UNIT-II

Control Unit:
Control Unit and instruction set,
Hardwired control and microprogrammed control,
Microoperation sequencing logic,
Control memory

+ Instruction set architecture:
Instruction set,
instruction cycle and state diagram,
Instruction factors, addressing modes
CISE and RISE systems

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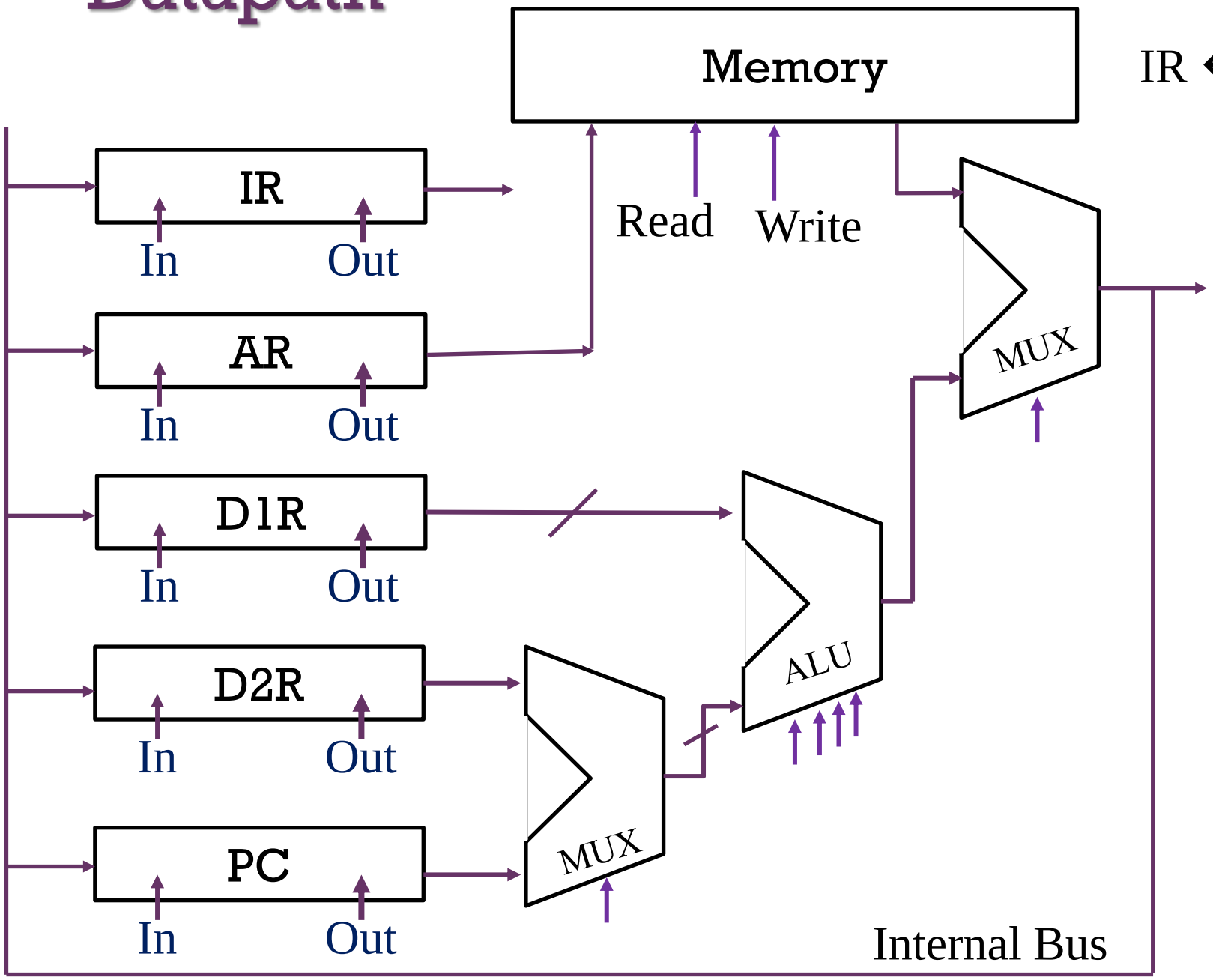
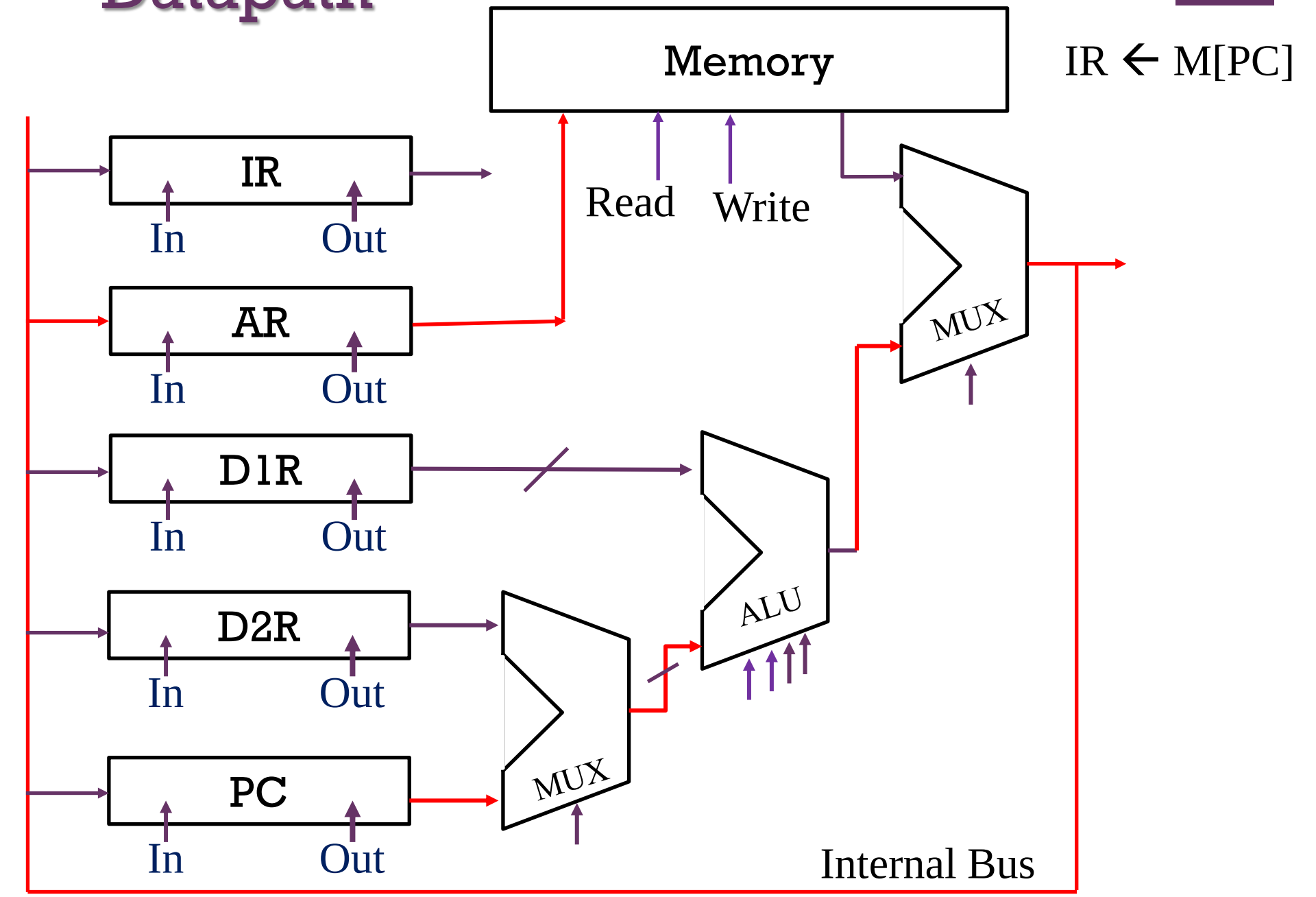
Control Unit

