A Flexible Virtual Development Environment for Embedded Systems

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Sang-Young Cho, Yoojin Chung, and Jung-Bae Lee*

CSE, Hankuk University of Foreign Studies
*CI, Sunmoon University

Contents

Introduction

Why Virtual Development Environment ?

- Time-to-market is very crucial for embedded systems
- Most embedded systems contains hardware IPs and software IPs
- Traditional development flow
  - Application software design is not started until the IPs are integrated
    - Development cycle is too long
- Virtual prototype approach
  - Virtually built inside a computer, and simulates real hardware
  - Software development can be performed without tangible hardware
  - Shorten the development time
    - Initial verification of SW/HW
    - Predicts performance values and guides a final design

Virtual Development Environment (VDE)

- Virtual hardware model & Simulation engine
- Software development tools & Software models

Introduction

Virtual Development Environment Examples

Virtual Platform

- Commercial Configurable VDE of Virtio
- Various cores of ARM, X-Scale, MIPS
- Software design, development, and verification

MaxSim

- Commercial VDE of ARM for SoC development
- Support SystemC
- ESL (Electronic System Level) Tool (SW+HW development)

Visual ESC

- Commercial VDE of Summit
- Processor models for ARM, MIPS
- ESL tool

- Expensive
- Tightly integrating hardware simulation & software development tools
- Limited flexibility of using hardware model and software tools

