

ECE 410/510: Emerging Functional Verification Methods

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ECE 410/510: Emerging Functional Verification Methods

Introduction to theory and techniques to shift digital circuit design verification to earlier stages of development

- Brief introduction to pre-silicon validation
- Emulation
- Formal Methods
 - System Specification and Verification
 - Formal Verification

- **Prerequisites:** Familiarity with computer architecture and hardware description languages required (e.g. ECE 351 and ECE 371).

- **Instructor:** Tom Schubert

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- **TA (for emulation questions):** Sameer Ghewari

- **D2L website now active**

ECE Graduate Track (Proposed)

Design Verification and Validation

CORE CLASSES

- ECE 571 System Verilog
- ECE 585 Microprocessor System Design
- ECE 510 Introduction to Pre-silicon Functional Verification (Simulation)
- ECE 510 Emerging Functional Verification Methods (Emulation, Formal Methods)

ELECTIVES

Validation

- ECE 510 POST-SILICON FUNCTIONAL VALIDATION
- ECE 510 POST-SILICON ELECTRICAL VALIDATION
- ECE 582 FORMAL VERIFICATION OF HARDWARE/SOFTWARE SYSTEMS

Computer Architecture

- ECE 586 COMPUTER ARCHITECTURE
- ECE 587 ADVANCED COMPUTER ARCHITECTURE I

Design/Modeling

- ECE 540 SYSTEM ON CHIP DESIGN WITH FPGAs
- ECE 581 ASIC: MODELING and SYNTHESIS
- ECE 590 DIGITAL DESIGN USING HARDWARE DESCRIPTION LANGUAGES

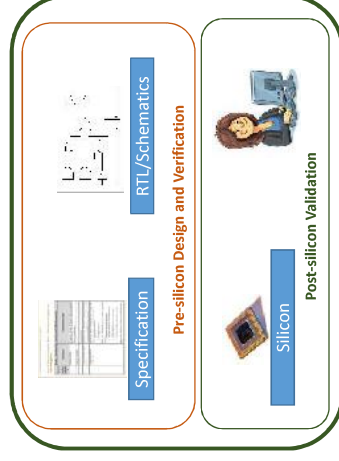
Note: all DVW 510 topics courses will transition to approved, university catalog listed courses

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Design Verification and Validation

- Verification: Does the product meet its requirements specification?
 - “Paper exercise”
 - “Does the design do what was intended based on the design input requirements?”
- Validation: Does the product meet customers expectations?
 - “Build and compare”
 - “Did I create what the customer wanted?”

- Pre-silicon
Post-silicon



**In practice, people often don't adhere to these definitions!

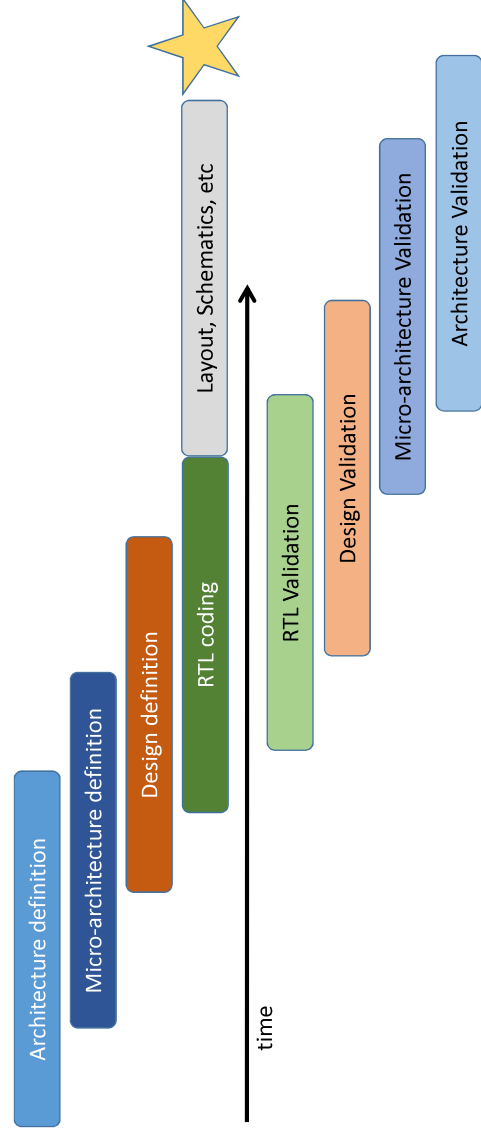
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Validation Crisis

- Validation has become the critical path to product development
- The trend is getting worse
 - More complex designs and tighter schedules ==> Increased risk
 - Good, targeted testing is mature, but most of design space not tested
- Validation dependencies
 - Architecture/microarchitecture/design documentation
 - Documentation often exceptional, meticulously created, and well thought out. But takes time!
 - Available later than desired. Incomplete, ambiguous, and often wrong (at least the drafts)
 - RTL availability
 - Need to wait for design to be available to test. Typically staged.
 - Resources (machines, tools, people)
 - Expensive and limited.
- What strategies can help fill the gap?
 - Shift effort to earlier in project development
 - Integration with other tasks (Friedman: “in-sourcing”)
 - Complements/improvements to current best practices

