

ECE 242

Digital Computers and Computing

Lecture 2. Microcomputers and Microprocessor Characteristics

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Microcontroller/Microcomputer

- Operates on sequences of binary digits (bits)
 - Coded machine instructions ~~from/to I/O, memory, ...~~
~~→ different formats of numbers.~~
 - Data value to be transferred, transformed, manipulated
~~→ after, change, adjust to execute~~
- Ease and speed of CPU and other elements determine the basic characteristics of the computer systems
 - Is it fast?
 - Can it handle large numbers of data values as well as large programs?
 - Is it cost-effective for a particular application?

Microcontroller/Microcomputer

(lecture)

- Microcomputer consists of CPU, memory elements, I/O circuits, connected electrically by a **system bus**.

- Requires understanding of electrical and mechanical details about system components

- Two important characteristics of the CPU's capabilities

- **Data Bus Size:** number of bits in a data item that may be transferred at one time (in parallel) between the CPU and other elements of the system.

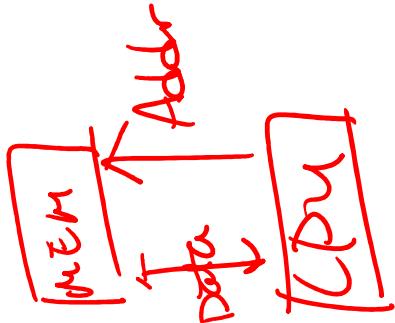
- **Addressing Range:** number of memory locations addressable by the CPU **memory** **reaches**

- MC68000 is a **16-bit processor**, uses **24 bits** to represent an address

- Data bus size : 16 bits at once

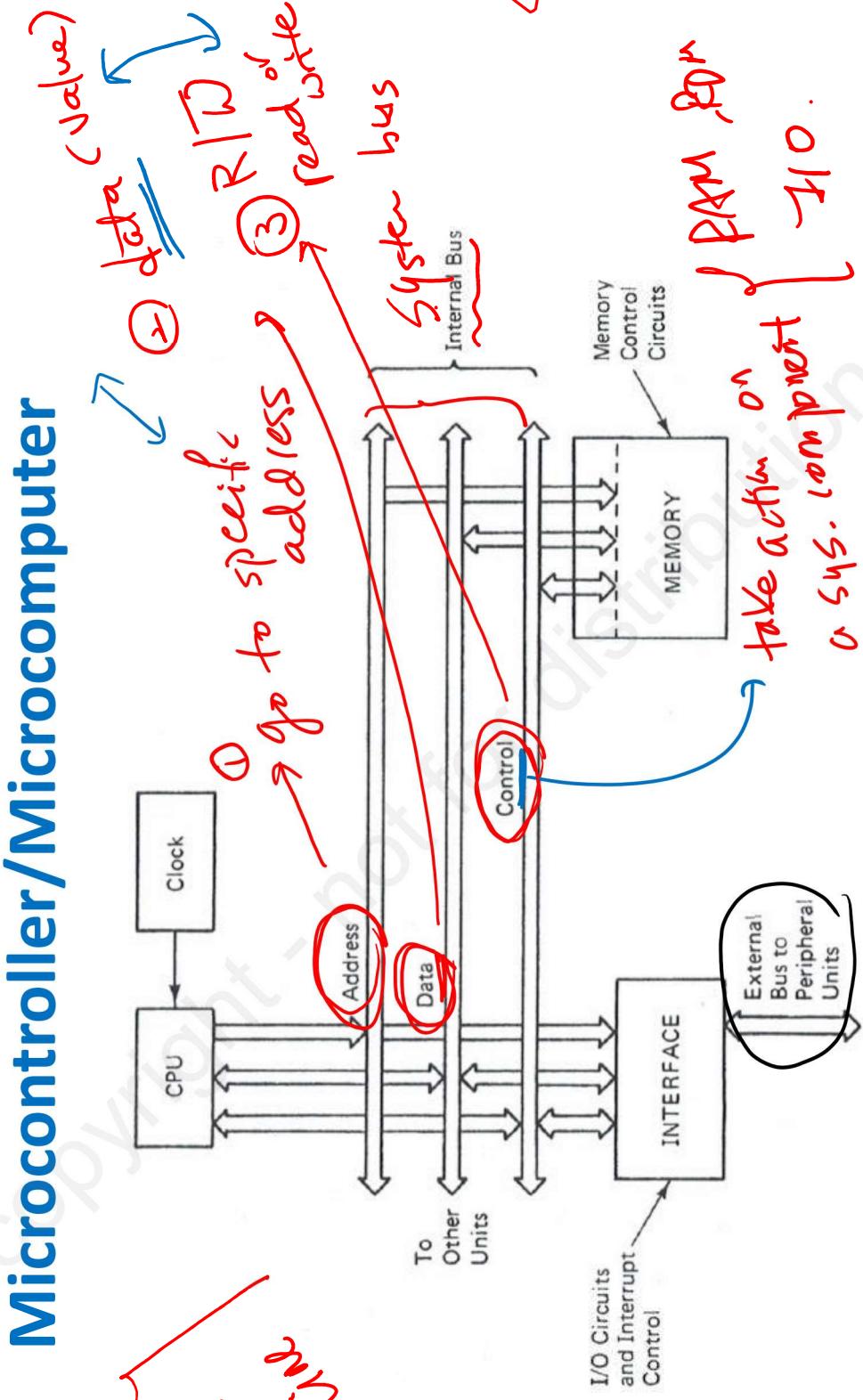
- Addressing range : 2^{24} (roughly 16 million) locations possible