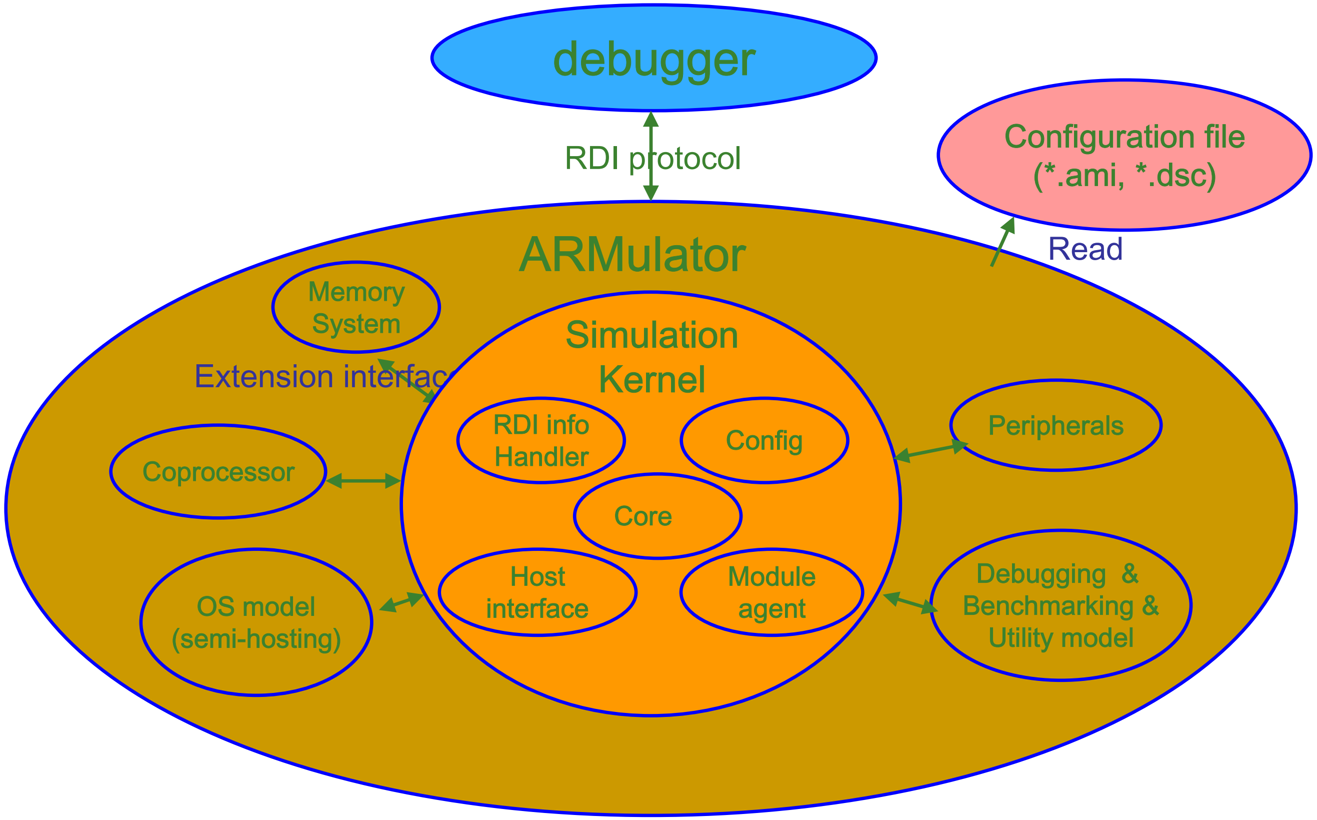
Introduction

Our Approach for Virtual Development Environment

- Useful and Cheap Solution
  - For ARM processor cores ← over 70% market-share
  - ARMulator based VDE ← ADS 1.2
    - Support upto ARM10 and Xscale
  - Hardware IPs for PDA
  - uCOS-II based programming
- Flexible Environment
  - SystemC Engine is attached to ASB bus
    - SystemC HW IP models
  - SystemC Engine is attached to AxD with RDI 1.5.1
    - Only SystemC models
  - User Interface for LCD panel,UART, LED display

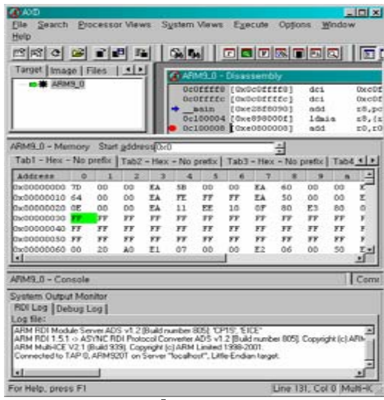
Describe a VDE implementation for SW development based on ARMulator and SystemC

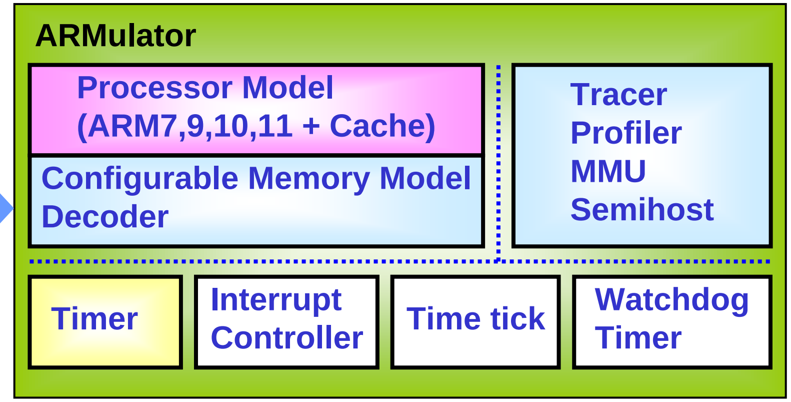
Related Studies: ARMulator Environment



- ARM's virtual software development environment
  - Cycle-based instruction set simulator
  - Basic memory model
  - Can be extended