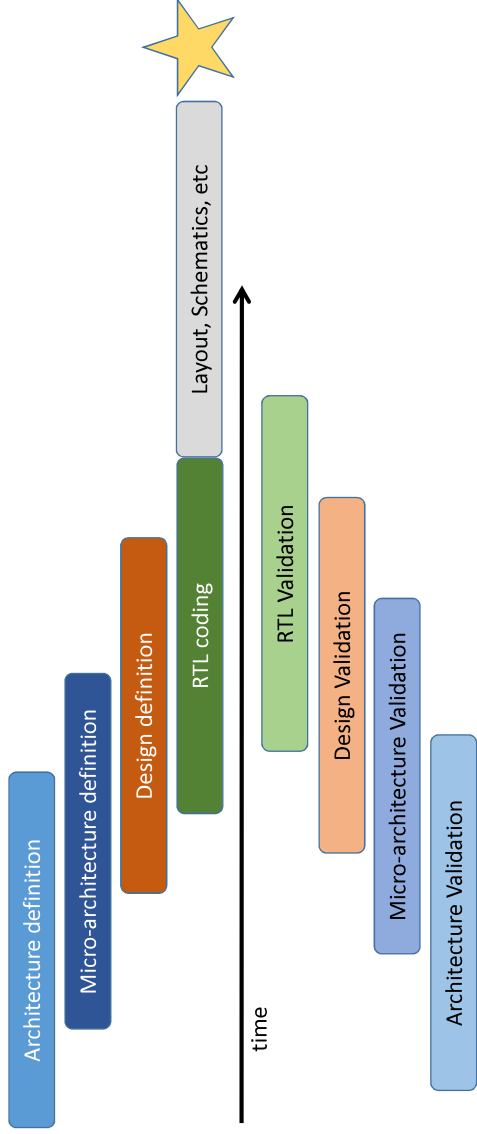
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Pre-silicon Product Schedule



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Pre-silicon Product Schedule



ECE 410/510: Emerging Functional Verification Methods

Outline of Course Content

Design Validation Principles	Problem definition and solution strategies Product lifecycle and risk management
Emulation	Methods for design stimulus, checking, and coverage Mentor Graphics Veloce system and tools
Formal Methods	Protocol and Architecture Specification Formal Verification
	TLA+ language, TLC validation tool
	Theory, BDDs, SAT, assertions, assumptions

Course requirements

- midterm (20%), final (25%), project (30%), homework (25%)
- On most, but not all, assignments collaboration is encouraged.
- To pass the course, each requirement must be completed on time in accordance with its collaboration guidelines.

Student Learning Outcomes

- Knowledge of role of validation in modern digital design projects
- Knowledge of formal verification theory and application to digital design
- Knowledge of emulation techniques as a complement to simulation
- Ability to test digital designs using emulation technology
- Ability to use formal verification tools to model and validate evolving architecture ideas
- Understanding of the central nature of validation and the need for a structured, measured approach

Course Reading

Required

- Papers (links or PDFs provided)
- Emulation (Mentor Graphics Veloce)
 - Videos
 - Manuals
 - Presentations
- Protocol and Architecture Specification
 - Specifying Systems Text, Leslie Lamport
 - hardcopy available at the bookstore
 - Tutorial/hyperbook
 - Papers



References

- ECE510 Fundamentals of PreSi Validation text
Comprehensive Functional Verification,
Wile, Goss, & Roesner
- ECE571 System Verilog textbook
SystemVerilog for Verification
Spear and Tumbush

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Course Admin

- Assignments
- **Homework**
 - Emulation assignments
 - TLA+ assignment
 - **ECE510 paper:** 3-5 page survey of research on topic of your choice.
- TLA+ installed on machines in FAB55-17 and available in the Westside Labs
- **Team project:** can be either TLA+ or Emulation based
 - Identify system with shared resources to verify (e.g. cache coherency system, PCI system)
 - Compile design (write from scratch or borrow and modify). No commercial design with IP concerns
 - Create Verification plan
 - Complete verification
 - Discuss with me potential bugs we might add to the design
 - Re-verify
 - 5-10 minute presentation

see the syllabus for more detail

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TLA+ Installation

Google “The TLA Home Page”

<http://research.microsoft.com/en-us/um/people/lamport/tla/tla.html>

Links on the TLA home page:

- The TLA Toolbox

<http://research.microsoft.com/en-us/um/people/lamport/tla/toolbox.html>

May require installation of java and eclipse

Once installed, the application can be found in the tool box subdirectory

- TLA Book: Specifying Systems

<http://research.microsoft.com/en-us/um/people/lamport/tla/book.html>

- TLA+ Hyperbook

<http://research.microsoft.com/en-us/um/people/lamport/tla/hyperbook.html>

Once downloaded, open start.pdf to view.

- The Pretty-Printer

<http://tla.msr-inria.inria.fr/tlatoolbox/doc/spec/pretty-printing.html>

<http://www.miktex.org/>

After installing, I needed to logout/login for TLA to find it.

On ECE machines, you may need to P:\Programs\MikTex 2.9\miktex\bin\pdflatex

TLA+ Installation

- Recommendations
 - Create (not copy) shortcuts to your desktop
 - For use in ECE labs, keep a copy of the book, hyperbook, example programs on a usb-drive
- Documentation
 - Hyperbook
 - Specifying Systems Text
 - Syntactic Analyzer (ch 12)
 - LaTeX Typesetter (ch 13)
 - TLC Model Checker (ch 14)