Introducing Multi-Phase Design Into a Junior-level course:

A case study of COE360 (Principles of VLSI Design)

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Outline

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- Phased Design
- The Course
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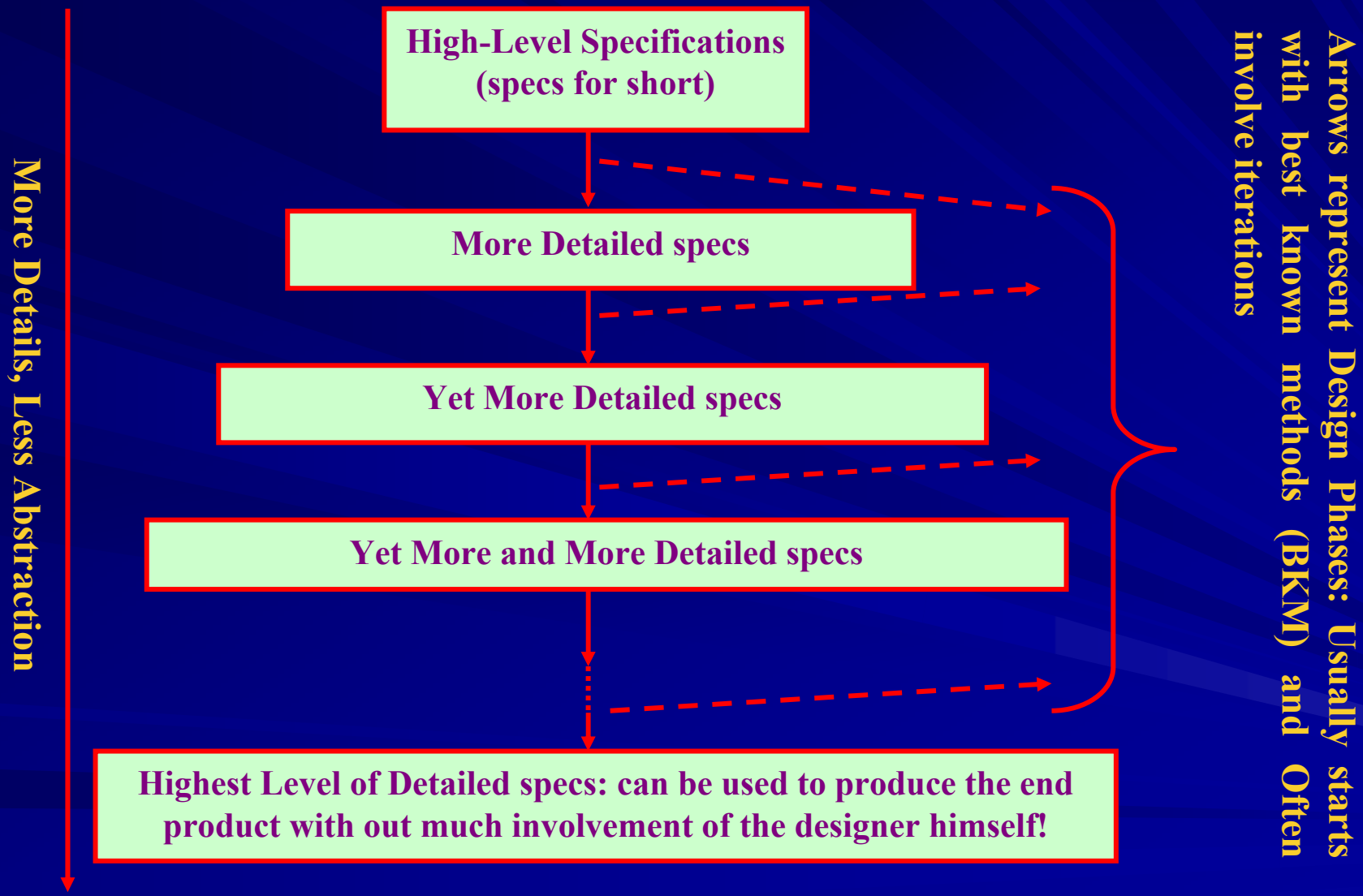
Introduction: Engineering Design

The International Technology Education Association (ITEA) defines engineering design as:

"The systematic and creative application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems" [ITEA]