Address lines / bus



her
Cmu
7/9
7/9

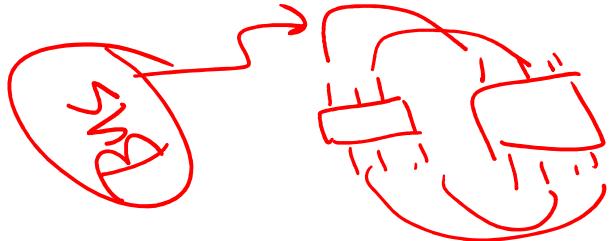
Microcontroller/Microcomputer



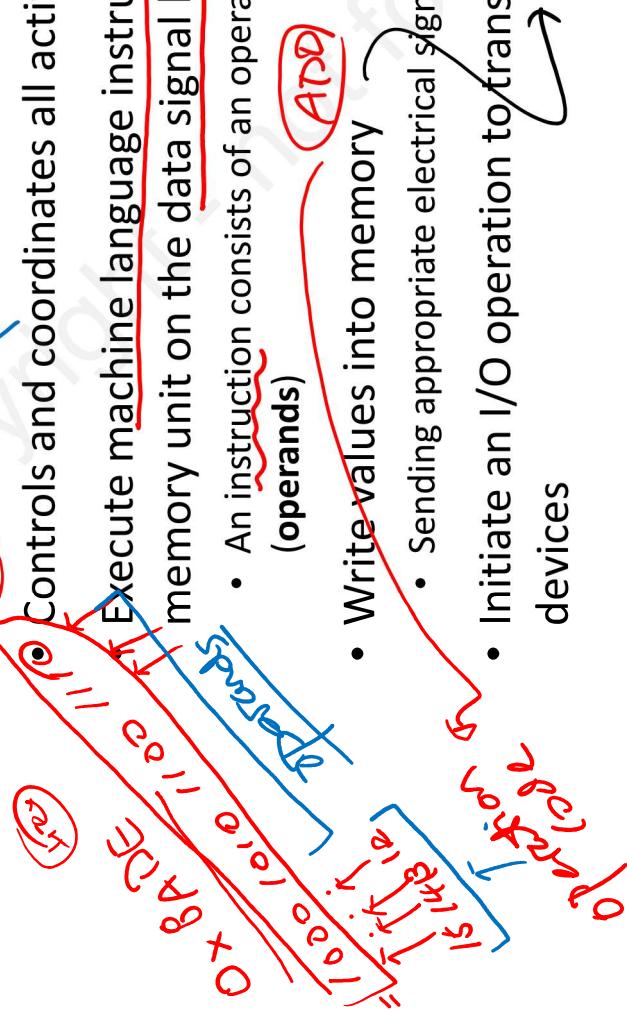
Bus
Address Bus
Data Bus
Control Bus

Microcontroller/Microcomputer

- Clock
 - To synchronize different parts of the system
- Internal Bus
 - Connect CPU electrically to circuits for the purpose of transferring data into and out of the microcomputer
 - Connect a memory unit holding instructions and data for the processor in memory, I/O Device
 - Address signal lines → location of program, data
 - Data signal lines → program code, data value,
 - Control signal lines → Read/Write, start/stop operation*
- External Bus
 - Connect peripheral units to the I/O Interface, where the interface brings data into the processor, memory, or to other units
 - Addr, Data, Control bus (all used).



CPU



Controls and coordinates all activities in the microcomputer

Execute machine language instructions fetched from the

memory unit on the data signal lines as binary sequence

- An instruction consists of an operation code (opcode) and data values (operands)