- Datapath
  - It is the collection of functional units such as ALU, multiplexers, registers, etc. Perform data processing operations

Datapath


Memory
IR ← M[PC]
IR
In
Out
AR
In
Out
D1R
In
Out
D2R
In
Out
PC
In
Out
Read
Write
MUX
ALU
MUX
Internal Bus

Datapath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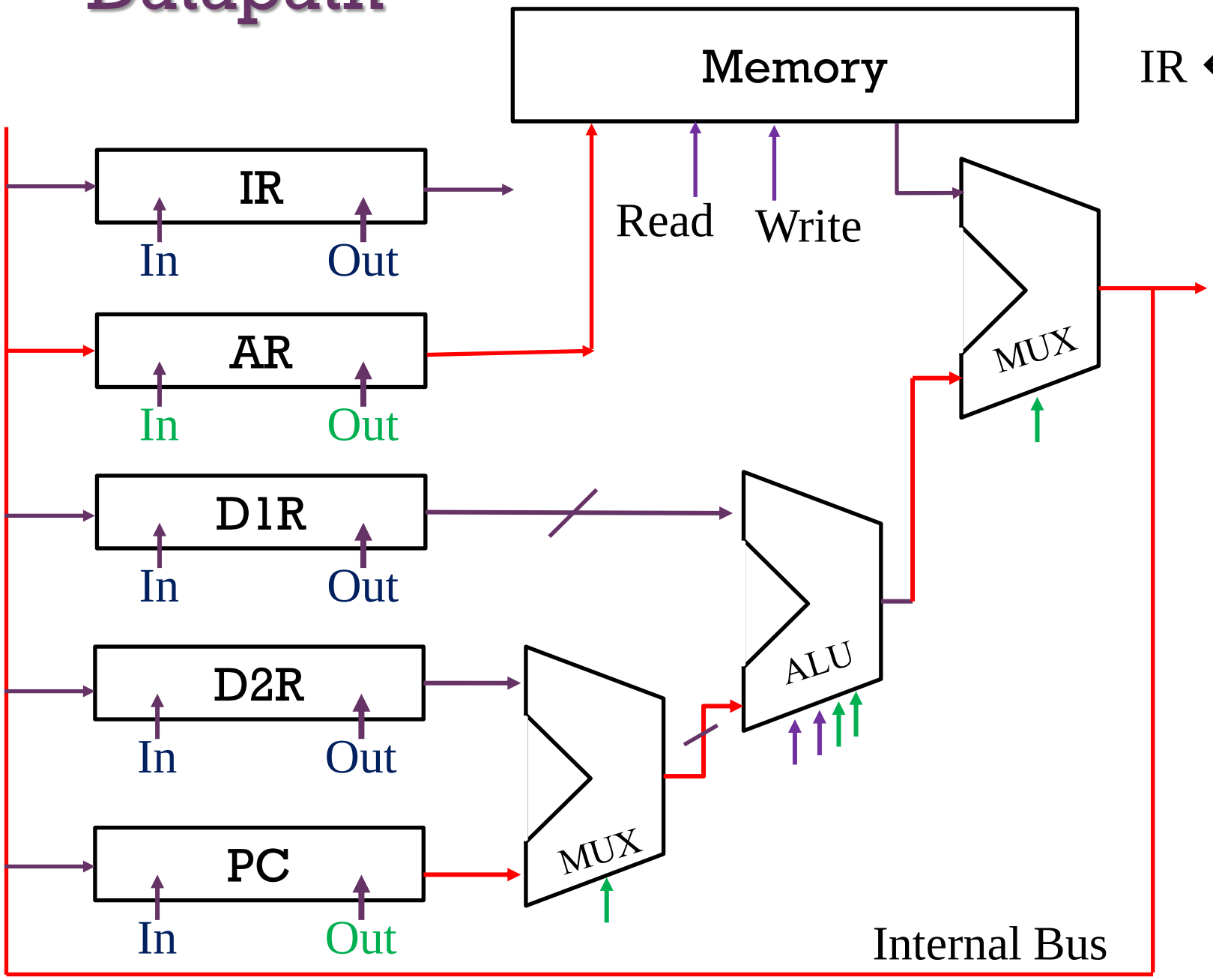
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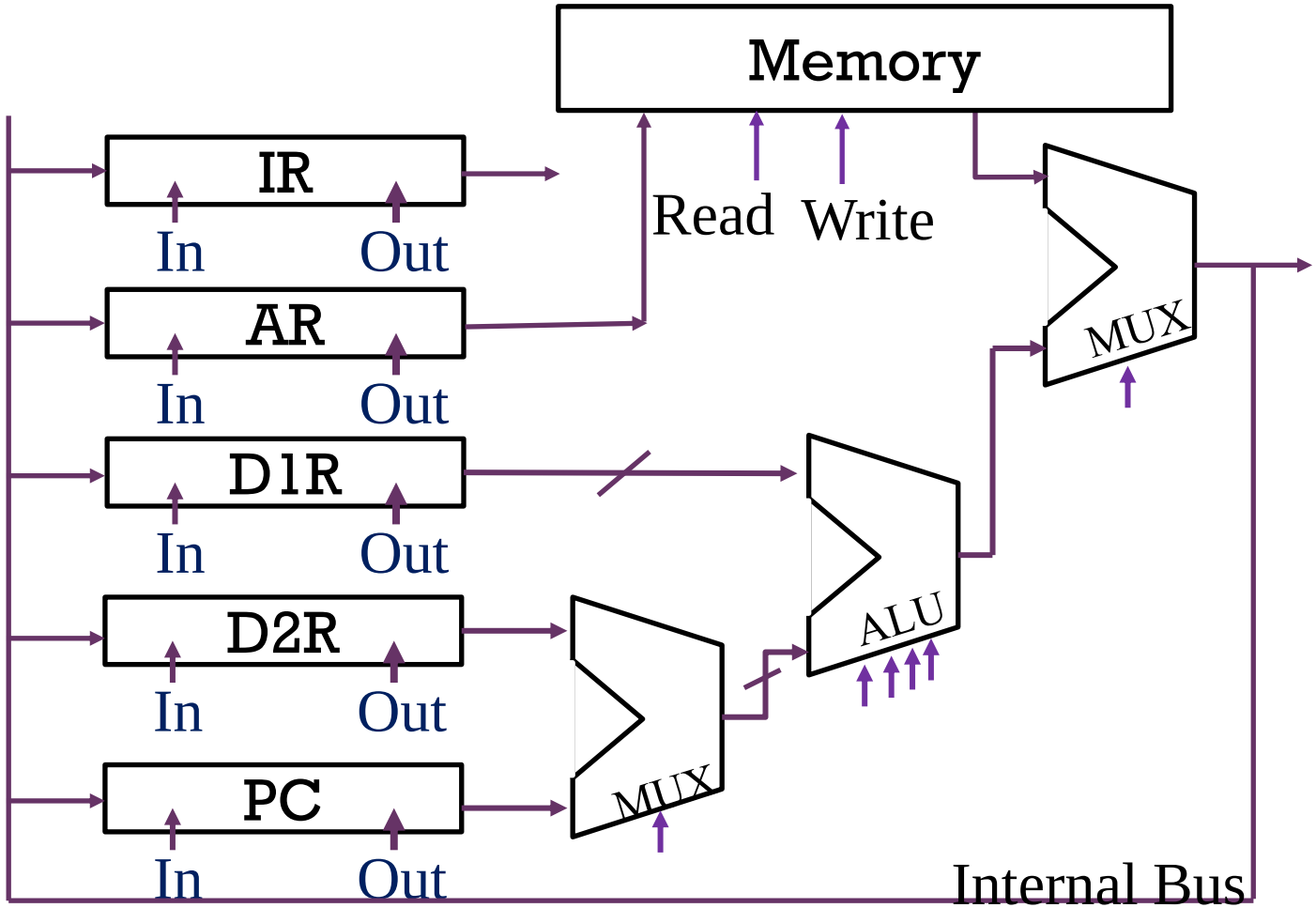
Control Unit

