Blu-ray vs HD-DVD war over? ⇒
As you know, there are two different, competing formats for the next generation DVD. NEC just announced they will ship a dual-format chip capable of playing discs in either format! I’ve been saying for years: Can’t we all just get along?

Peer Instruction

Which of the following instr. may need to be edited during link phase?

Loop: 

lui $at, 0xABCD  
oi $a0,$at, 0xFEDC  
jal add_link  
bne $a0,$v0, Loop

Below the Program

• High-level language program (in C)

```c
swap int v[i], int k){
    int temp;
    temp = v[k];
    v[k] = v[k+1];
    v[k+1] = temp;
}
```

• Assembly language program (for MIPS)

```assembly
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 0001000010000000 000000 00100 00010 0001000000100000 . . .
```

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.
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.

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 current is NOT flowing in Gate, transistor turns "off" (cut-off) and Drain-Source NOT connected
    - If current IS flowing in Gate, transistor turns "on" (triode) and Drain-Source ARE connected

Transistor Circuit Rep. vs. Block diagram

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

Signals and Waveforms

The Clock Signal

PowerPC Die Photograph

Let’s look closer...
Type of Circuits

- Synchronous Digital Systems are made up of two basic types of circuits:
  - **Combinational Logic (CL) circuits**
    - Our previous adder circuit is an example.
    - Output is a function of the inputs only.
    - Similar to a pure function in mathematics, \( y = f(x) \). (No way to store information from one invocation to the next. No side effects)
  - **State Elements**: circuits that store information.

Circuits with STATE (e.g., register)

Peer Instruction

A. SW can peek at HW (past ISA abstraction boundary) for optimizations
B. SW can depend on particular HW implementation of ISA
C. Timing diagrams serve as a critical debugging tool in the EE toolkit

And in conclusion...

- ISA is very important abstraction layer
  - Contract between HW and SW
- Clocks control pulse of our circuits
- Voltages are analog, quantized to 0/1
- Circuit delays are fact of life
- Two types of circuits:
  - Stateless Combinational Logic (\&,\|,\~)
  - State circuits (e.g., registers)