Related Studies: ARMulator Environment


Debugger



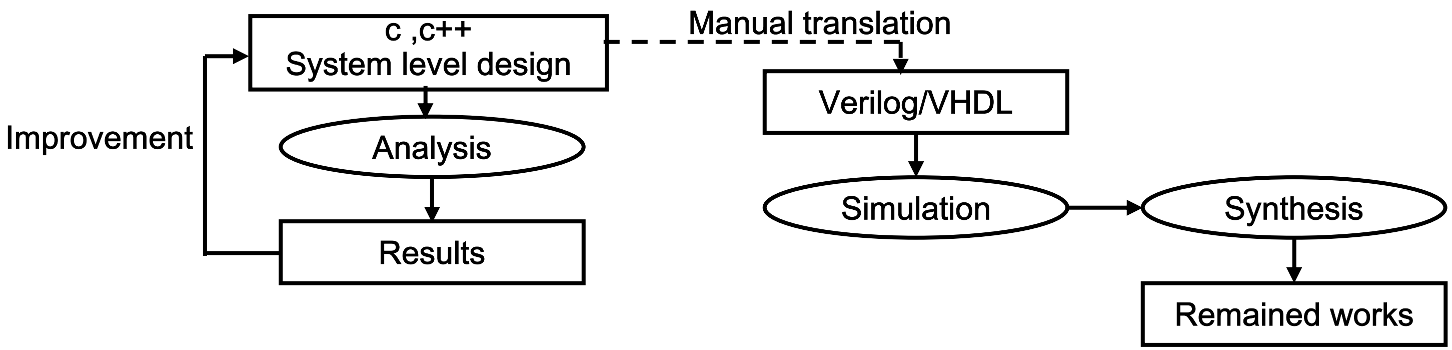
- In usual ARMulator environment
  - AxD of ADS1.2 or RealView Debugger of RVDS 3.0
  - Processor cores + Basic hardware IP's
  - Profiler, MMU, Semihosting

Related Studies: SystemC

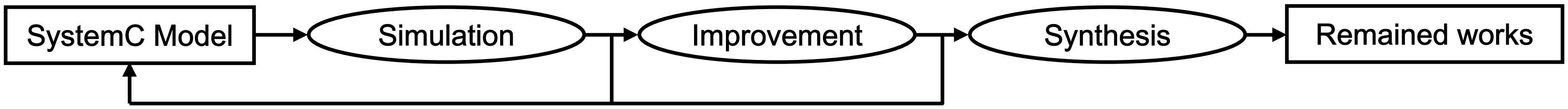
SystemC ?

- C++ class library to support system level design
- SystemC ver. 2.x : register transfer, algorithm/function level
- Coming version : will support real-time OS and analog circuit

