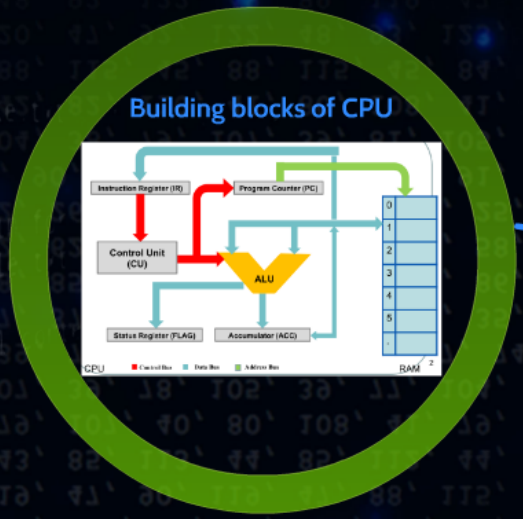
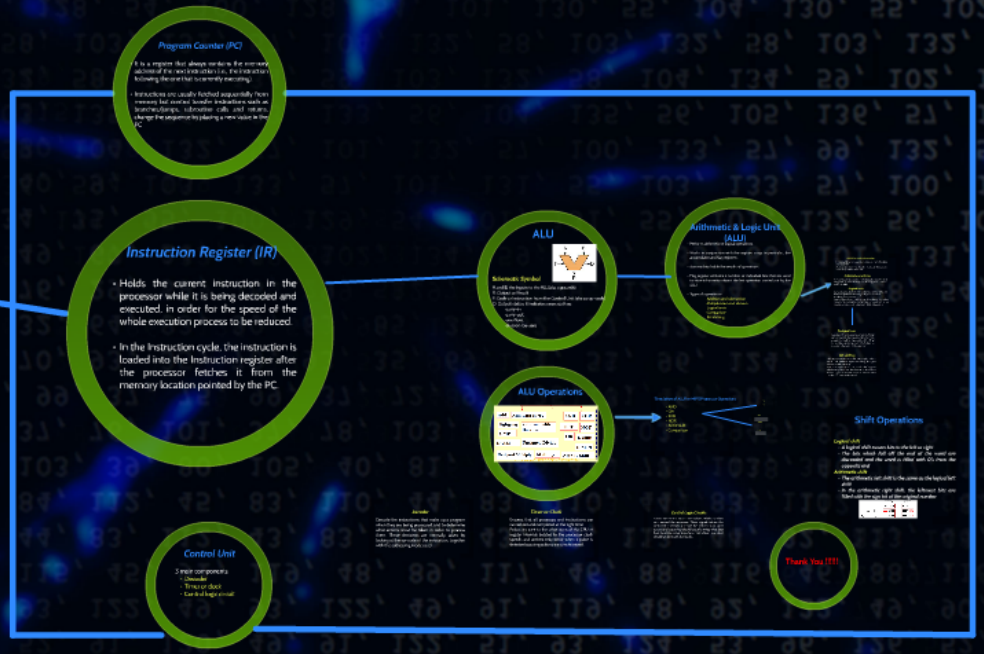
ALU Fundamentals & Design





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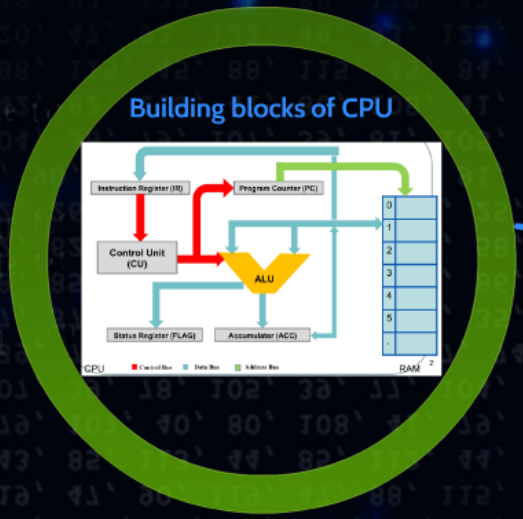