• ADD

$$a = b + c$$

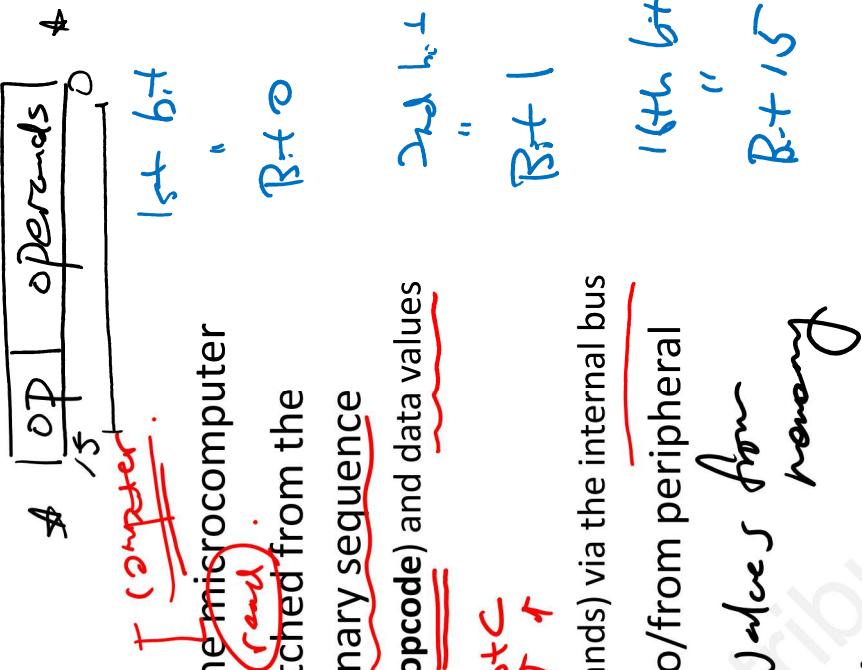
• Write values into memory

- Sending appropriate electrical signals (commands) via the internal bus

• Initiate an I/O operation to transfer data to/from peripheral devices

→ Read values from memory

- All done consistently with the system clock



1st bit

2nd bit

3rd bit

4th bit

5th bit

6th bit

7th bit

8th bit

9th bit

10th bit

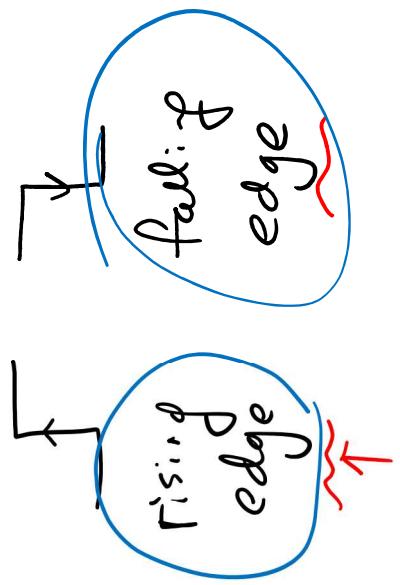
11th bit

12th bit

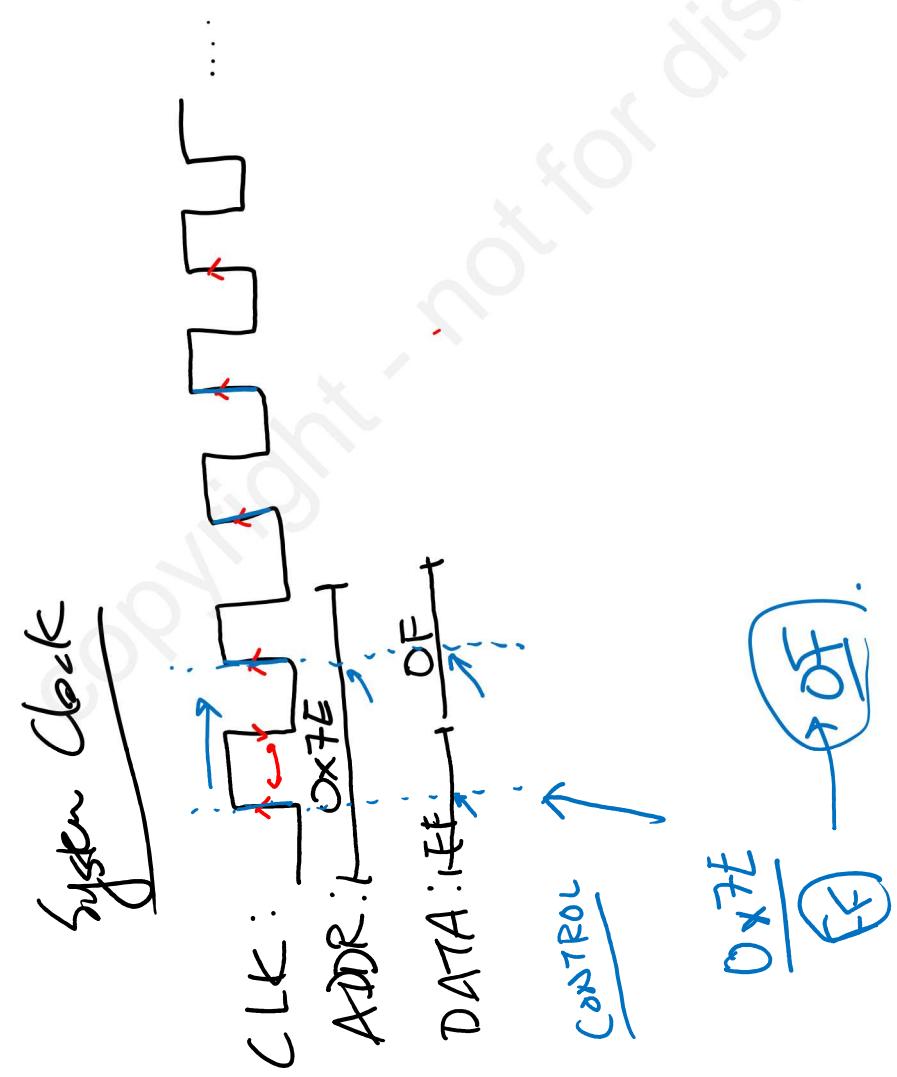
13th bit

14th bit

15th bit



mouse : $0x7E$
 mem : $0x8E$
 mouse2 : $0x66$

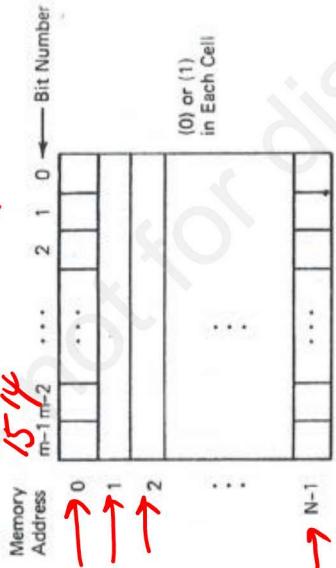


Memory Unit

16

- Memory location containing m bits referenced by a positive number (address), indicating the position of that location in memory

16 bits



Scramulation

$N \times n$ bits \Rightarrow size of memory.



