Introduction

VHDL

- What is VHDL?

VHISC → Very High Speed Integrated Circuit

Hardware

Description

Language

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

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
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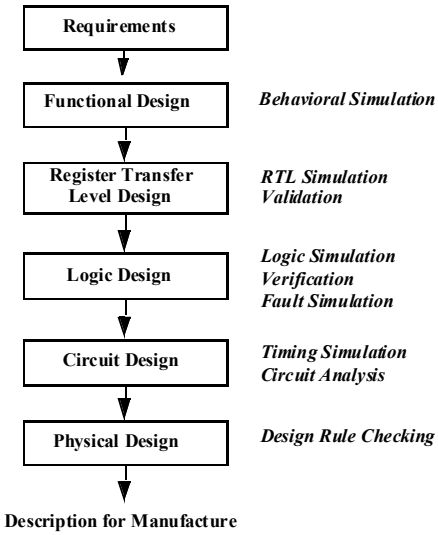
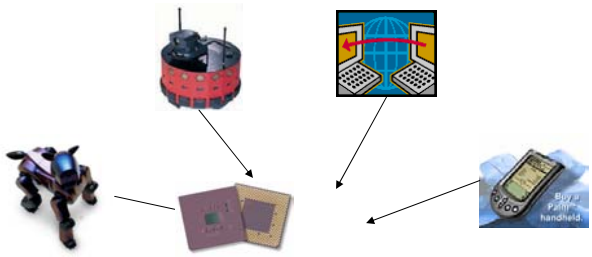
- Design Synthesis
  - Automated generation of a hardware design

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

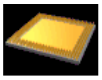


- Embedded systems requirements
  - Physical: footprint, power
  - Behavior: performance, predictability
  - Performance characteristics typically determined by a few application kernels
  - **Economic: time to market, NRE cost constraints dominate**

Customization is the key !

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

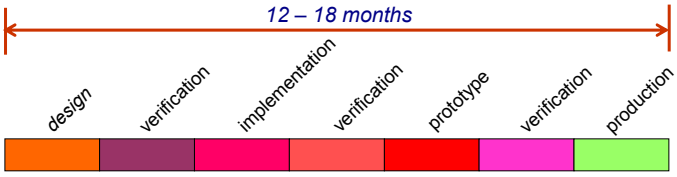
Increasing Cost of Customization*



Estimated Cost - $85 M -$90 M

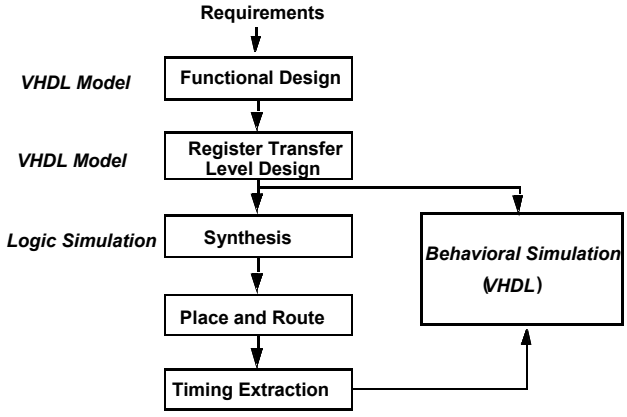
Example: Design with 80 M transistors in 100 nm technology

- 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



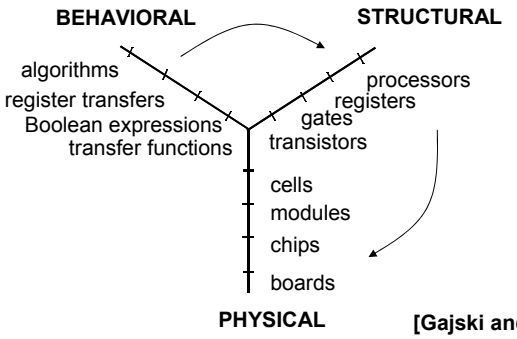
*Handel H. Jones, "How to Slow the Design Cost Spiral," *Electronics Design Chain*, September 2002, www.designchain.com

A Synthesis Design Flow



- Automation of design refinement steps
- Feedback for accurate simulation
- Example targets: ASICs, FPGAs

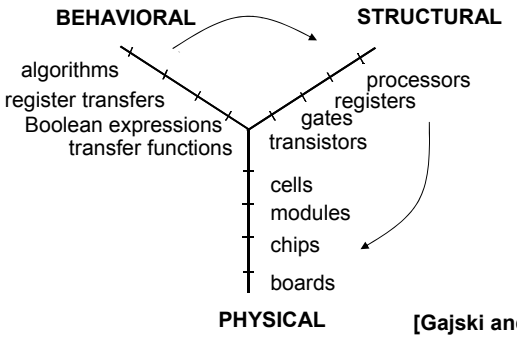
The Role of Hardware Description Languages



[Gajski and Kuhn]

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

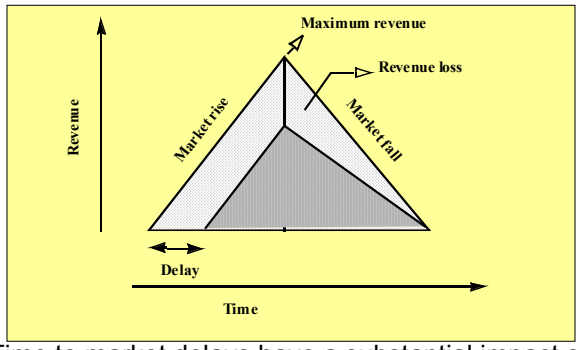
The Role of Hardware Description Languages



[Gajski and Kuhn]

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

The Marketplace



From V. K. Madisetti and T. W. Egolf, "Virtual Prototyping of Embedded Microcontroller Based DSP Systems," IEEE Micro, pp. 9–21, 1995.

- 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

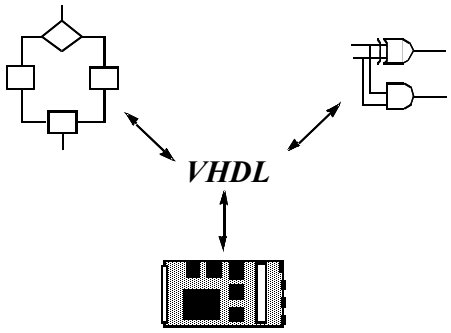
Role of VHDL

V *Very High Speed Integrated Circuit*

H *Hardware*

D *Description*

L *Language*



- System description and documentation
- System simulation
- System synthesis