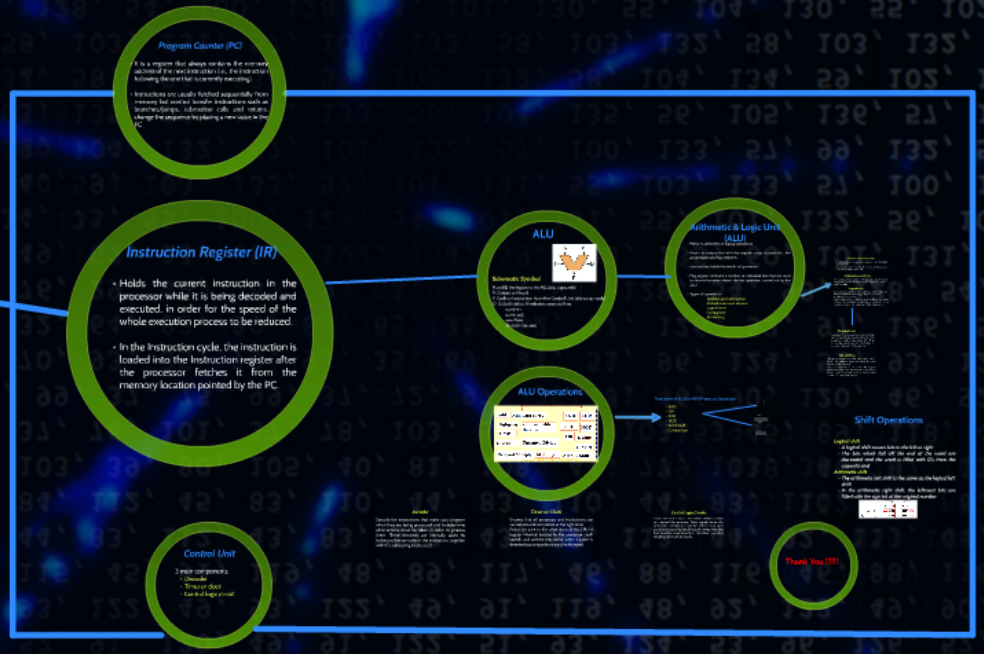

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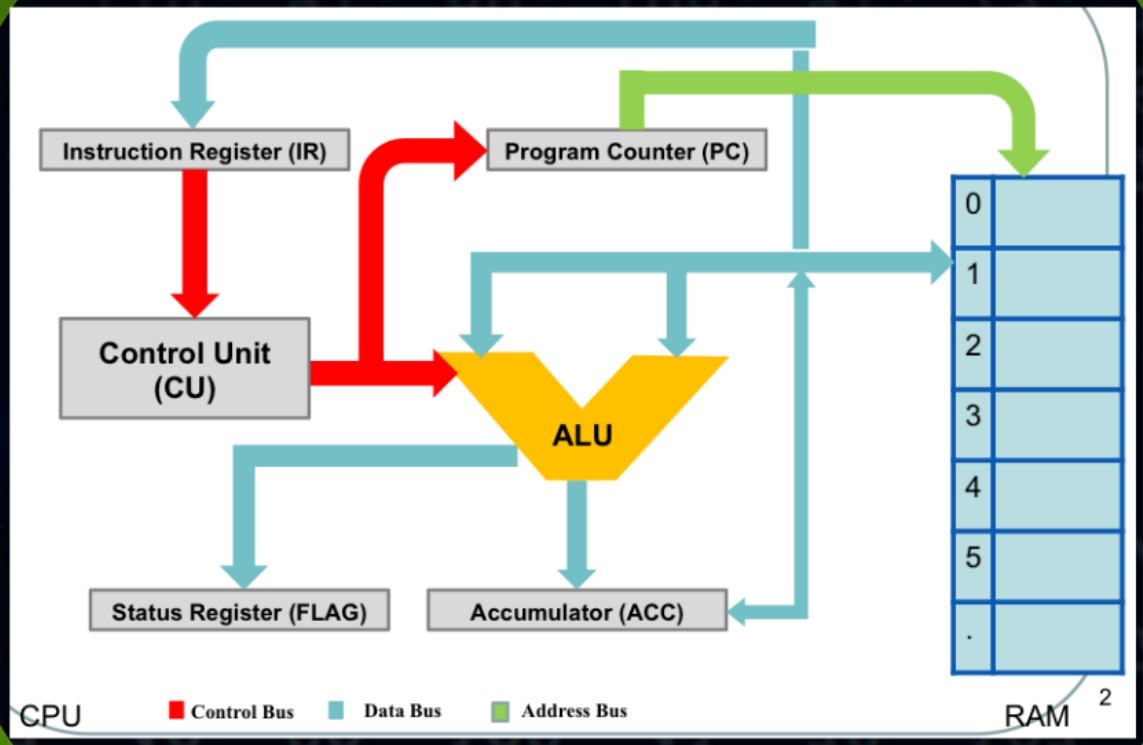
Building blocks of CPU