R/\bar{Q}

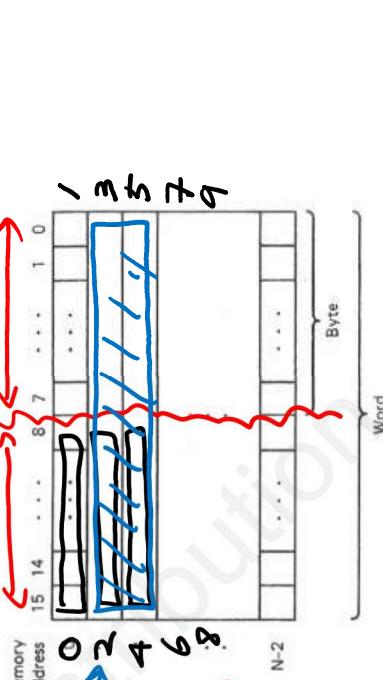
- CPU references a memory location by
 - Placing the address value on the address bus signal lines.
 - Control the operation of the memory with selected control signal lines. R/\bar{Q}

Memory Unit

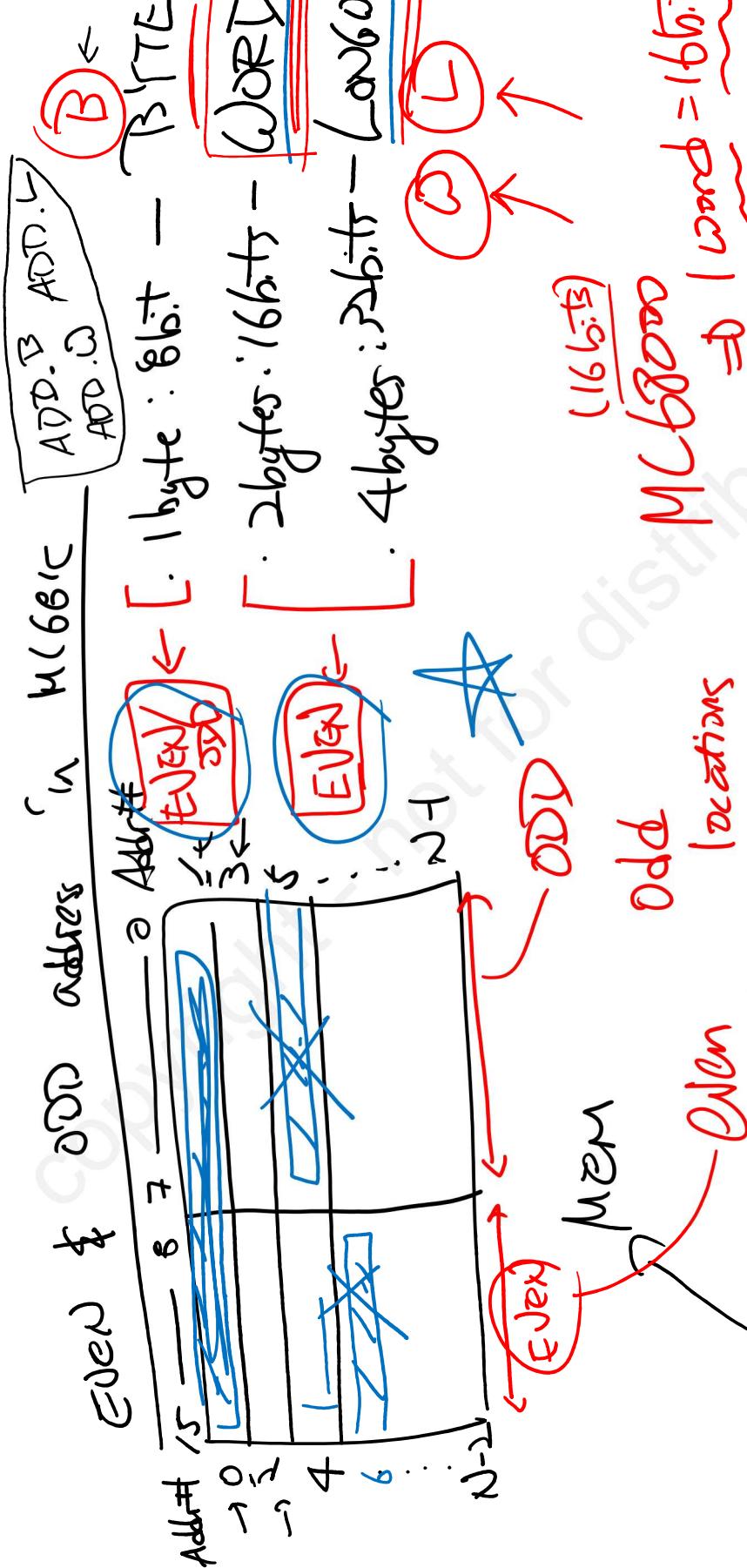
"byte-addressable".