- It generates control signals and sends them to various components of the computer. All components operate according to these control signals.
- **Control Variables**: Name of a control signals
- **Control word**: Collections of signals generated by control at once.

IR	AR	D1	D2	PC	Mux1	Mux2	ALU	Mem

In	out	in	out	in	out	in	out	in	out	inc	Sel	Sel	opcode	R	W



AR ←PC

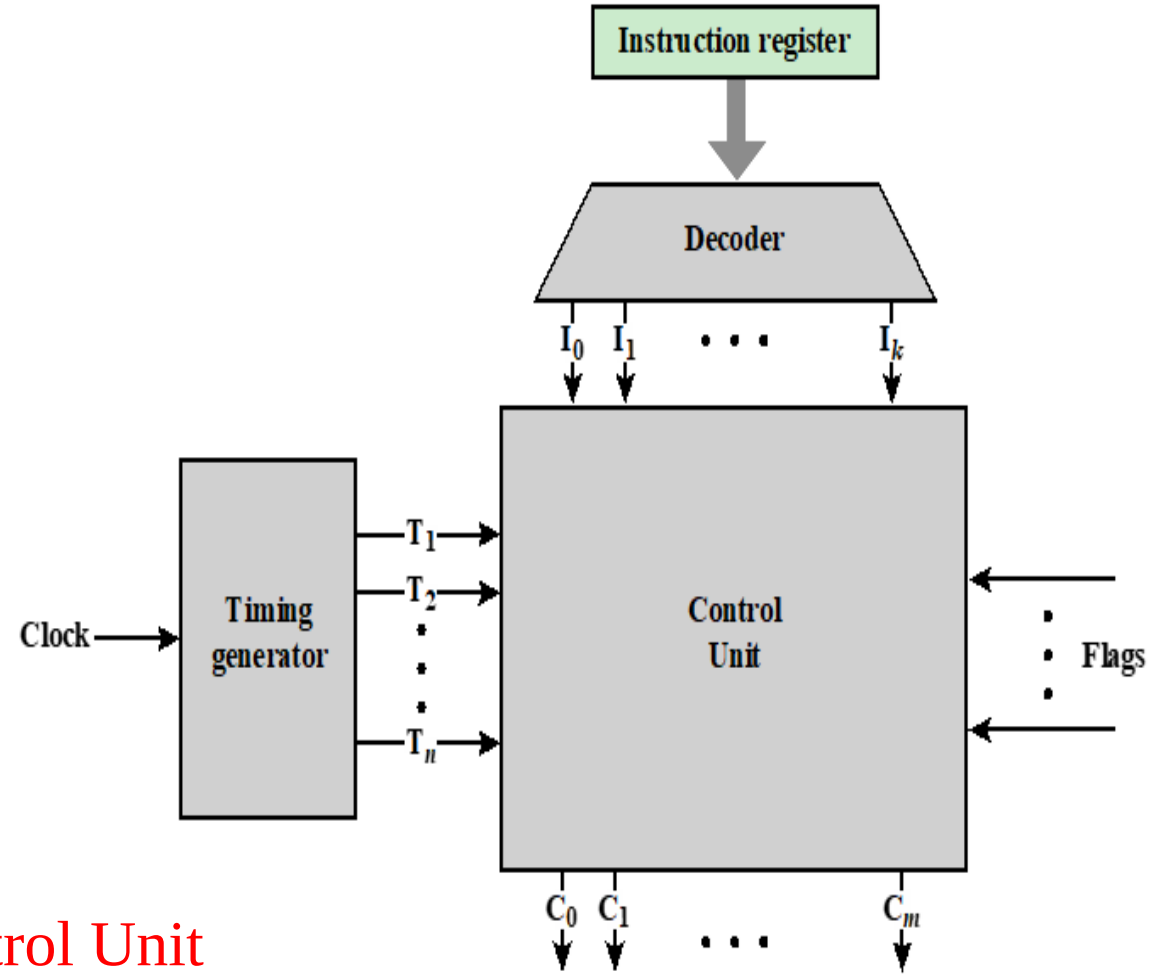
IR		AR		D1		D2		PC			Mux1	Mux2	ALU		Mem	
In	out	in	out	in	out	in	out	in	out	inc	Sel	Sel	opcode		R	W
0	0	1	0	0	0	0	0	0	1	0	1	1	0010		0	0

Control Unit Functional Requirements

- Three step process to lead to a characterization of the control unit:
  - Define basic elements of processor
  - Describe micro-operations processor performs
  - Determine the functions that the control unit must perform to cause the micro-operations to be performed
- The control unit performs two basic tasks:
  - Sequencing
  - Execution

Control Unit Organization

- How Control Unit generates the control signals:



- **Two mechanisms**:
  - Hardwired Control Unit
  - Microprogrammed Control Unit