Instruction Register (IR)

- Holds the current instruction in the processor while it is being decoded and executed, in order for the speed of the whole execution process to be reduced.

- In the Instruction cycle, the instruction is loaded into the Instruction register after the processor fetches it from the memory location pointed by the PC.

Program Counter (PC)

- It is a register that always contains the memory address of the next instruction (i.e., the instruction following the one that is currently executing).
- Instructions are usually fetched sequentially from memory but control transfer instructions such as branches/jumps, subroutine calls and returns, change the sequence by placing a new value in the PC

Control Unit

3 main components

- Decoder
- Timer or clock
- Control logic circuit

Decoder

Decode the instructions that make up a program when they are being processed, and to determine what actions must be taken in order to process them. These decisions are normally taken by looking at the op-code of the instruction, together with the addressing mode used.

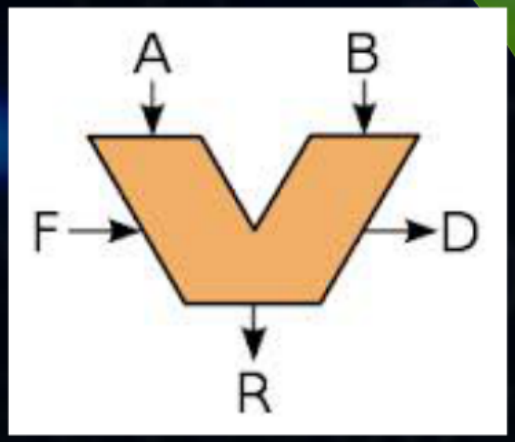
Timer or Clock

Ensures that all processes and instructions are carried out and completed at the right time
Pulses are sent to the other areas of the CPU at regular intervals (related to the processor clock speed), and actions only occur when a pulse is detected assuring actions are synchronized.

Control Logic Circuits

Create the control signals themselves, which are then sent around the processor. These signals inform the arithmetic and logic unit and the register array what actions and steps they should be performing, what data they should be using to perform said actions, and what should be done with the results.

ALU



Schematic Symbol

A and B: the inputs to the ALU(aka operands)
R: Output or Result
F: Code or Instruction from the Control Unit (aka as op-code)
D: Output status; it indicates cases such as:

- carry-in
- carry-out,
- overflow,
- division-by-zero

Arithmetic & Logic Unit (ALU)

- Perform arithmetic or logical operations.
- Works in conjunction with the register array, in particular, the accumulator and flag registers.
- Accumulator holds the results of operations
- Flag register contains a number of individual bits that are used to store information about the last operation carried out by the ALU.
- Types of operations-
  - Addition and subtraction
  - Multiplication and division
  - Logical tests
  - Comparison
  - Bit Shifting

Addition and subtraction

Performed by constructs of logic gates, such as half adders and full adders.
They can also perform subtraction via use of inverters and 'two's complement' arithmetic.

