University Of Diyala
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Department of Computer Engineering

Digital System Design II
Microprogramming

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Third stage

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Microprogramming Overview

- Part 1 – Datapaths
  - Introduction
  - Datapath Example
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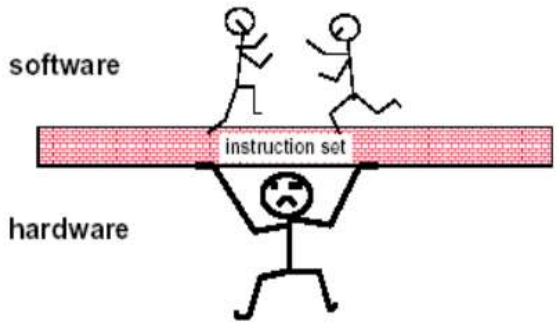
    - Shifter
  - Datapath Representation and Control Word
- Part 2 – A Simple Computer
  - Instruction Set Architecture (ISA)
  - Single-Cycle Hardwired Control
- Part 3 – Multiple Cycle Hardwired Control
  - Single Cycle Computer Issues
  - Sequential Control Design

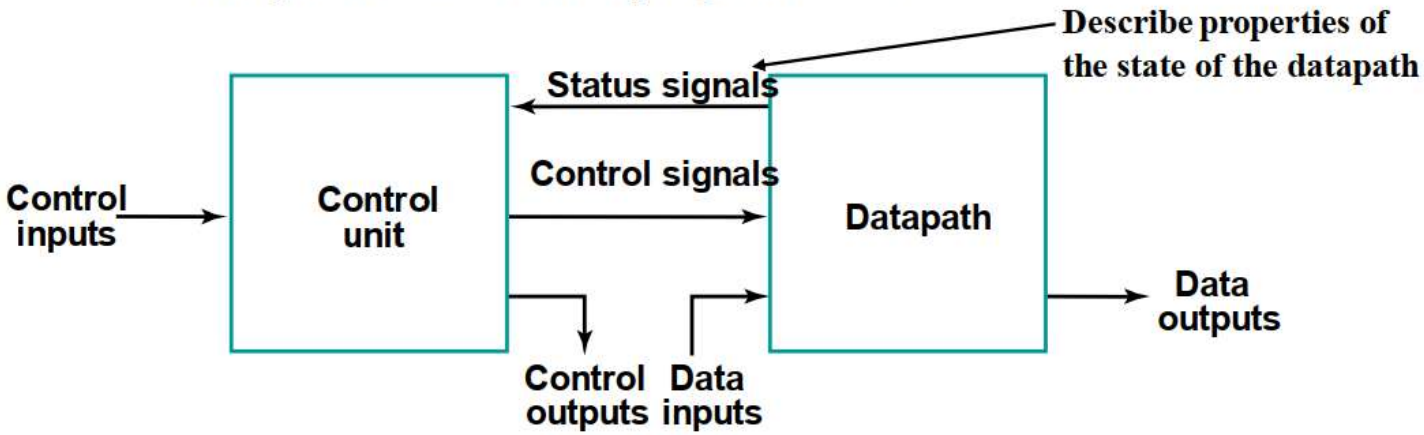
Introduction

- Computer Specification
  - *Instruction Set Architecture (ISA)* - the specification of a computer's appearance to a programmer at its lowest level
  - *Computer Architecture* - a high-level description of the hardware implementing the computer derived from the ISA
  - The architecture usually includes additional specifications such as speed, cost, and reliability.