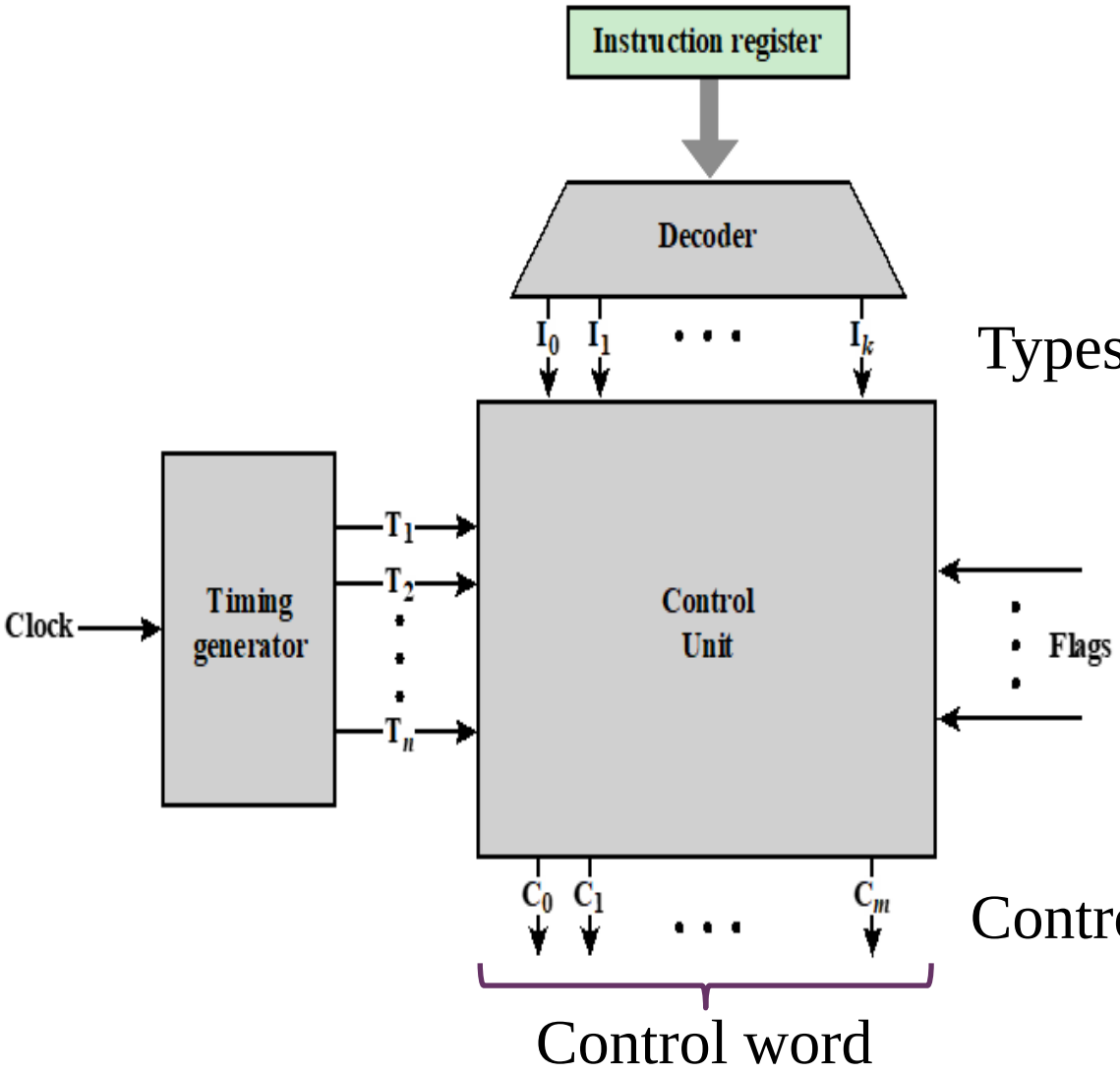
Hardwired Control Unit

- Control logic is implemented with Gates, Flip-flops, Encoder, decoder, multiplexer, and other digital circuits:

- Advantages:
  - Can be optimized to produce a faster mode of operation.

- Disadvantages
  - Adapting additional requirements is very difficult.

Hardwired Control Unit



Hardwired Control Unit

Inst./ Timer	I1	I2	I3	I4	In
T1	C2, C6,C8	…	…	…	…
T2	C1, C5	…	…	…	…
T3	…	…	…	…	…
T4	…	…	…	…	…
T5	…	…	…	…	…
T6	…	…	…	…	…

Hardwired Control Unit

A hardwired CPU uses 10 control signals S_1 to S_{10}, in various time steps T_1 to T_5, to implement 4 instructions I_1 to I_4 as shown below:

	$\mathbf{T_1}$	$\mathbf{T_2}$	$\mathbf{T_3}$	$\mathbf{T_4}$	$\mathbf{T_5}$
$\mathbf{I_1}$	S_1, S_3, S_5	S_2, S_4, S_6	S_1, S_7	S_{10}	S_3, S_8
$\mathbf{I_2}$	S_1, S_3, S_5	S_8, S_9, S_{10}	$S_5, S_6 S_7$	S_6	S_{10}
$\mathbf{I_3}$	S_1, S_3, S_5	S_7, S_8, S_{10}	S_2, S_6, S_9	S_{10}	S_1, S_3
$\mathbf{I_4}$	S_1, S_3, S_5	S_2, S_6, S_7	S_5, S_{10}	S_6, S_9	S_{10}

Which of the following pairs of expressions represent the circuit for generating control signals S_5 and S_{10} respectively?

$((I_j + I_k)T_n$ indicates that the control signal should be generated in time step T_n if the instruction being executed is I_j or $l_k)$

A. $S_5 = T_1 + I_2 \cdot T_3$ and

$$S_{10} = (I_1 + I_3) \cdot T_4 + (I_2 + I_4) \cdot T_5$$

B. $S_5 = T_1 + (I_2 + I_4) \cdot T_3$ and

$$S_{10} = (I_1 + I_3) \cdot T_4 + (I_2 + I_4) \cdot T_5$$

C. $S_5 = T_1 + (I_2 + I_4) \cdot T_3$ and

$$S_{10} = (I_2 + I_3 + I_4) \cdot T_2 + (I_1 + I_3) \cdot T_4 + (I_2 + I_4) \cdot T_5$$

D. $S_5 = T_1 + (I_2 + I_4) \cdot T_3$ and

$$S_{10} = (I_2 + I_3) \cdot T_2 + I_4 \cdot T_3 + (I_1 + I_3) \cdot T_4 + (I_2 + I_4) \cdot T_5$$

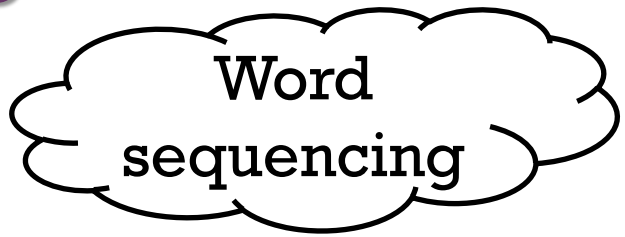
Microprogrammed Control Unit

- **Hardwired Control**:
  - It generates the signal for each instruction type.