SystemC Design Methodoly



SoC development without SystemC

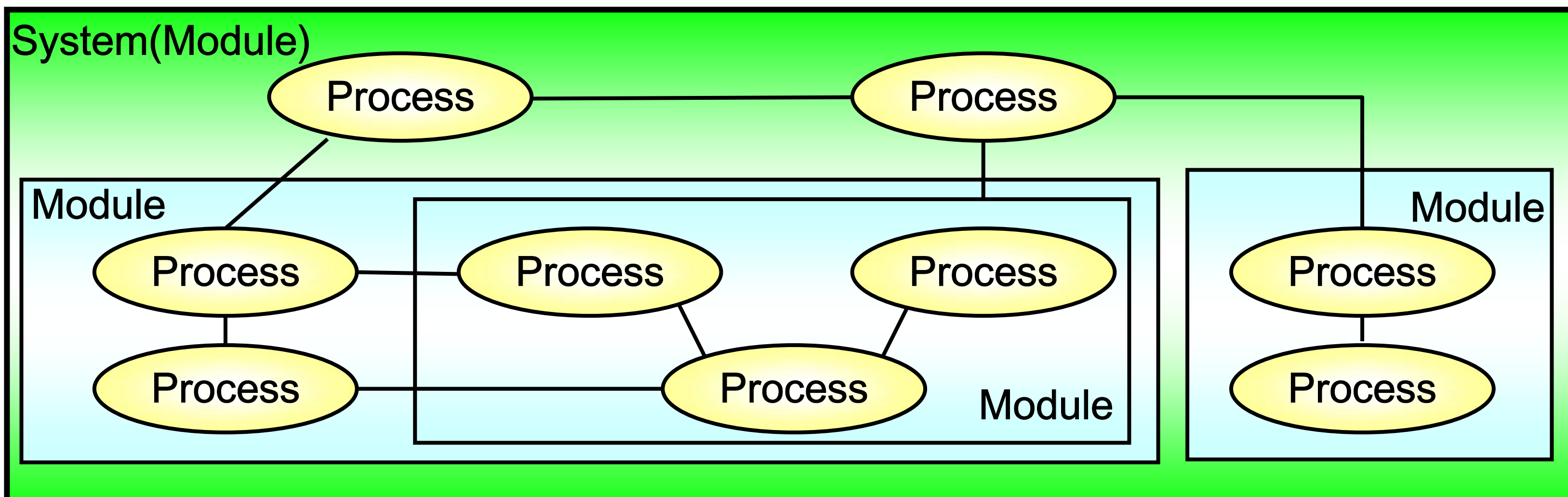


SoC development with SystemC

SystemC Structure

System Modeling with SystemC

- Consists of modules and processes with hierarchical structure
- Module includes other modules or processes (Container class)
- Processes model functionalities and defined within a module
- Port: Module has ports and modules are connected via ports
- Signals connect modules through ports
- Clock: SystemC's special signal for a system clock
- Cycle-based simulation: untimed model with clock cycle accuracy