Multiplication and division

In most modern processors, the multiplication and division of integer values is handled by specific floating-point hardware within the CPU.

Logical tests

Logical gates are used within the ALU to perform a number of different logical tests, including seeing if an operation produces a result of zero.
Most of these logical tests are used to change the values stored in the flag register, so that they may be used later by separate operations or instructions in further processing.

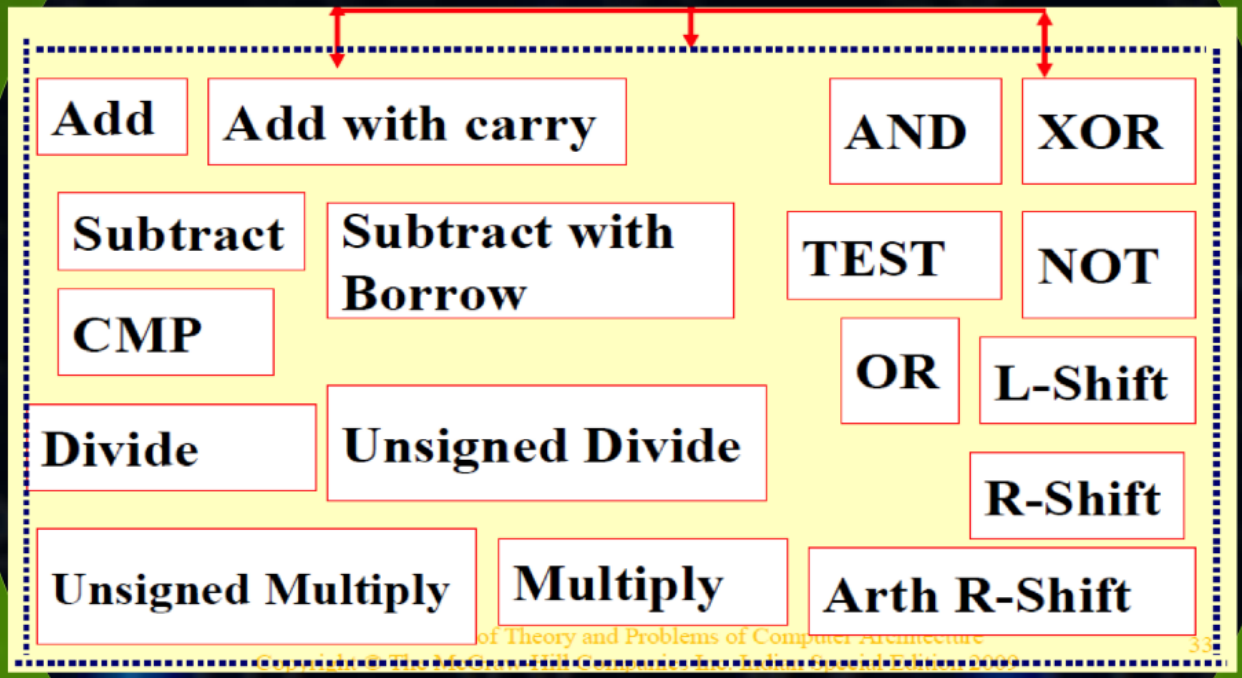
Comparison

Compare values in order to determine things such as one number is greater than, less than or equal to another. Appropriate status flags in the flag register are set and checked to determine the result of the operation.

Bit shifting

Shifting operations move bits left or right within a word, with different operations filling the gaps created in different ways.
This is accomplished via the use of a shift register, which uses pulses from the clock within the control unit to trigger a chain reaction of movement across the bits that make up the word.