- **Microprogrammed Control**:
  - It stores all the defined **Control words** in the **Control memory**.
  - Control logic is implemented with micro-programs.

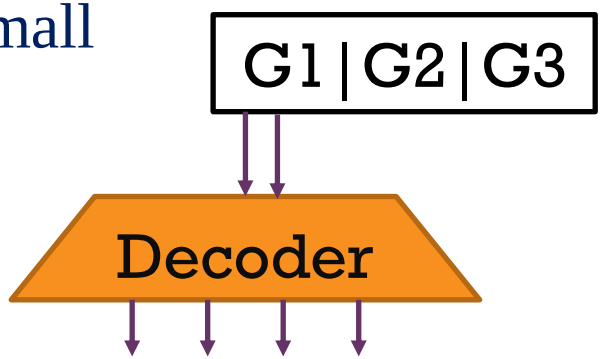
- Advantage:
  - Updating the control logic is easy.
- Disadvantage:
  - Slower than hardwired control

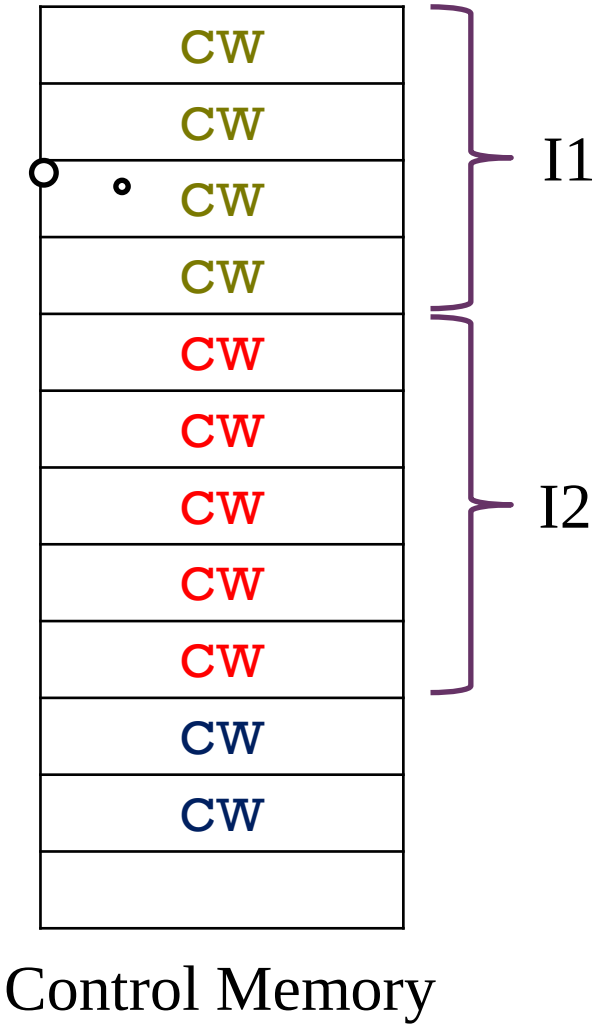
Microprogrammed Control Unit