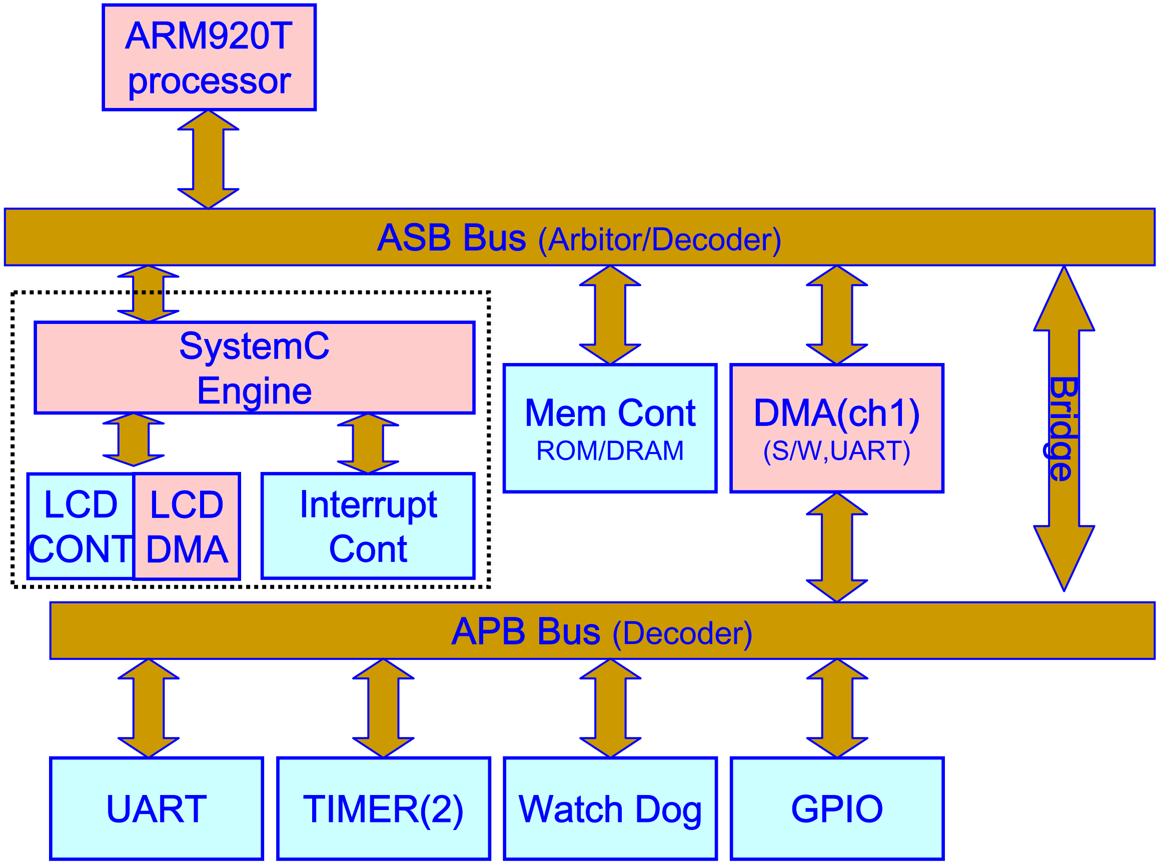


SystemC's System Modeling

Design and Implementation

Extension of ARMulator Environment

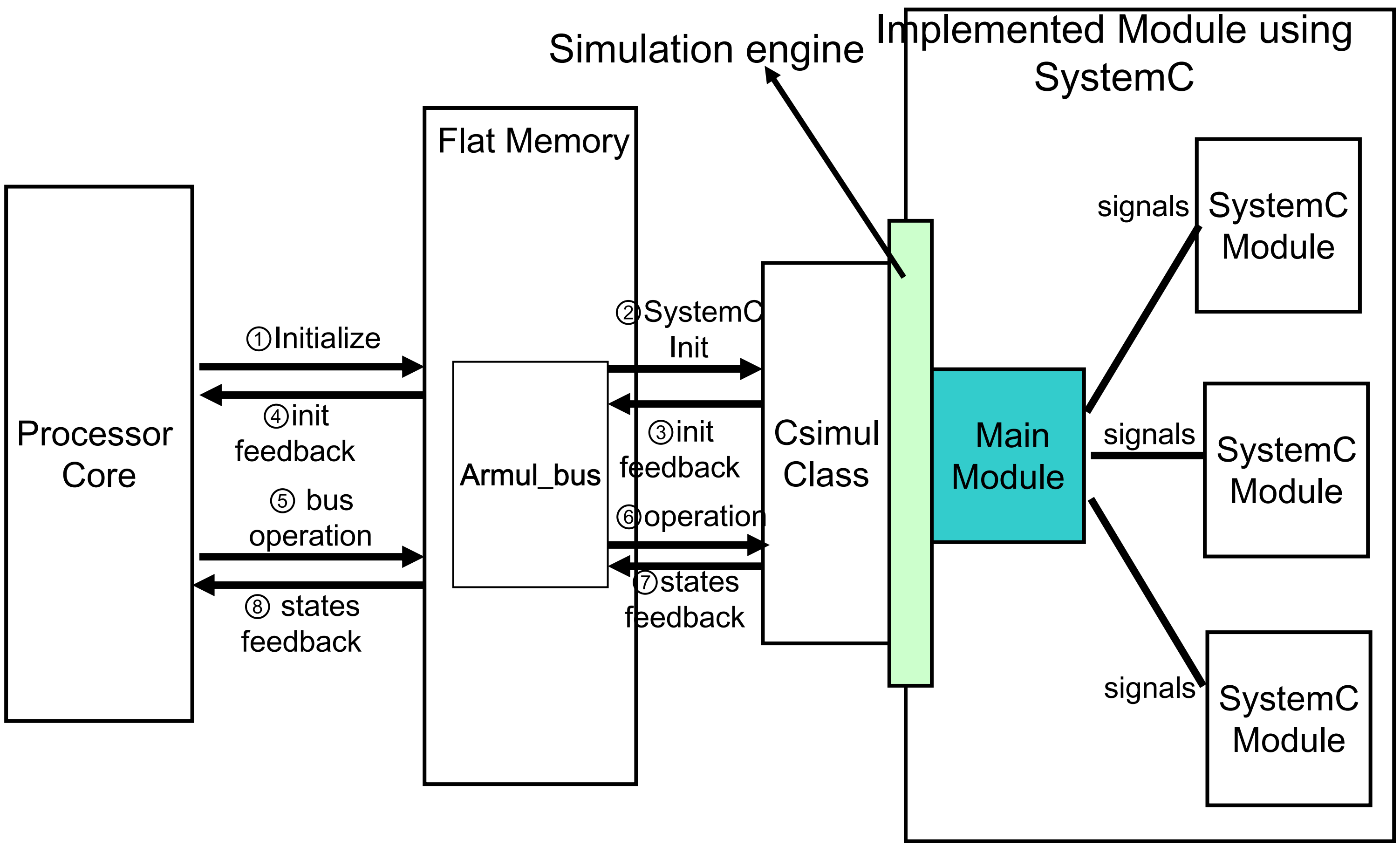
- Refer to S3C2410
  - for PDA
- ARMulator
  - ARM920T
    - MMU, Cache
  - ASB, APB
    - SystemC
  - MC, DMA, UART TIMER, WDT, GPIO, Bridge
- SystemC
  - LCDC, INTC