- For addressing purposes, modern computers have divided its memory into **8-bit locations**, holding a **byte** of information.
- MIC68000 has 16 data lines (16-bit processor)
 - Size of memory addressed can be specified in terms of the number of 16-bit words
- One memory word** in MC68000 is **16 bits or 2 bytes**
 - MC68000 is "byte-addressable" (either 1 byte or 2 bytes)
- MC68000 can address word **operands**
 - 1 byte = 8 bits **BYTE (B)**
 - 1 word = 2 bytes = 16 bits **WORD (D)**
 - 2 words = 4 bytes = 1 longword = 32 bits **LONGWORD (L)**

of bytes
CPU can handle
at one time



Operands (data values) can be fetched in 1 byte, D
2 bytes, 4 bytes in MIC68000



Odd locations

Even locations

Call Q (100m)

Microbiology = practical application of biology

(١٦٦٣)

A diagram consisting of two red circles. The top circle contains a small red heart. Two red arrows point towards these circles from the right side of the page.

• 4 bytes : ~~32 bits~~ - ~~long word~~

Word

o Arbeitstext → [. byte : gibt - BITE]

Memory Unit

~~Addr Bus~~

- Number of addressable locations is typically 2^k
- k = an integer that represents number of bits used to represent 2^{60}

$$10^9 \rightsquigarrow 2^{30} \text{ bytes} = 1 \text{ gigabyte}$$

$$10^{12} \rightsquigarrow 2^{40} = 1 \text{ terabyte}$$

$$10^{15} \rightsquigarrow 2^{50} = 1 \text{ petabyte}$$

$$10^{18} \rightsquigarrow 2^{60} = 1 \text{ exabyte}$$

- So how many memory locations possible in MC68000?

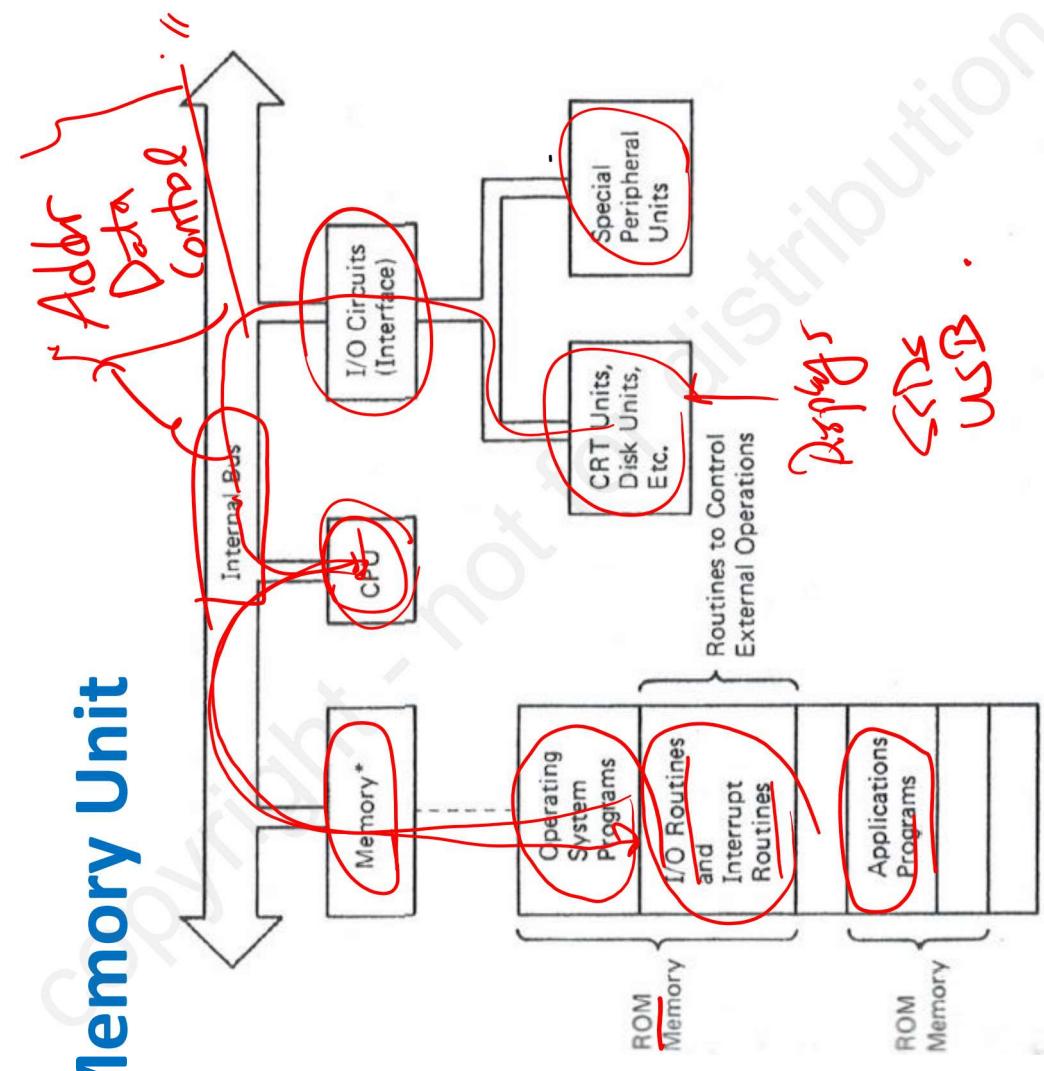
$$2^{24} = 16,777,216 \text{ addresses possible}$$