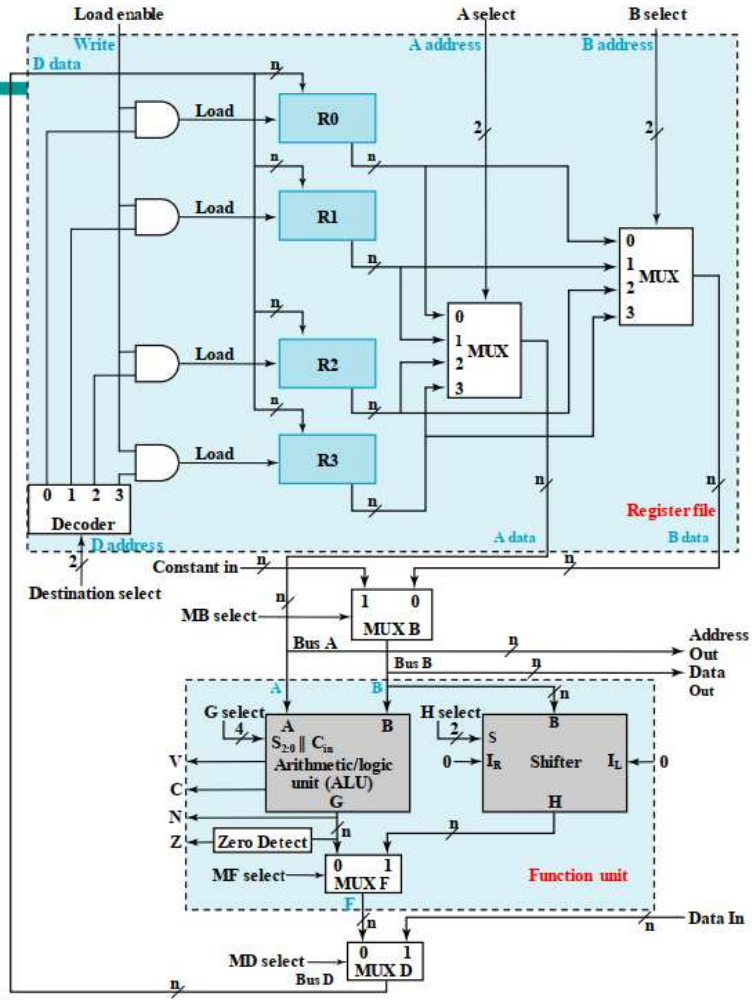
Introduction (Contd.)

- Simple computer architecture decomposed into:
  - Datapath: performing operations
    - A set of registers
    - Microoperations performed on the data stored in the registers
    - A control interface
  - Control unit: controlling datapath operations
    - Programmable & Non-programmable



Datapath Example

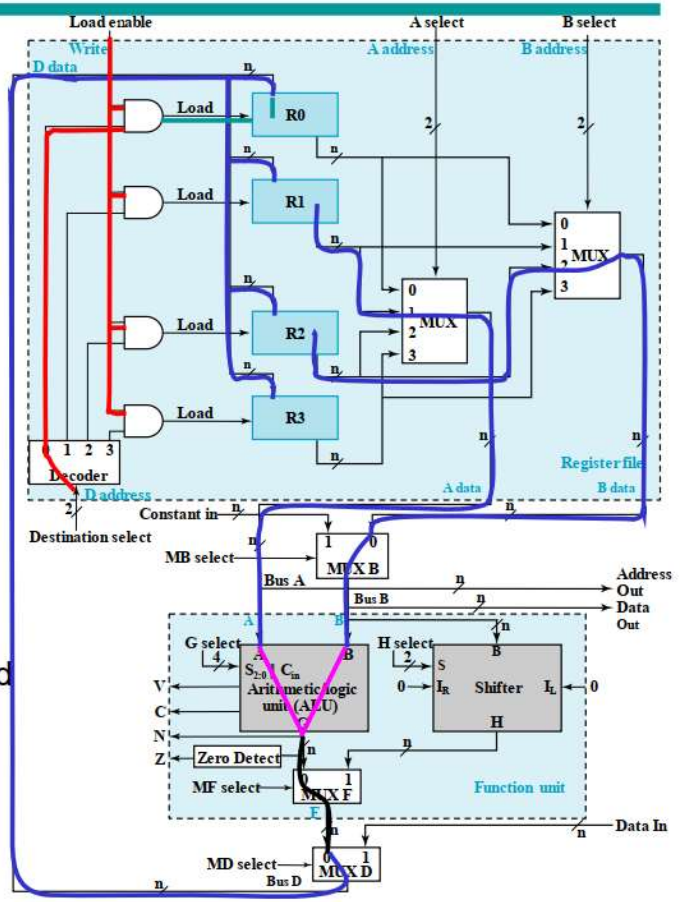
- Register file:
  - Four parallel-load regs
  - Two mux-based register selectors
  - Register destination decoder
- Microoperation Implementation
  - Mux B for external constant input
  - Buses A and B with external address and data outputs
  - Function Unit:
    - ALU and Shifter with Mux F for output select
    - Mux D for external data input
    - Logic for generating status bits V, C, N, Z