Overall Structure

Design and Implementation

SystemC Extension



Design and Implementation

SystemC Extension

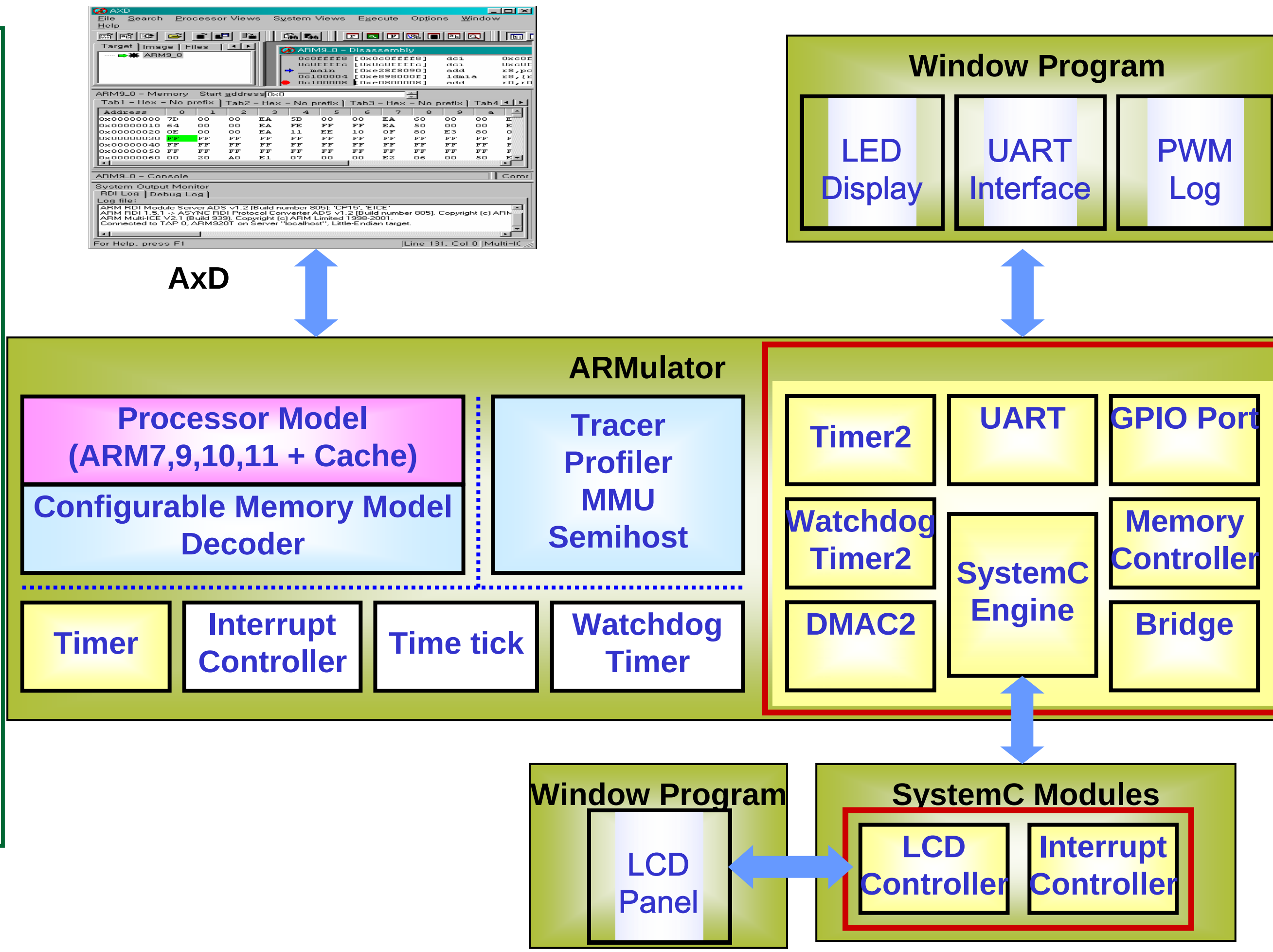
- In InitializeModule() function of Armul_bus
  - SystemC modules are initialized by Csimul class
  - SystemC.lib is modified
    - Main() → sc_main()
    - Clock is synchronized with ASB clock
- Csimul behavior
  - Generates modules
  - Make sc_signal to control input/output wires of modules
  - Connect signals after a main module in SystemC is made
  - Create functions for read/write of connected modules
  - During simulation, a callback function is called by Armul_bus
  - Allow simulation result to be reported to Armul_bus

