTskt);

// Bus iSkt[0] connected to Main Memory
bus.iSkt[0]->bind(simple_mem.tSkt);

// Clock
core.clk(cpu_clk);
simple_mem.clock.bind(cpu_clk);
uart.clk.bind(cpu_clk);
bus.clk.bind(cpu_clk);
```

For information about signal bindings, clock bindings, performance data generation, command line arguments, and simulation calls, use the instructions in 4.3.1 Modifying the test bench for pin-level models on page 4-29.
Chapter 5
Troubleshooting

This chapter provides solutions for problems that may occur when working with CPAKs.

It contains the following sections:

- **5.1 carbon_sc_multiwrite_signal.h build error on page 5-34.**
- **5.2 Unrecognized command line option on page 5-35.**
- **5.3 Licensing errors on page 5-36.**
- **5.4 Bytes requested error when specifying application on page 5-37.**
5.1 carbon_sc_multiwrite_signal.h build error

Incorrectly set CARBON_HOME environment variable results in fatal error.

Cause

When using a version of the Cycle Model Studio runtime other than the one included in the CPAK, the environment variable CARBON_HOME defines the runtime location. When unset (this is the default for the CPAK), the Cycle Model Studio runtime included in the CPAK is used.

If CARBON_HOME is set, it must be set to a Cycle Model Studio runtime installation, or full version of Cycle Model Studio, that is Version 11 or later. Otherwise, an error similar to the following may occur when building the CPAK:

```plaintext
../MODELS/CortexR52_2CPU/gcc483/SystemC/libCortexR52.systemc.h:19:48: fatal error: carbon/carbon_sc_multiwrite_signal.h: No such file or directory
#include "carbon/carbon_sc_multiwrite_signal.h"
compilation terminated.
make: *** [system_test.o] Error 1
```

Solution

Either:

- Source the location of a Version 11.0 or later Cycle Model Studio runtime or Cycle Model Studio.
- Unset CARBON_HOME to use the version of the Cycle Model Studio runtime included in the CPAK.
5.2 Unrecognized command line option

Running an unsupported GCC version results in the build error unrecognized command line option "-std=c++11".

Cause

Using an unsupported GCC version may result in a build error similar to the following:

```
cc1plus: error: unrecognized command line option "-std=c++11"
make: *** [system_test.o] Error 1
```

Solution

Check your GCC version against the supported versions listed in 1.2 System requirements and prerequisites on page 1-11. In the following example, GCC 4.4.7 is unsupported and GCC 4.8.3 (a supported version) is sourced:

```
$ gcc --version
gcc (GCC) 4.4.7 20120313 (Red Hat 4.4.7-11)
Copyright (C) 2010 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

$ source /o/Linux64/etc/setup.sh
$ gcc --version
gcc (GCC) 4.8.3
Copyright (C) 2013 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
```
5.3 Licensing errors

A valid Arm Cycle Model runtime license is required to run CPAK simulations.

Cause

If a valid license is not available, an error similar to the following may occur when running the test bench simulation:

The license files (or license server system network addresses) attempted are listed below. Use LM_LICENSE_FILE to use a different license file, or contact your software provider for a license file.
Feature: CM_ARM_Runtime
Filename: /license
License path: /license:

Solution

- Ensure that the environment variable ARMLMD_LICENSE_FILE is set to your license server; for example, export ARMLMD_LICENSE_FILE=port@host.
- Contact Arm Technical Support (support-esl@arm.com).
5.4 Bytes requested error when specifying application

Number of bytes requested error message occurs when starting a simulation and specifying an application.

Cause

When launching a simulation with a specified application, use the -a or --application flag only with TLM-based CPAKs. Using these flags with pin-level CPAKs results in an error similar to the following:

$ Number of bytes requested for write (1) does not match numbers of bytes reportedly written(0)

Solution

Specify the application according to the instructions in 4.2 Application loading on page 4-28.