Datapath Example: Performing a Microoperation

Microoperation: R0 ← R1 + R2

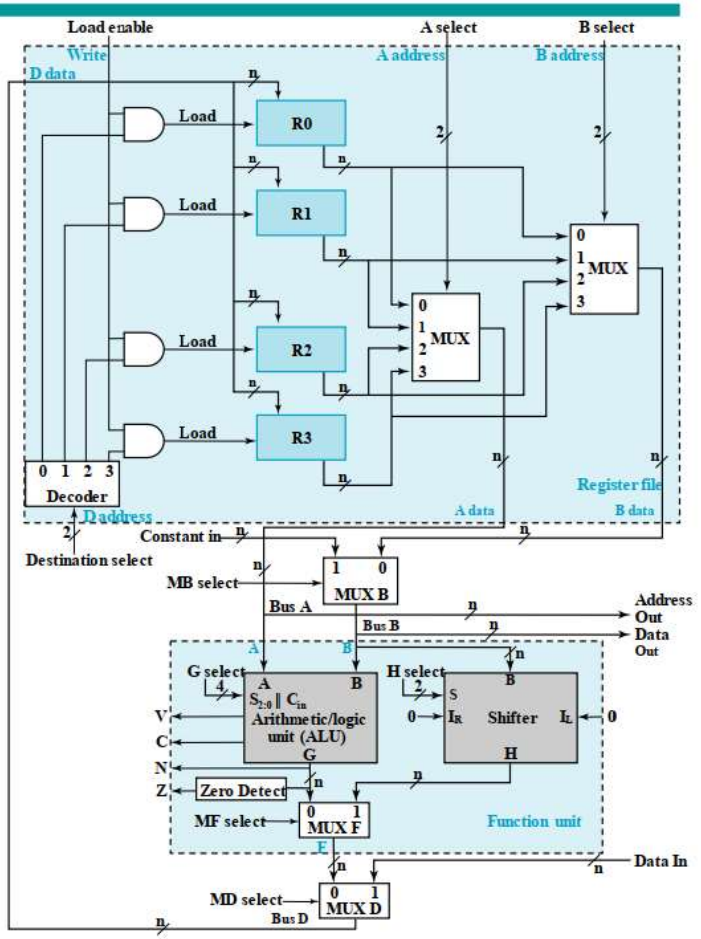
- Apply 01 to A select to place contents of R1 onto Bus A
- Apply 10 to B select to place contents of R2 onto B data and apply 0 to MB select to place B data on Bus B
- Apply 0010 to G select to perform addition G = Bus A + Bus B
- Apply 0 to MF select and 0 to MD select to place the value of G onto BUS D
- Apply 00 to Destination select to enable the Load input to R0
- Apply 1 to Load Enable to force the Load input to R0 to 1 so that R0 is loaded on the clock pulse (not shown)
- The overall microoperation requires 1 clock cycle