SystemC engine is connected to ASB bus

Design and Implementation

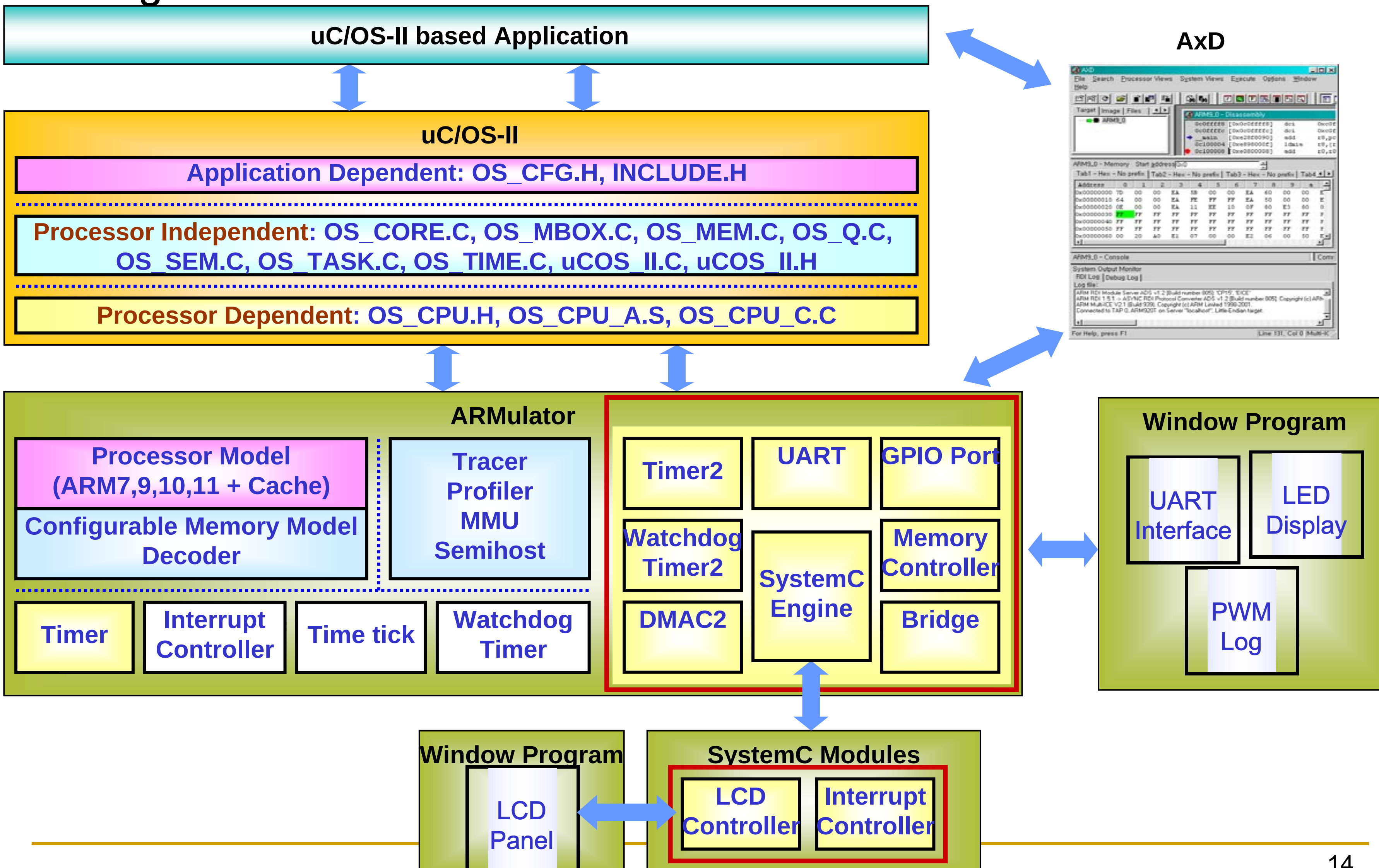
Peripheral Features of the Implemented Environment

