Introduction

VHDL

• What is VHDL?

**V**ery **H**igh **S**peed **I**ntegrated **C**ircuit

**H**ardware

**D**escription

**L**anguage

IEEE Standard 1076-1993
History of VHDL

- Designed by IBM, Texas Instruments, and Intermetrics as part of the DoD funded VHSIC program
- Standardized by the IEEE in 1987: IEEE 1076-1987
- Enhanced version of the language defined in 1993: IEEE 1076-1993
- Additional standardized packages provide definitions of data types and expressions of timing data
  - IEEE 1164 (data types)
  - IEEE 1076.6 (numeric)
  - IEEE 1076.4 (timing)

Traditional vs. Hardware Description Languages

- Procedural programming languages provide the how or recipes
  - For computation
  - For data manipulation
  - For execution on a specific hardware model

- Hardware description languages describe a system
  - Systems can be described from many different points of view
    - Behavior: what does it do?
    - Structure: what is it composed of?
    - Functional properties: how do I interface to it?
    - Physical properties: how fast is it? How much power does it generate?
**Usage**

- Descriptions can be at different levels of abstraction
  - Switch level: model switching behavior of transistors
  - Register transfer level: model combinational and sequential logic components
  - Instruction set architecture level: functional behavior of a microprocessor
  - Behavioral level: model the computations

- Descriptions can used for
  - Simulation
    - Verification, performance evaluation
  - Synthesis
    - First step in hardware design

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**Why do we Describe Systems?**

- Design Specification
  - Unambiguous definition of components and interfaces in a large design

- Design Simulation
  - Verify system/subsystem/chip performance prior to design implementation

- Design Synthesis
  - Automated generation of a hardware design
Digital System Design Flow

- Design flows operate at multiple levels of abstraction
- Need a uniform description to translate between levels
- Increasing costs of design and fabrication necessitate greater reliance on automation via CAD tools
  - $5M - $100M to design new chips
  - Increasing time to market pressures

Embedded Systems

- Embedded systems requirements
  - Physical: footprint, power
  - Behavior: performance, predictability
  - Performance characteristics typically determined by a few application kernels
  - Economic: time to market, NRE cost constraints dominate

- Customization has been met with custom hardware solutions
  - Chip market as a whole is expected to be $250B by 2008

Customization is the key!
Increasing Cost of Customization*

- Cost and Risk rising to unacceptable levels
- Top cost drivers
  - Verification (40%)
  - Architecture Design (23%)
  - Embedded Software Design
    - 1400 man months (SW)
    - 1150 man months (HW)
  - HW/SW integration

Example: Design with 80 M transistors in 100 nm technology

Estimated Cost - $85 M - $90 M

12 – 18 months


A Synthesis Design Flow

- Requirements
- VHDL Model
  - Functional Design
- VHDL Model
  - Register Transfer Level Design
- Logic Simulation
  - Synthesis
  - Place and Route
  - Timing Extraction
- Behavioral Simulation (VHDL)

- Automation of design refinement steps
- Feedback for accurate simulation
- Example targets: ASICs, FPGAs
The Role of Hardware Description Languages

- Design is structured around a hierarchy of representations
- HDLs can describe distinct aspects of a design at multiple levels of abstraction

[Interoperability: models at multiple levels of abstraction]
[Technology independence: portable model]
[Design re-use and rapid prototyping]
The Marketplace

- Time to market delays have a substantial impact on product revenue
- First 10%-20% of design cycle can determine 70%-80% of the cost
- Costs are rising rapidly with each new generation of technology
- Need standards and re-use → automation centered around HDL based tools such as VHDL


Alternatives

- The Verilog hardware description language
  - Finding increasing use in the commercial world
    • SystemVerilog gaining prominence
  - VHDL dominates the aerospace and defense worlds

- Design flows based on procedural programming languages
  - SystemC
    • C++ with additional hardware-based language elements
  - C-based design flows
    • (C + extensions) as well as ANSI C based
  - Other
    • Java, MATLAB, and specialized languages
Role of VHDL

Very High Speed Integrated Circuit

Hardware

Description

Language

- System description and documentation
- System simulation
- System synthesis