~~if 16MB~~ iff 1 address represents
~~if 64bit~~ ~~1 byte~~

$$\frac{2^{32}}{2^{32}} = \frac{4,294,967,296}{4GB} = 1,073,709,851,616$$

$\div 16 \text{ exabytes}$

Memory Unit



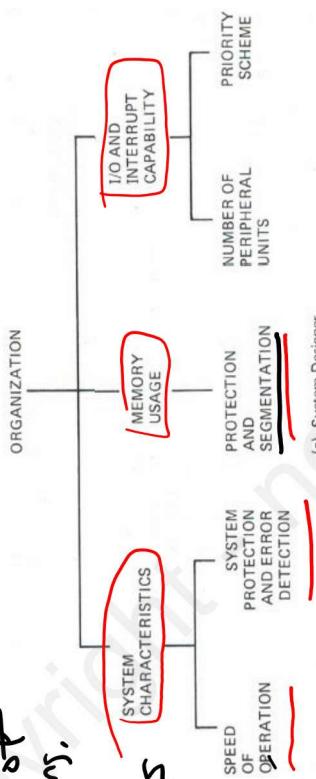
Design Views – System Designer

Supervisor: full control of CPU instructions.

User mode
I/O, memory locations

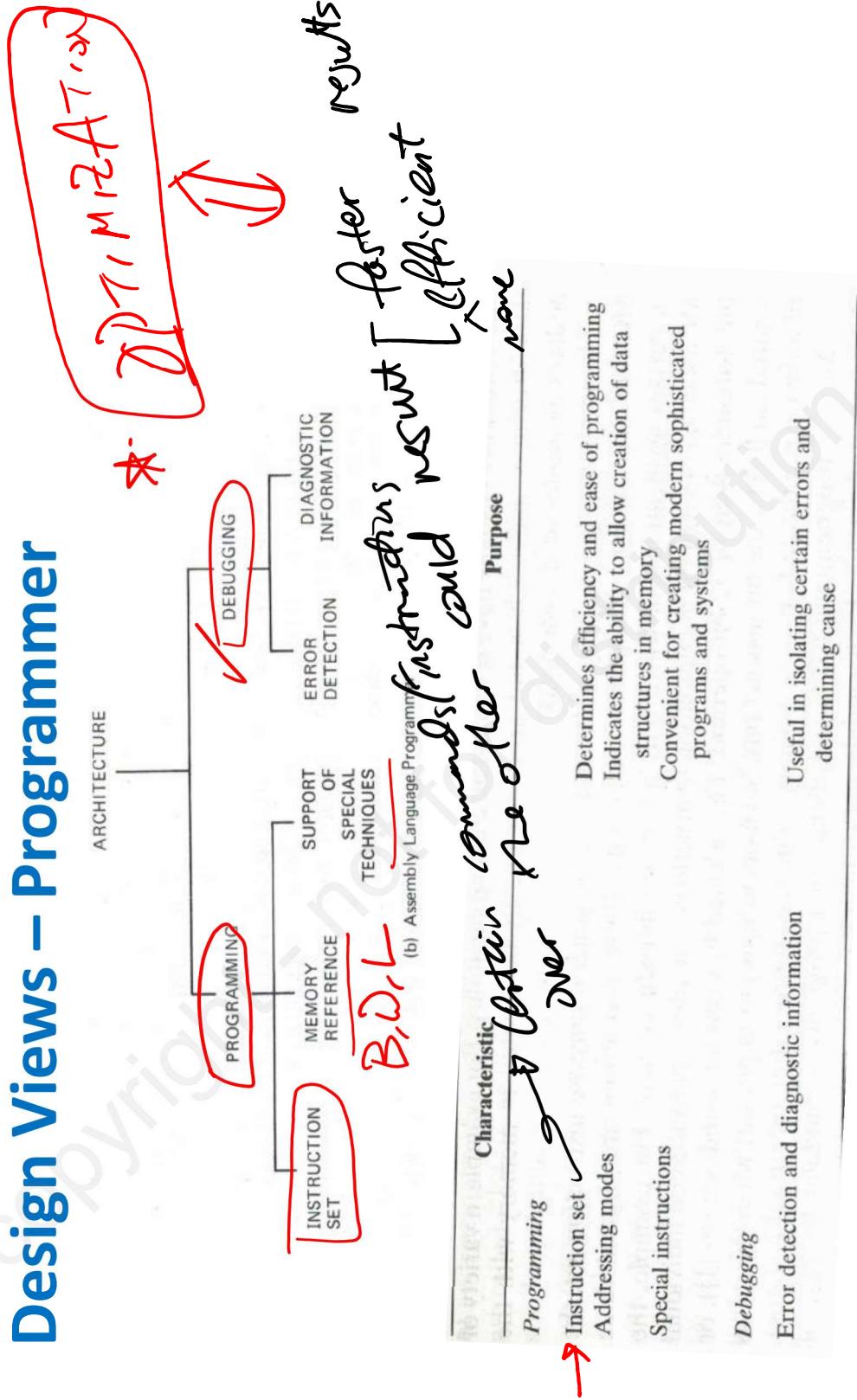
User mode
→ limited access
for protection