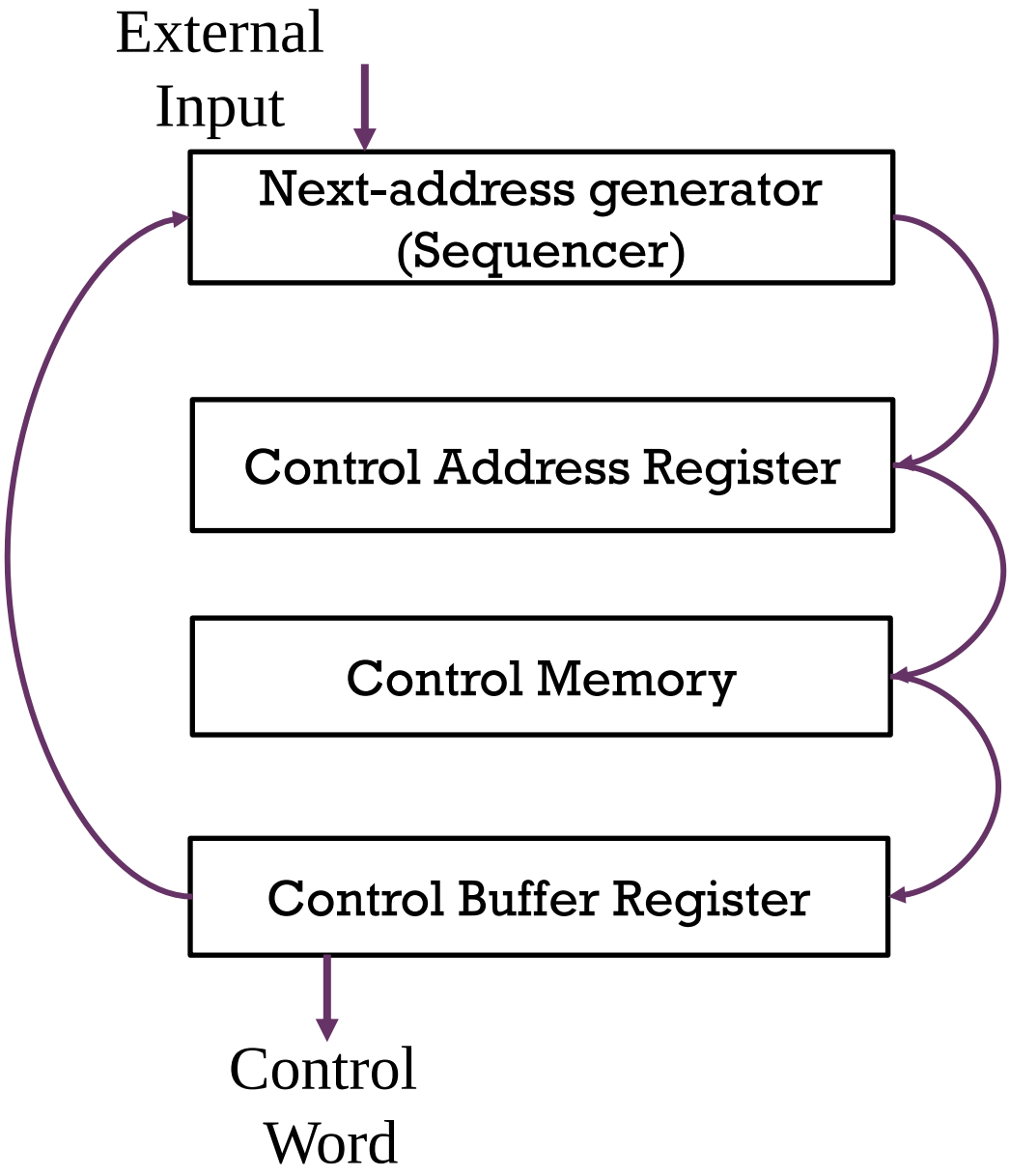
Types

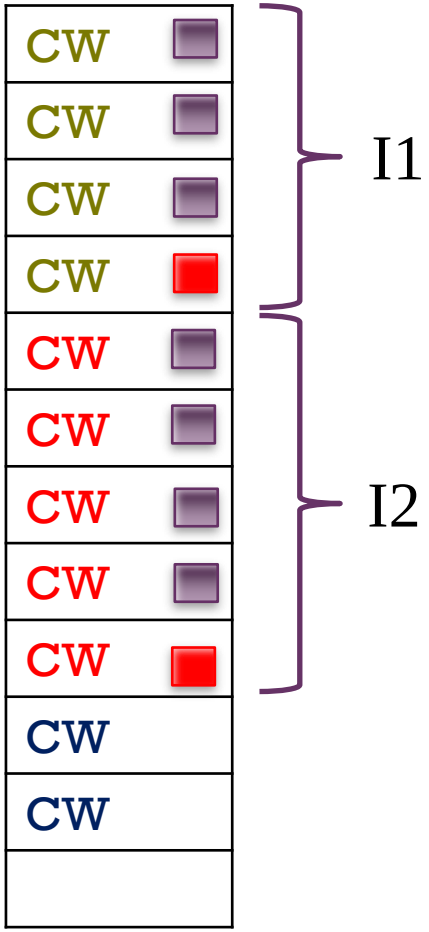
- **Horizontal**
  - One bit for each control signal
  - CW size is large
- **Vertical**
  - Signals are divided into multiple groups is such a way that within each group, only one signal can be active at a time.
  - CW size is small





Control Word Sequencing





Functioning of Microprogrammed Control Unit