My definition: The gradual Refinement of Specifications

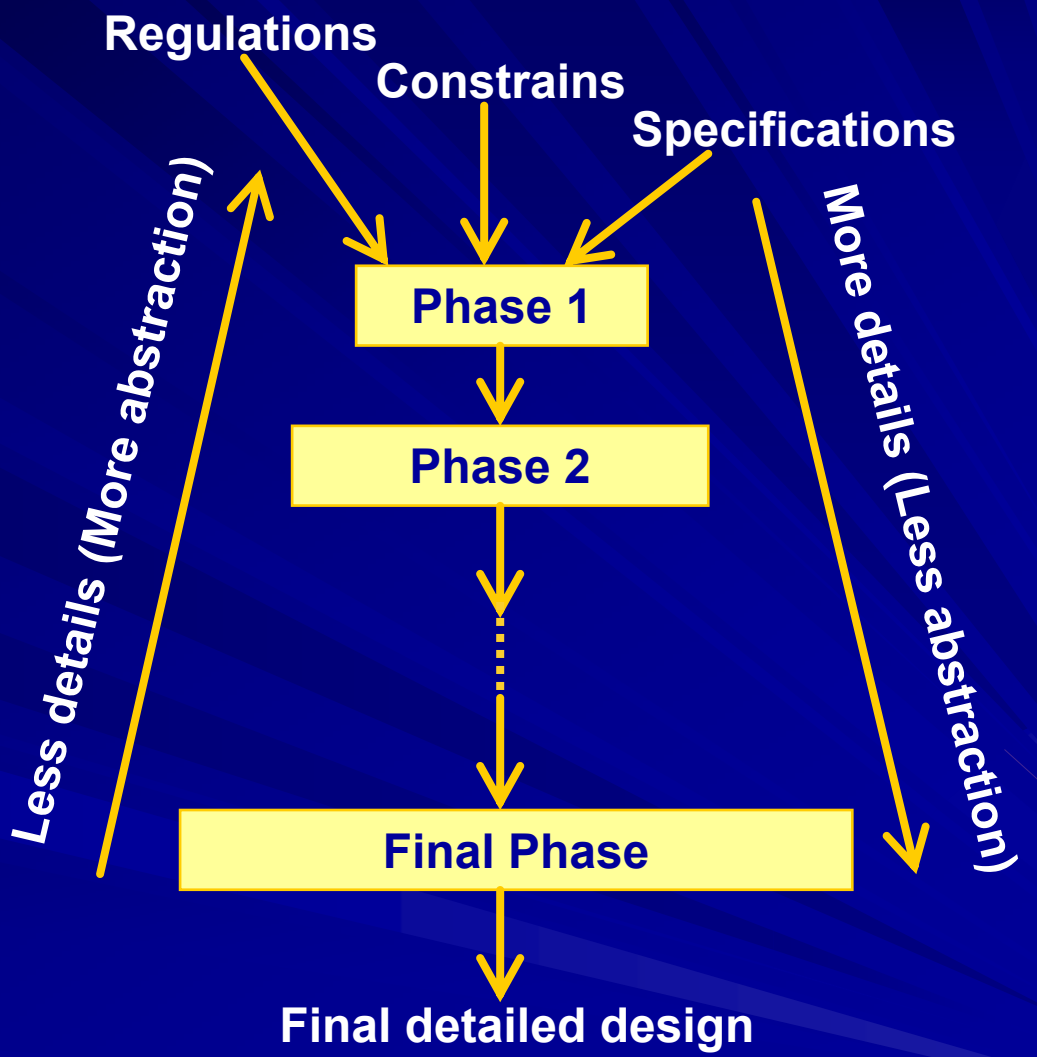


Introduction

- Difficulty of infusing engineering design into UG curricula:
  - Project courses → Too late in the program
  - Course Projects:
    - Short semesters
    - Need to build necessary background
    - Projects starts late in the semester
    - No time to do a significant project → insufficient exposure to design concepts and practices
- Solution: Course Projects with Phased-Design

Phased Design

- The over all design is divided into logical phases, with the outcome of every phase representing a major milestone and serving as an input to the next phase.
- The design process is viewed as a gradual refinement of design specifications → makes design complexity manageable



The Course: Principles of VLSI Design

- **Design of state-of-the art digital integrated circuits with emphasis on very-large-scale integration of functions into a single chip (IC)**
- **Design complexity ranges from few hundred transistors (basic processing unit) to millions of transistors**
- **Design specifications typically include functional specifications, performance specifications (e.g. Speed) and time constrains**

Design concepts

1. **Phased-Design:** Project is divided into 3 phases; Logic Design, Circuit Design and Mask design (>12 layers). CAD tools used throughout all design phases

   → Students can start their course project from day 1! (Logic design is based on earlier courses)

2. **Design Abstraction:** Hiding unnecessary design details

   → Early phases of the design would not require detailed knowledge of the implementation. Students are only required to identify the components of the final design, their functions, and interaction

3. **Modularity:** The design is divided into independent components with clear interfaces (information hiding)

   →Helps managing design complexity, allows parallel engineering (team designs) and enables design re-use → very important for low-cost product development

Design concepts, *Contd.*

4. **Design Hierarchy:** Modules form larger modules (Top-Bottom design strategy)

   → Helps manage design complexity, verification and re-use

5. **Best-Known-Methods (BKMs):** Only tried and tested methods should be used in designing the modules

   → Manage complexity, design time and reduce the probability of design errors

6. **Design Verification:** The outcome of each phase is verified against the input specifications to that phase

7. **Design Documentation:** precise and concise account of all design decisions taken in a specific phase and their consequences (simple risk analysis) → helps backtracking and reduce design iterations

8. **Design Validation:** The final design is verified against the initial specifications

Sample Designs

- Design of a 128Kbyte Synchronous SRAM with minimum operating frequency of 100 MB/S
- Design of a 250 MHz 256words X 64bit FIFO
- Design of 256 X 64bits Dual port Register File with operating frequency of 200 MHz.
- Design of a 250 MHz 32Kbyte 2-way set-associative Cache
- Design of 1 GB/S UART
- … all using a 0.5 µm, 5V technology.

Sample Designs, *contd.*

- Phase 1 Samples (1,2): Logic Design (Xillinx Foundation ISE, Logic Works)
- Phase 2 Samples (1,2): Circuit Design (WinSpice)
- Phase 3 Samples (1,2): Mask Design (Magic, IRSim)

Conclusions

- Complex engineering designs could be introduced in regular courses (i.e. other than capstone courses) through phased-designs
- Universal engineering themes (or concepts) could be introduced throughout the design process
- CAD Tools are essential for this purpose