Datapath Example: Key Control Actions for Microoperation Alternatives

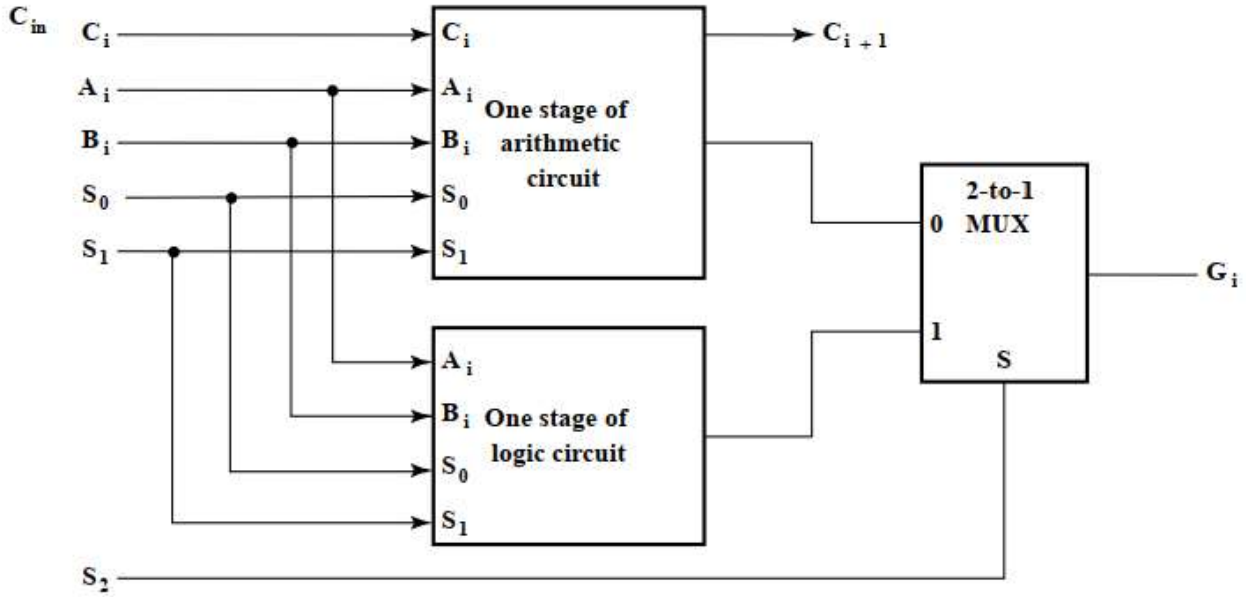
Various microoperations:

- Perform a shift microoperation: apply 1 to MF select
- Use a constant in a micro-operation using Bus B: apply 1 to MB select
- Provide an address and data for a memory or output write microoperation – apply 0 to Load enable to prevent register loading
- Provide an address and obtain data for a memory or output read microoperation – apply 1 to MD select
- For some of the above, other control signals become don't cares



Arithmetic Logic Unit (ALU)

- Decompose the ALU into:
  - An arithmetic circuit & A logic circuit
  - A selector to pick between the two circuits

