Project Ideas

...anything digital?
... something that’s “interesting enough?”

What have people done?

- Lots of variations on processors
  - Usually 16-bit
  - Usually custom RF, perhaps custom ALU
  - Usually distinctive I/O
    - R/W pins, memory mapped I/O, UART, VGA, LCD, PS/2, etc.

- Some quite customized
  - CORDIC processor
  - Controller for a light-based toy
  - Stack-based processor
  - Communicating multiprocessor node
Processor Info

- Lots of good information on the CS/ECE 3710 class web site
  - http://www.eng.utah.edu/~cs3710/
  - OR http://www.ece.utah.edu/~kalla/index_3710.html

Baseline 3710 ISA

- ADD, ADDI, SUB, SUBI
- CMP, CMPI
- AND, ANDI, OR, ORI, XOR, XORI
- MOV, MOVI
- LSH, LSHI (restricted to shift of one)
- LUI, LOAD, STOR
- Bcond, Jcond, JAL
Class Encoding

- In the handout on the web
- Much more regular than real CR16

<table>
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<tr>
<th>Mnemonic</th>
<th>Operands</th>
<th>ImmHi/</th>
<th>ImmLo/</th>
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<tr>
<td>ADD</td>
<td>Rsrc, Rdest</td>
<td>0000</td>
<td>Rdest 0101 Bit</td>
</tr>
<tr>
<td>ADDI</td>
<td>Imm, Rdest</td>
<td>0101</td>
<td>Rdest ImmHi</td>
</tr>
<tr>
<td>ADDU</td>
<td>Rsrc, Rdest</td>
<td>0000</td>
<td>Rdest 0110 Bit</td>
</tr>
<tr>
<td>ADDUI</td>
<td>Imm, Rdest</td>
<td>0110</td>
<td>Rdest ImmHi</td>
</tr>
<tr>
<td>ADDC</td>
<td>Rsrc, Rdest</td>
<td>0000</td>
<td>Rdest 0111 Bit</td>
</tr>
<tr>
<td>ADDCI</td>
<td>Imm, Rdest</td>
<td>0111</td>
<td>Rdest ImmHi</td>
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<tr>
<td>MUL</td>
<td>Rsrc, Rdest</td>
<td>0000</td>
<td>Rdest 1110 Bit</td>
</tr>
<tr>
<td>MULI</td>
<td>Imm, Rdest</td>
<td>1110</td>
<td>Rdest ImmHi</td>
</tr>
</tbody>
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Memory Map

- 16 bit PC and LOAD/STOR addresses
  - 64k addresses
  - Each address is a 16-bit word
  - So, 128k bytes of data, but organized as words
    - Clearly this needs to go off chip!

- You probably need to reserve some I/O addresses
  - Up to you, but I recommend using the some top address bits
  - Upper 16k words (32kbytes) as I/O space?

- You probably need to reserve some part of the address space for boot ROM
  - Up to you, but I recommend low addresses
Example Memory Map

- Word addresses
  - FFFF
  - 8000
  - 7FFF
  - C000
  - BFFF
  - 4000
  - 3FFF
  - 0000

Split code/data into ROM and SRAM portions?

- I/O
  - Switches/LEDs
  - UART
  - Not used?

- SRAM
  - (code/data)
  - Ext. RAM

- ROM
  - (code)
  - Ext. ROM

16k words (32k bytes)

16k words (32k bytes)

16k words (32k bytes)

RAM/ROM chips

- Lots of them out there!
  - Be careful – 5v Vdd is not all that common any more

- I have some of these…
  - Cy7C199-35: 32kx8 SRAM
    - 35ns access time = 28MHz max for one-read-per-cycle
  - 27C256: 32kx8 EPROM
    - 55ns access time = 18MHz max for one-read-per-cycle

- Maybe you don't need one read per cycle…
What have people done?

- Application-specific circuits
- Many look a little processor-like...
  - Bike speedometer/odometer
  - Basketball scoreboard display (to VGA output)
  - Fingernail pressure sensor
  - Musicman tone generator
  - Waveform generator
  - Encryption/decryption
  - Digital metronome

What have people done?

- Circuits for parts of a more complex system
  - 2-way set-associative Cache controller with LRU replacement
  - Memory management unit for virtual memory system
  - Gshare branch predictor
  - Asynchronous FIFO
  - Asynchronous network interface
  - Network-on-chip router
What have people done?

- Hard-coded games
  Usually with VGA output
  Usually with very few colors
  - Snake
  - Bomb/Minesweeper
  - Pong
  - Tetris
  - Tic Tac Toe
  - Life

What have people done?

- Arithmetic circuits
  - Floating point multiplier
  - Floating point divider
  - Triangle intersection computation
  - Cross-product generator
  - Bilinear interpolation function unit
Other ideas…

- There are lots of interesting chips to interface to!
  - MAX7219 LED driver – drives up to 64 LEDs, can be chained together
  - LCD controller – many are based on a HD44780U controller so they’ll be a standard interface
  - Hobby servos are controlled by PWM
  - Stepper motor controllers – build a CNC controller?
  - Go to Sparkfun.com, Adafruit.com, or RobotShop.com and look around!

- Lots of interesting protocols to explore
  - SPI, I2C, Serial (UART), VGA, PS/2, etc.

16-bit processor

- Approx 18,500 transistors
- 3mm on a side
Another processor
• 16-bit Processor, approx 27,000 transistors

Same Chip (no M2, M3)
• 1.5mm x 3.0mm, 72 I/O pads
Processor

Asynchronous FIFO
Array multiplier with testing circuitry
1 TCU

I Don’t Remember ...

...
Stack Processor

Snake Game
SRAM

X10 home automation controller
DES encrypt/decrypt

16-bit CORDIC processor
Life Processor/Game

More Pictures of Chips
More Pictures of Chips

Chip in Package