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COMP-3350

HW #2

1. **Name all eight 32-bit general-purpose registers. What is the general function of each of the registers? Which of these registers cannot be addressed in parts of 8-bits?**

- **EAX** - *"The Accumulator"*
  - Stores return values
  - Special Arithmetic Calculations
- **EBX** - *"Extended Base"*
  - General Purpose Register
  - Often set to value such as "0" to speed up calculations
  - Used as pointer, also for address calculations
- **ECX** - *"Extended Counter"*
  - Used as a loop counter, counts number of iterations
- **EDX** - *"Extended Data"*
  - Used for I/O control
  - Performs arithmetic operations
  - Can store variables
- **ESI** - *"Extended Source Index"*
  - A pointer to source index
  - String / Memory operations
- **EDI** - *"Extended Destination Index"*

- Pointer similar to ESI
- Used as destination for data instead

- **EBP** - *"Extended Base Pointer"*
  - Accesses variables / parameters from the stack
  - 32 bit register, so cannot be addressed in parts of 8 bits.
- **ESP** - *"Extended Stack Pointer"*
  - Stores value on the top of the stack
  - 32 bit register, so cannot be addressed in parts of 8 bits.

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2. **What do the Sign, Zero, Carry, Auxiliary Carry, Parity and Overflow flags indicate when they are '1'? How do OF and CF differ in what do they signify?**

- **Sign** (SF) - Sets to “1” when a value is negative
- **Zero** (ZF) - Sets to “1” when result is equal to zero
- **Carry** (CF)- Sets to “1” when there is a carry / borrow after an arithmetic operation
- **Auxiliary Carry** (AF) - “1” when there is a carry / borrow after a Binary Coded Decimal (BCD) arithmetic operation, when the carry / borrow is between the low-4 and the high-4 bits
- **Parity** (PF) - Represents evenness / oddness by returning “1” for a string with an even number of 1s and “0” when it has an an odd number of 1s
- **Overflow**(OF) - Sets to “1” if the value is too big or too small for the destination register
    - The overflow and carry flags differ in what they signify. The overflow is set to 1 when the overall size (in bits) is not able to fit in the register. The carry flag is used while performing arithmetic operations to represent “carrying” or “borrowing” a number between bits.

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3. **What is cache memory and what are its benefits?**

Cache memory is the level memory closest to the CPU, it is small & fast memory.

Cache memory is high-speed memory, expensive static RAM. Cache memory exists in 2 levels:

1. Inside CPU
2. Outside CPU

*Its benefits include*: a) Fast Access Speeds, b) Low Memory Latency, c) Improved Power Consumption, and d) Reduced Bus Traffic.

a) Access speed is improved because frequently used data and instructions are stored in cache memory, which the CPU checks first. If the requested data is found in cache, it is considered a “cache hit”, otherwise if it is not there, it is called “cache miss”

b) Low latency is due to how fast the CPU can access cache memory. On cache hits, latency is greatly reduced compared to accessing main memory for the same data.

c) Power consumption is reduced by lessening the amount of times that the CPU has to access main memory.

d) Less trips to main memory also lead to less bus traffic!

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4. **Is memory protection available from unauthorized accesses in real-address mode? Explain. How is memory protection achieved in Protected mode?**

Memory protection *does not* exist in real-address mode. Any operation (read, write, execute) can be performed on any part of memory. This is dangerous because unauthorized access cannot be prevented. This is why protected mode was introduced for x86 systems. The new additions in protected mode allow for memory protection by using the following mechanisms:

1. Segmentation - Protected mode allows memory to be stored into logical segments. Each segment can have its own access rights / privileges.
2. Paging - Support now added for virtual memory. Paging maps virtual addresses that programs use to physical addresses in memory.
3. Privilege Levels - Introduced a scale from (0-3) to determine access rights to certain parts of memory

5. **In a 22-bit computer what is the maximum memory amount that can be addressed in protected mode?**

$2^{22}$ = **4,194,304**

6. **Let us say your computer is running at 4 GHz. You come to know that the ADD instruction takes 5 clock periods on your computer. Express the time taken by the instruction in nanoseconds.**

Time (in nanoseconds) = (Clock periods / Frequency) times 1,000,000

So,

(5 / 4,000,000) * 1,000,000 = (5/4)*1 = 5/4 =

**1.25 nanoseconds**