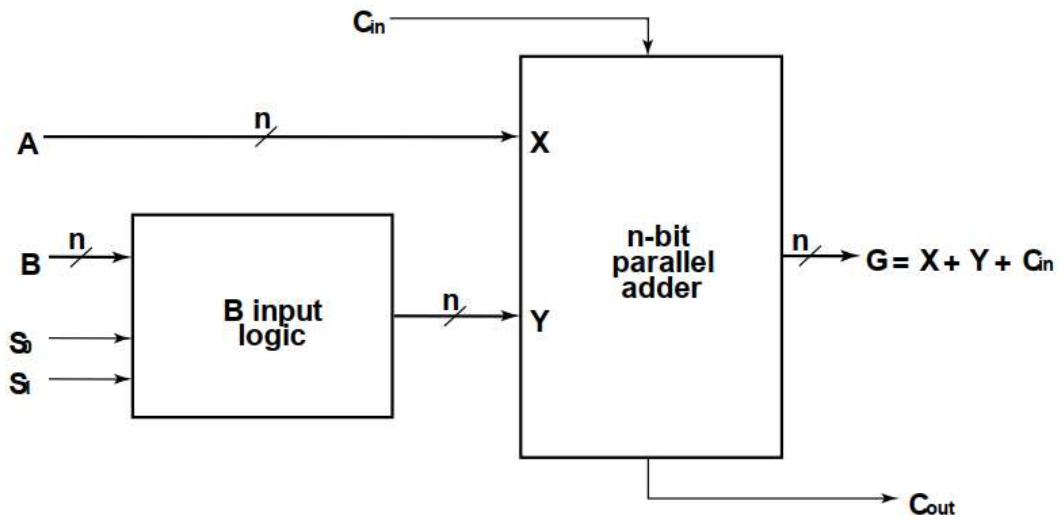


Arithmetic Circuit Design

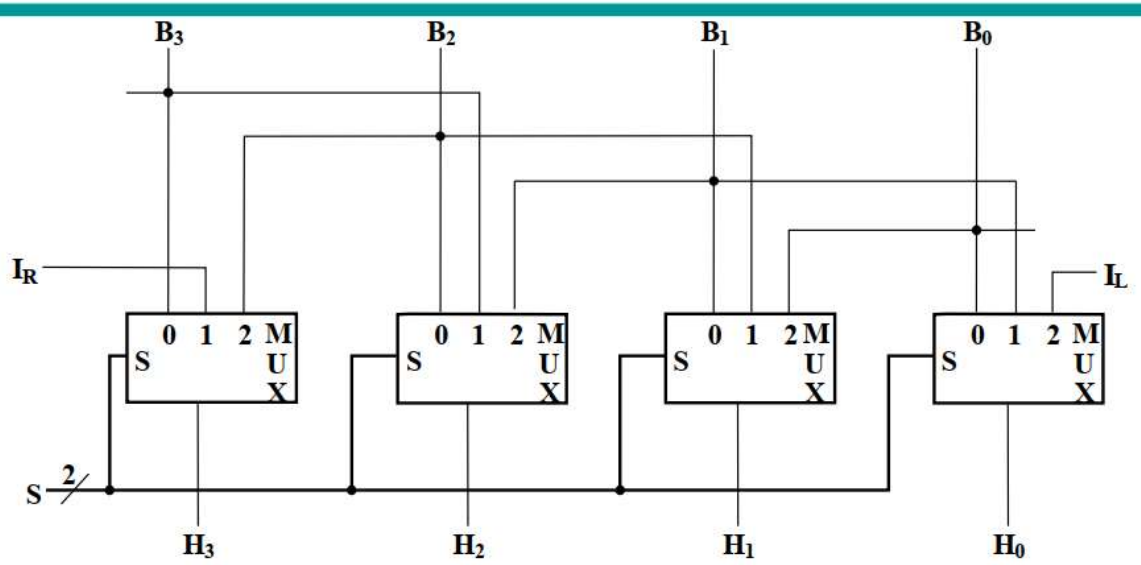
- Arithmetic circuit design
  - Decompose the arithmetic circuit into:
    - An n-bit parallel adder
    - A block of logic that selects four choices for the B input to the adder

- There are only four functions of B to select as Y in $G = A + Y + C_{in}$:

	$C_{in} = 0$	$C_{in} = 1$
• 0	$G = A$	$G = A + 1$
• B	$G = A + B$	$G = A + B + 1$
• $\overline{B}$	$G = A + \overline{B}$	$G = A + \overline{B} + 1$
• 1	$G = A - 1$	$G = A$