for each instruction
I/O devices,
User locations

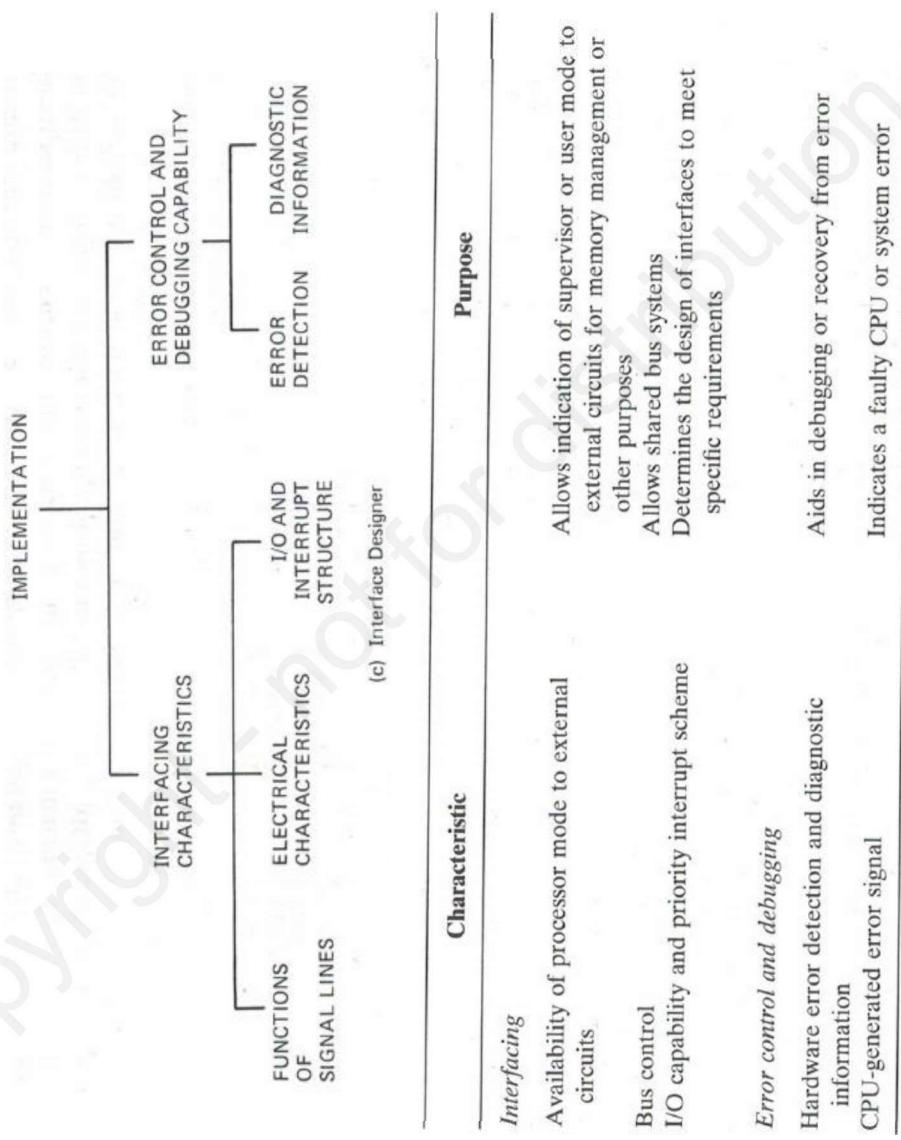


Characteristic	Purpose
System	One measure of system performance To prevent user programs from interfering with the operating system To detect and isolate various errors through traps and interrupts
Memory usage and protection	To prevent user programs from interfering with memory allocated to the operating system or other user programs
I/O and interrupt capability	To determine the I/O capability of the system (e.g., number of devices and response times for data transfer)

