


inst.eecs.berkeley.edu/~cs61c
CS61C : Machine Structures


Lecture 20
Introduction to Synchronous Digital Systems

2010-03-08 Hello to Alejandro Torrijos listening from España!



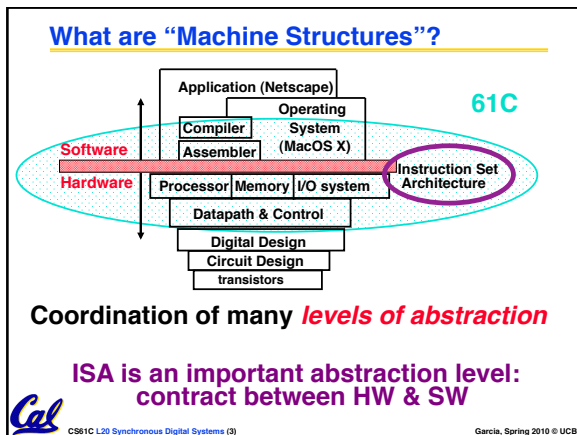
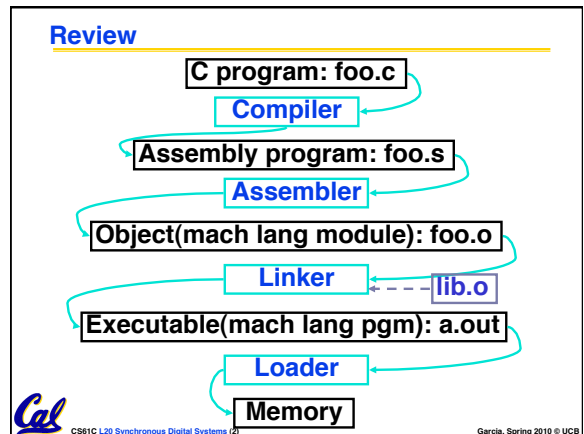
Lecturer SOE Dan Garcia
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What to call 1,000 yottas? => UC Davis physics student Austin Sendek has earned his 15 min of fame by suggesting that the next SI unit be (you guessed it) ... "hella". He wanted to pay homage to Northern California (UCB, UC, Stanford, LBNL).



www.huffingtonpost.com/2010/03/02/hella-number-scientists-n_482260.html

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Below the Program

- High-level language program (in C)


```
swap int v[], int k){
    int temp;
    temp = v[k];
    v[k] = v[k+1];
    v[k+1] = temp;
}
```
- Assembly language program (for MIPS)


```
swap: sll $2, $5, 2
      add $2, $4, $2
      lw $15, 0($2)
      lw $16, 4($2)
      sw $16, 0($2)
      sw $15, 4($2)
      jr $31
```
- Machine (object) code (for MIPS)


```
000000 00000 00101 00010000010000000
000000 00100 00010 00010000000100000 . . .
```

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Synchronous Digital Systems

The hardware of a processor, such as the MIPS, is an example of a Synchronous Digital System

Synchronous:

- Means all operations are coordinated by a central **clock**.
 - It keeps the "heartbeat" of the system!

Digital:

- Mean all values are represented by discrete values
- Electrical signals are treated as 1's and 0's and grouped together to form words.

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Logic Design

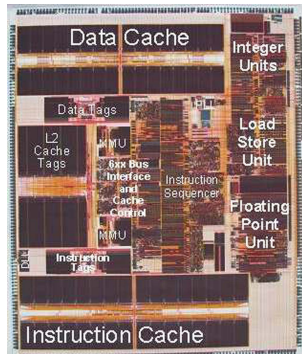
- Next 4 weeks: we'll study how a modern processor is built: starting with basic elements as building blocks.
- Why study hardware design?
 - Understand capabilities and limitations of hardware in general and processors in particular.
 - What processors can do fast and what they can't do fast (avoid slow things if you want your code to run fast!)
 - Background for more detailed hardware courses (CS 150, CS 152)
 - There is just so much you can do with processors. At some point you may need to design your own custom hardware.

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PowerPC Die Photograph



Let's look closer...



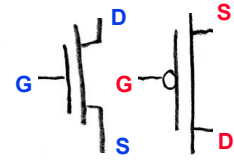
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Transistors 101

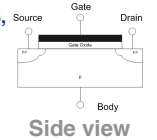
• MOSFET

- Metal-Oxide-Semiconductor Field-Effect Transistor
- Come in two types:
 - n-type NMOSFET
 - p-type PMOSFET



• For n-type (p-type opposite)

- If voltage not enough between G & S, transistor turns "off" (cut-off) and Drain-Source NOT connected
- If the G & S voltage is high enough, transistor turns "on" (saturation) and Drain-Source ARE connected



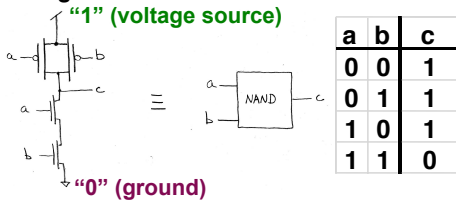
www.wikipedia.org/wiki/Mosfet

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Transistor Circuit Rep. vs. Block diagram

- Chips is composed of nothing but transistors and wires.
- Small groups of transistors form useful building blocks.



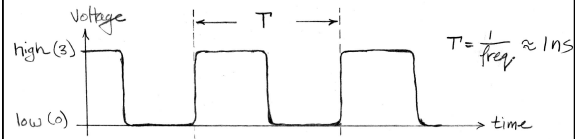
- Block are organized in a hierarchy to build higher-level blocks: ex: adders.



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Signals and Waveforms: Clocks



• Signals

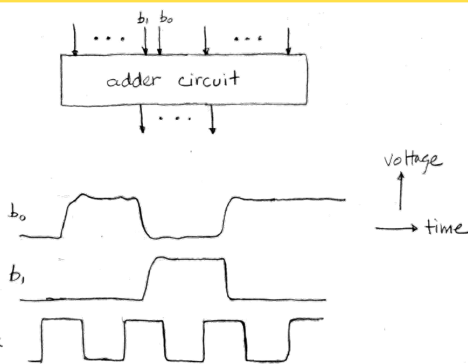
- When digital is only treated as 1 or 0
- Is transmitted over wires continuously
- Transmission is effectively instant
 - Implies that any wire only contains 1 value at a time



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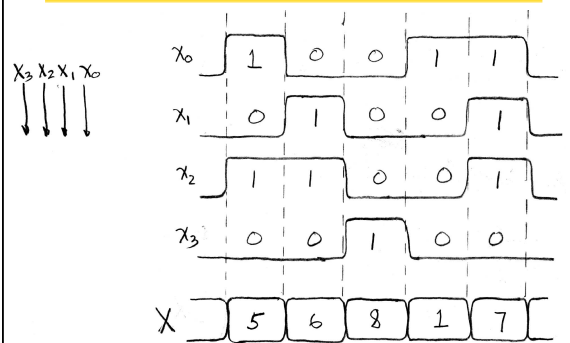
Signals and Waveforms



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Signals and Waveforms: Grouping



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