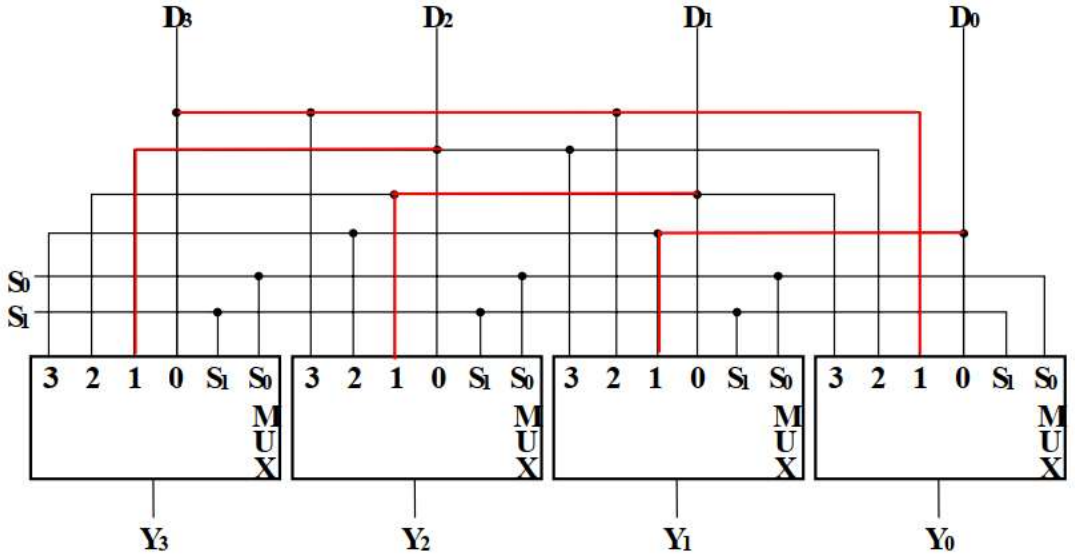
4-Bit Basic Left/Right Shifter



- Serial Inputs:
  - I_R for right shift
  - I_L for left shift

- Shift Functions:
  (S_1, S_0) = 00 Pass B unchanged
  01 Right shift
  10 Left shift
  11 Unused

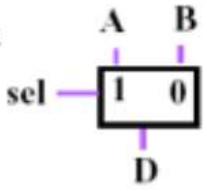
Barrel Shifter



- A rotate is a shift in which the bits shifted out are inserted into the positions vacated
- The circuit rotates its contents left from 0 to 3 positions depending on S:
  S = 00 position unchanged
  S = 01 rotate left by 1 positions
  S = 10 rotate left by 2 positions
  S = 11 rotate left by 3 positions

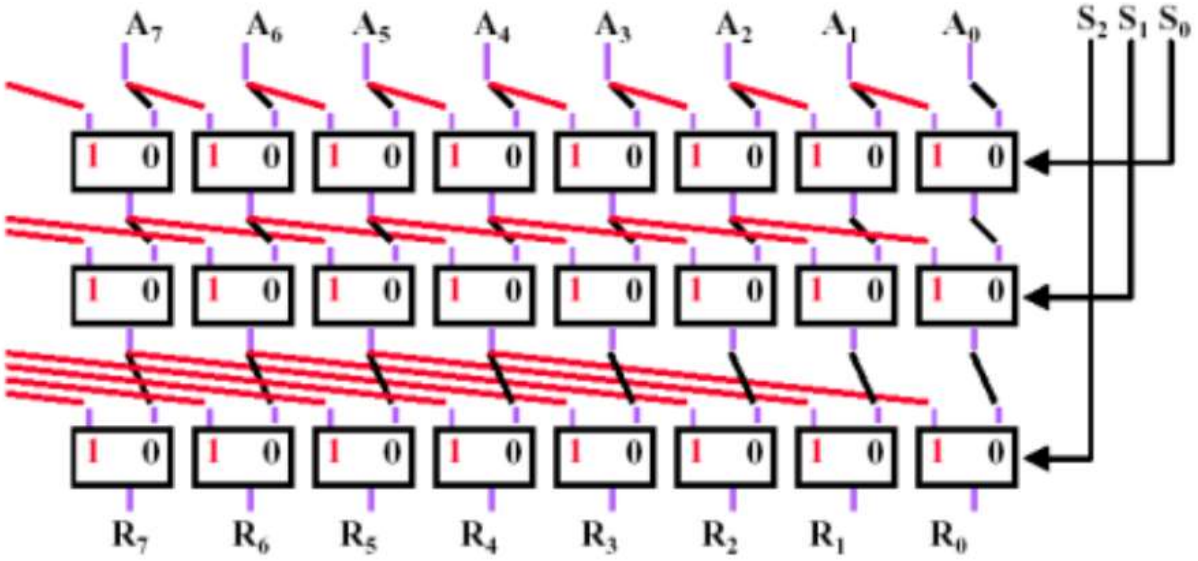
Combinational Shifter from MUXes

Basic Building Block



- Example 8-bit:
  - Layer 1 shifts by 0, 4
  - Layer 2 shifts by 0, 2
  - Layer 3 shifts by 0, 1

8-bit right shifter



- Large barrel shifters can be constructed using:
  - Layers of multiplexers
  - 2 - dimensional array circuits designed at the electronic level