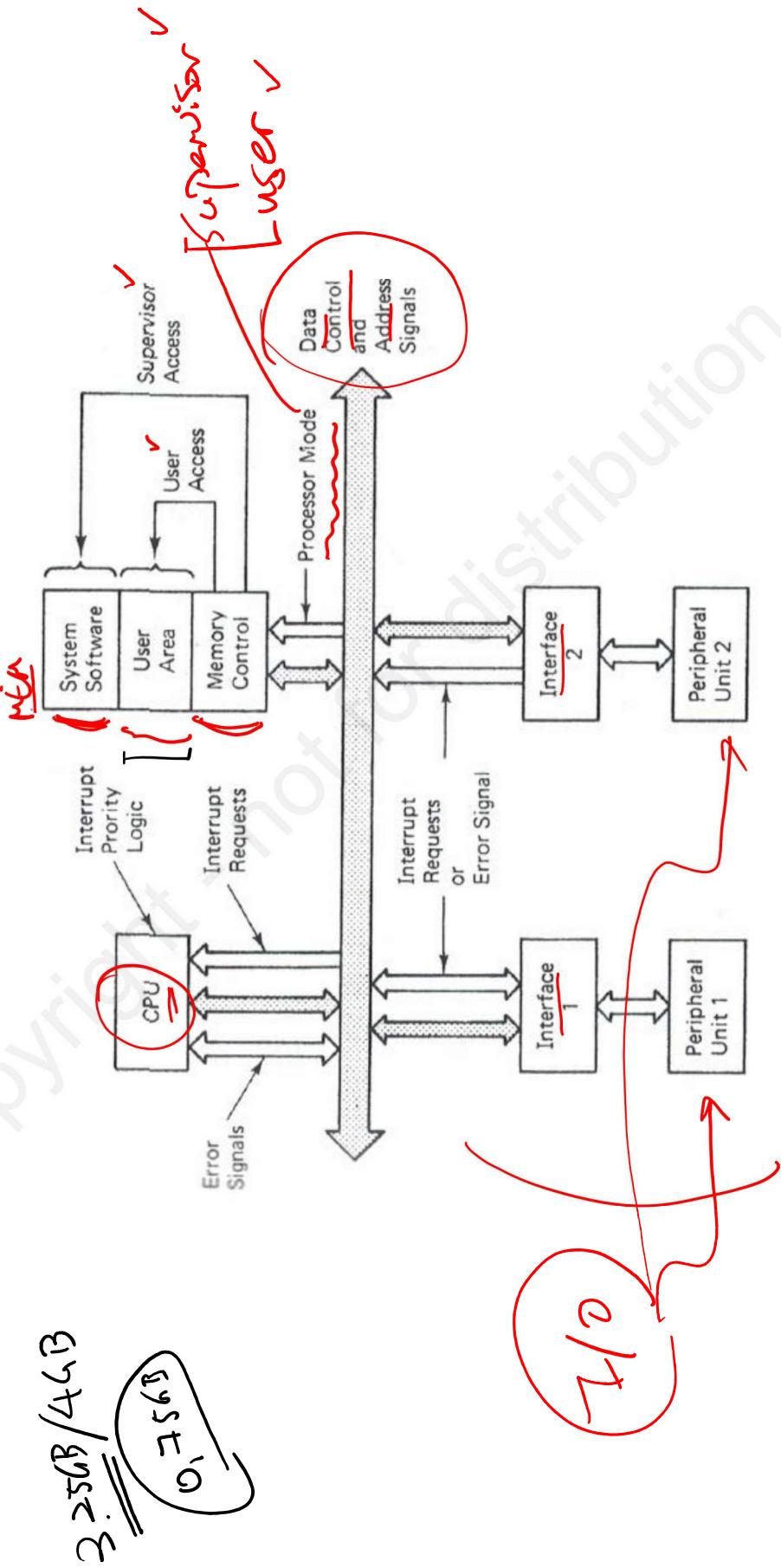
Design Views – Programmer



Design Views – Interface Designer



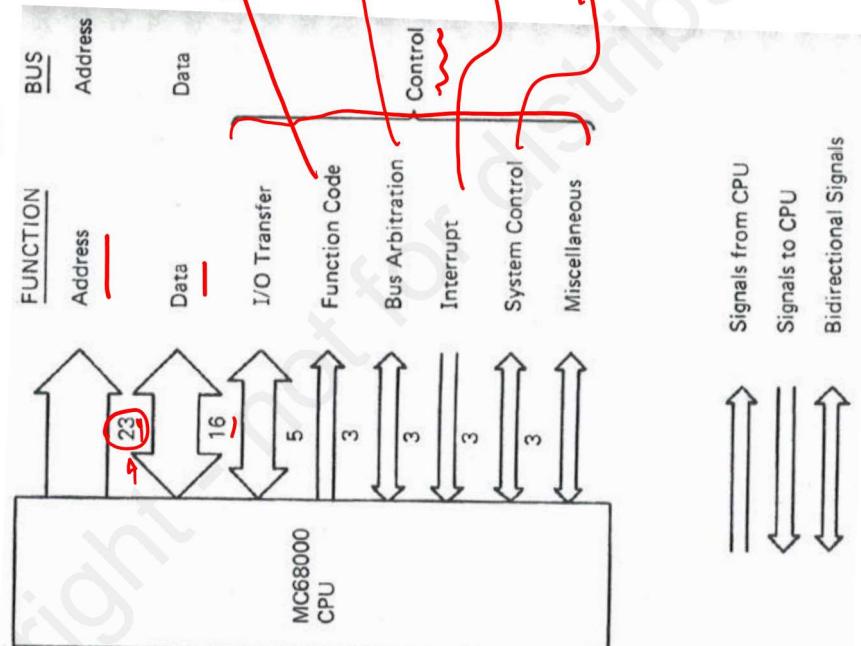
Microcomputer System Bus Architecture



32568/463
0,7563

MC68000 Signal Lines

24 bits



Address bus
Data bus
Control bus