- ARMulator
  - Timer2
  - WDT2
  - DMAC2
  - UART
  - GPIO
  - MC
  - Bridge
  - SystemC
- SystemC
  - LCDC,
  - NTC
- Windows
  - LCD panel
  - LED display
  - UART interface
  - PWM log



Design and Implementation

Porting uC/OS-II



Design and Implementation

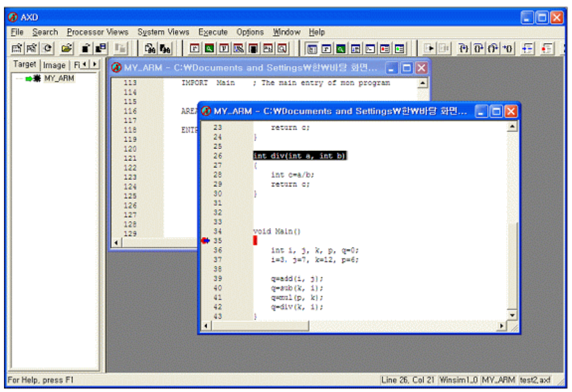
Testing the implemented VDE

- Testing Environment
  - OS : Microsoft Windows XP
  - Compiler : Microsoft Visual C++
  - Debug Controller : AXD Debugger of ARM Developer Suite v1.2
  - Test sample program : CodeWarrior of ARM Developer Suite v1.2

- 3-Task Test Program
  - Main() creates TASK1 → TAS1 createsTASK2, TASK3
  - TASKs are moving side-to-side with different delay values
  - Each TASK draws its image to Image Buffer
  - Can verify scheduling with timer and interrupt controller
  - Can verify LCD displaying with ASB bus, LCD controller and LCD panel
- With small sample programs
  - Verify GPIO, DMAC, UART

Design and Implementation

Testing the implemented VDE



Conclusion

- Virtual Development Environment (VDE)
  - Provide embedded software development environment without real hardware →Reduce embedded system development cost
- We implemented a flexible VDE with ARMulator and SystemC models
  - Target processor core → adapts ARM920T processor core widely used in commercial
  - Debugger → ARM’s AxD
  - Extension of ARMulator: TIMER, WDT, MC, DMAC, UART, GPIO, SystemC engine
  - SystemC Module → LCD Controller, Interrupt Controller
  - User Interface → LCD panel, LED display, UART int., PWM logging
  - uC/OS-II Porting → Multi-threaded application
- Benefits of the implemented VDE
  - Multi-modeling
    - ARMulator model and SystemC model
  - Multi-threaded programming
    - With uC/OS-II API
  - Construct cost is very low
    - ADS 1.2 with public SystemC models