ALU Operations



Simulation of ALU for MIPS Processor Operation

- AND
- OR
- XOR
- NOR
- ADD/SUB
- Comparison

AND

2 Input AND gate		
A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

OR

2 Input OR gate		
A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

XOR

2 Input EXOR gate		
A	B	A⊕B
0	0	0
0	1	1
1	0	1
1	1	0

NOR

2 Input NOR gate		
A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

ADDER

INPUTS		OUTPUTS	
A	B	SUM	CARRY
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

SUB

INPUT		OUTPUT	
A	B	DIFF	BORR
0	0	0	0
0	1	1	1
1	0	1	0

Shift Operations

Logical shift

- *A logical shift moves bits to the left or right*
- *The bits which fall off the end of the word are discarded and the word is filled with 0's from the opposite end*

Arithmetic shift

- *The arithmetic left shift is the same as the logical left shift*
- *In the arithmetic right shift, the leftmost bits are filled with the sign bit of the original number*

	x >> 3	x << 3
	10011101	10011101
Logical shift	00010011	11101000
Arithmetic shift	11110011	11101000

Thank You !!!!!!

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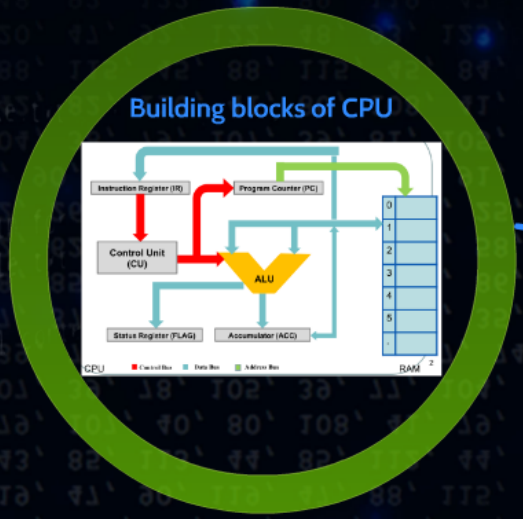

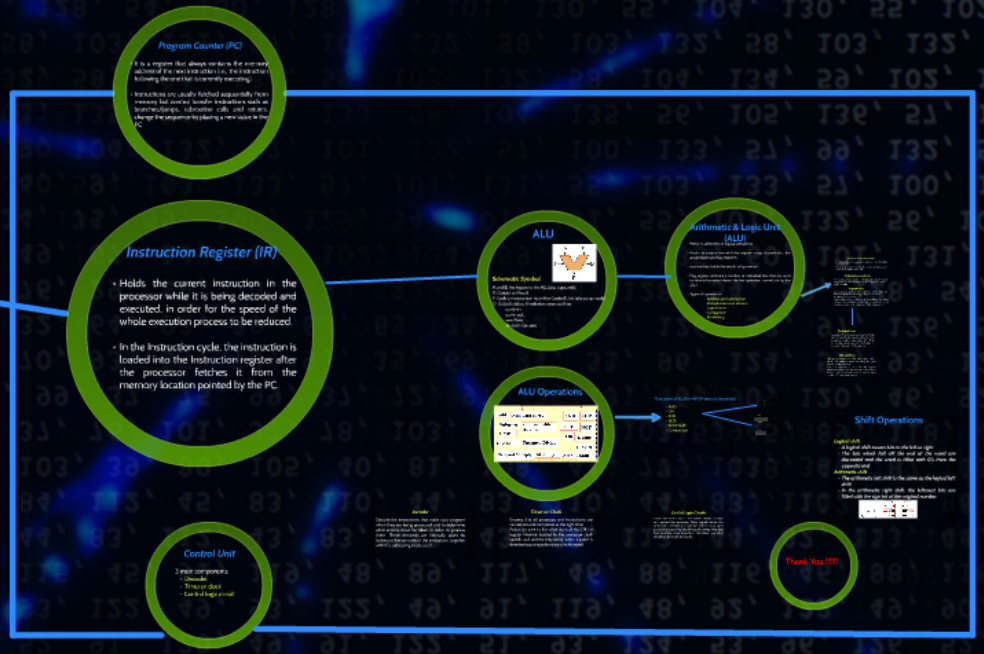

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