ECE 554: Digital Engineering Laboratory Course Introduction

Department of Electrical and Computer Engineering

University of Wisconsin – Madison

Course Project

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- Design, simulate, synthesize, test, download and demonstrate a non-trivial computer with an original instruction set architecture (ISA)
- Four key requirements
  - It must be an original ISA (somewhat negotiable)
  - It must be non-trivial (a significant step above 552 ISA)
  - It must be tractable - everything takes at least twice as long as you expect
  - It must interface through the serial port with the terminal emulator (negotiable, but recommended for debug)
- Utilizes FPGA board interfaces in significant way
- Has significant firmware component (code running on your ISA)
- Might have software component if interfaces with host
- Encouraged to include research or novel component

Ideas for ECE554 Designs (1)

- A pipelined general-purpose computer with
  - A conventional ISA
    - Must support at least 14 general purpose registers.
    - Must support signed and unsigned MUL, and PUSH/POP
    - Must create an assembler for your ISA
    - If Harvard architecture, it must support a MOVC instruction
    - A gimmick that makes the machine non-trivial
  - Examples of gimmicks include
    - Superscalar *(on your own…we can't help you)*
    - VLIW or SIMD
    - Multithreading
    - Dynamic branch prediction
    - Floating point support
    - Interrupt support (vectored interrupts) + specialized peripheral
    - Non-trivial specialized instructions (multi-cycle)
    - Coprocessor/accelerator support
    - Fault tolerance support

Ideas for ECE554 Designs (2)

- A programmable special-purpose processor
  - Graphics Processor *(can't help you much with this)*
  - Binary Coded Decimal (BCD) Processor
  - String Processor
  - Neural Network processor
  - Tensor processor

- Make sure your processor can be implemented on the board, but don't let quirks of the system limit your creativity

Ideas for ECE554 Designs (3)

- Processor design relevant to current research projects,
  - Your own research
  - Bioinformatics Processor (BlastN, RNASeq, Denovo Sequencing)
  - Network Coding Accelerator, Viterbi Decoder
  - https://github.com/byeongkeun-kang/FingerspellingRecognition
  - https://devmesh.intel.com/groups/680/#projects
  - https://people.ece.cornell.edu/land/courses/ece5760/FinalProjects/
  - https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5377605

Hardware Additions

- Do you want to add some custom hardware to the system?
  - User interface
    - Joystick, push buttons, slide potentiometers
    - Inertial Sensor
    - Bluetooth transceiver
    - ???
  - If doing custom periph board get on it right away:
    - Must have board files submitted for fabrication by spring break

Software Component

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- Projects should also have significant software components. For example,
  - Assembler for your processor
  - Simple compiler for your processor would be a bonus
  - Software simulator for your processor?
  - Demonstration and testing software

- Software on an external host PC that your project interacts with?

Incorporating I/O Interfaces

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- The interfaces may be useful in implementing or demonstrating your project
  - VGA for displaying graphics
  - Camera (will see this in 2nd capability exploration)
  - USB/UART interface
  - PS/2 interface for mouse/keyboard
  - Ethernet interface to network
  - Audio in/out codec for music, speech recognition, etc.
  - IR rx/tx
  - Custom from board you design
- Become familiar with the board and its features early to know strengths/limitations.

Project Milestones

- Several major milestones
  - Project team selection
  - Project proposal presentation
  - Architecture document due
  - Interface document due
  - Weekly progress reviews
  - Down scoping (if necessary 3 weeks prior to demo)
  - Testing and demo review presentation
  - Project demonstrations
  - Project report due

- Will discuss these in more detail later

Start Thinking

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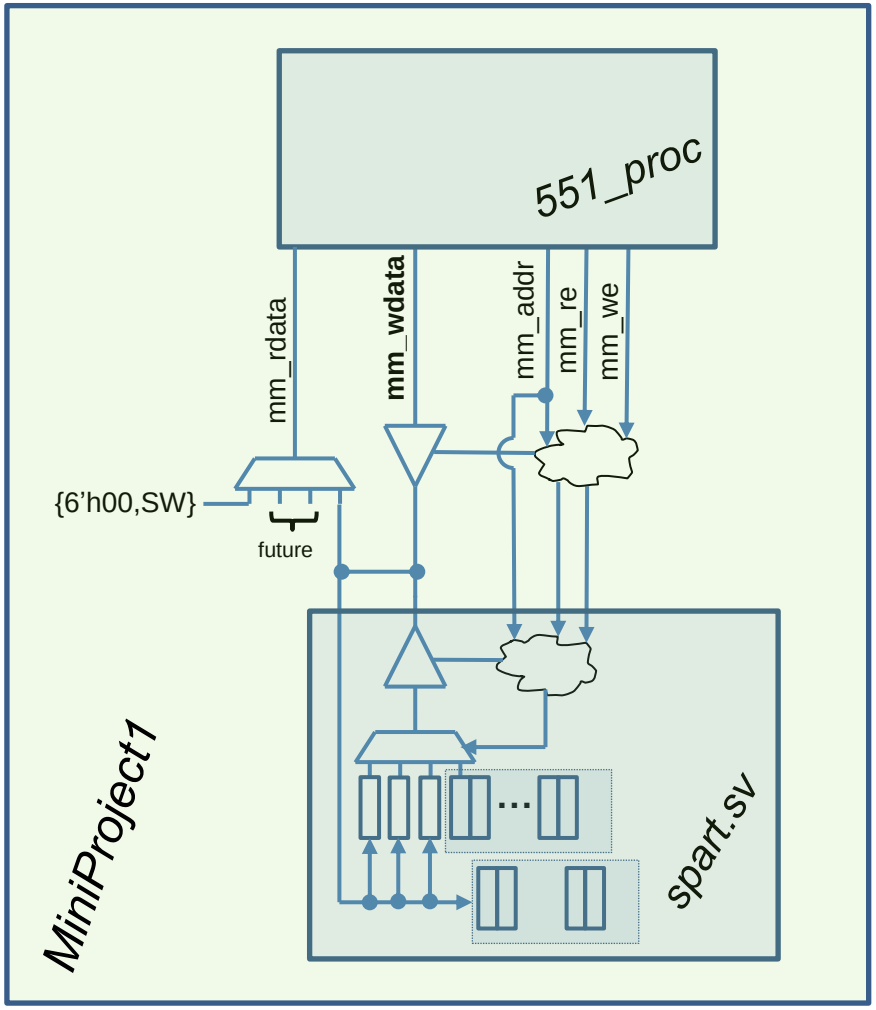
- Whole team has to agree to any presented idea
  - Give it some thought
  - Can think about ISA details without necessarily knowing exact project

Spart databus (bi-directional)



Example of inferring a tri-state:

```
assign bus = (enable) ? mm_wdata : 16'hzzzz;
```

HelloWorld.asm (more of a pain in the butt than you might think)

- Clear screen and Center text using VT100 escape codes
- Printing any string with pathetic instruction set is difficult
- Need to poll status register to know when can send next character
- Need to poll status register to know if char of name available
- Need to compare char typed to 0x0D
- Need to echo chars of typed name
- Need to store off chars of typed name into memory
- Need to read from memory and print chars of name.