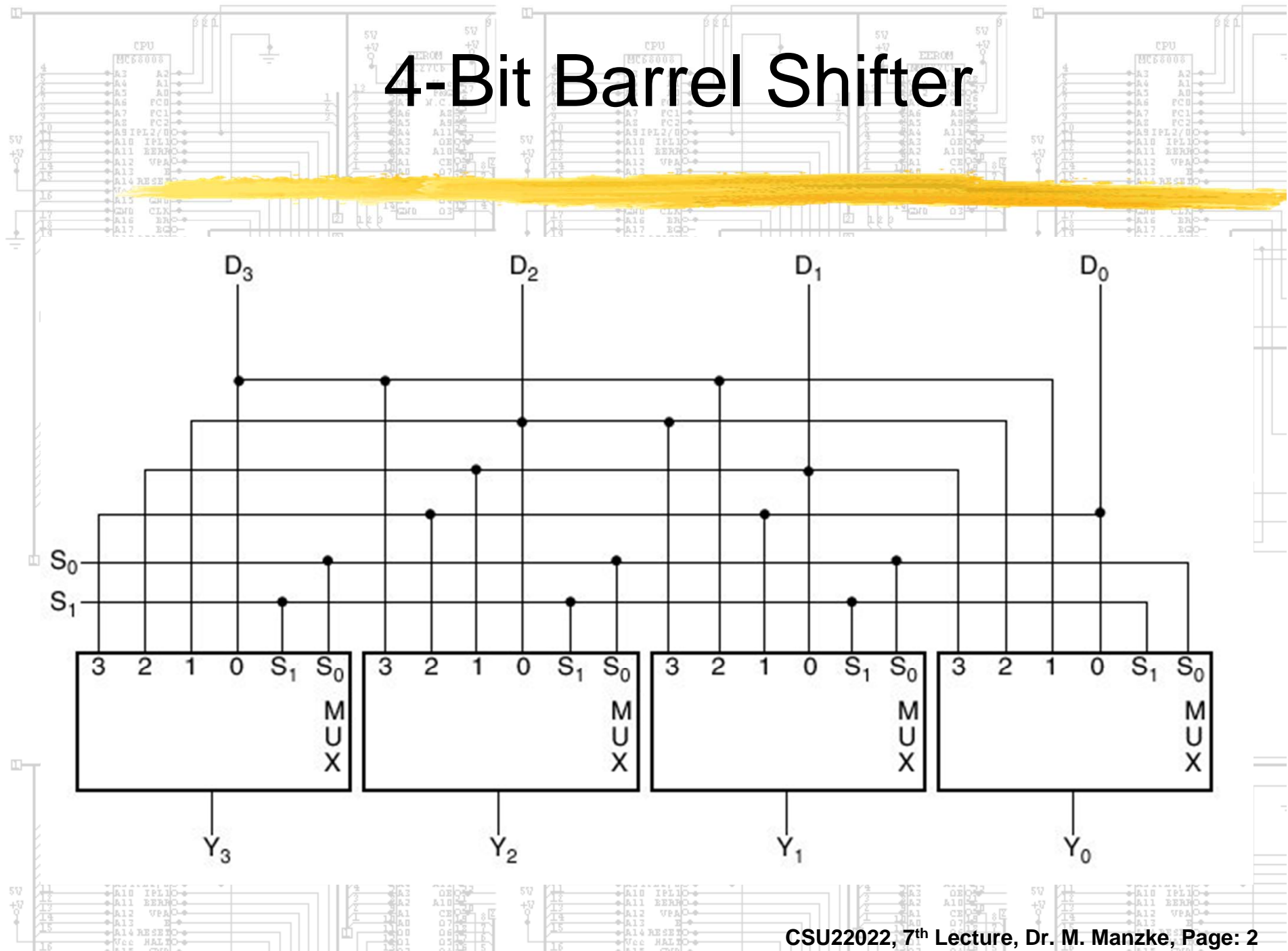


Shift Operations

By controlling IR and IL with multiplexers it is straightforward to adapt this circuit to perform arithmetic shifts, constructive and destructive shifts, Rotates and rotate-then-carry operation

4-Bit Barrel Shifter



Multiple Shifts

► If multiple shifts are required we wire them into multiplexers that have an input for every bit on the bus to obtain a Barrel shifter (Previous slide).

S₁ S₂

0 0

0 1

1 0

1 1

Y₃ Y₂ Y₁ Y₀

D₃ D₂ D₁ D₀

D₂ D₁ D₀ D₃

D₁ D₀ D₃ D₂

D₀ D₃ D₂ D₁

Micro-ops

No Rotate

Rotate One

Rotate Two

Rotate Three

Controlling a Datapath

The Control Word

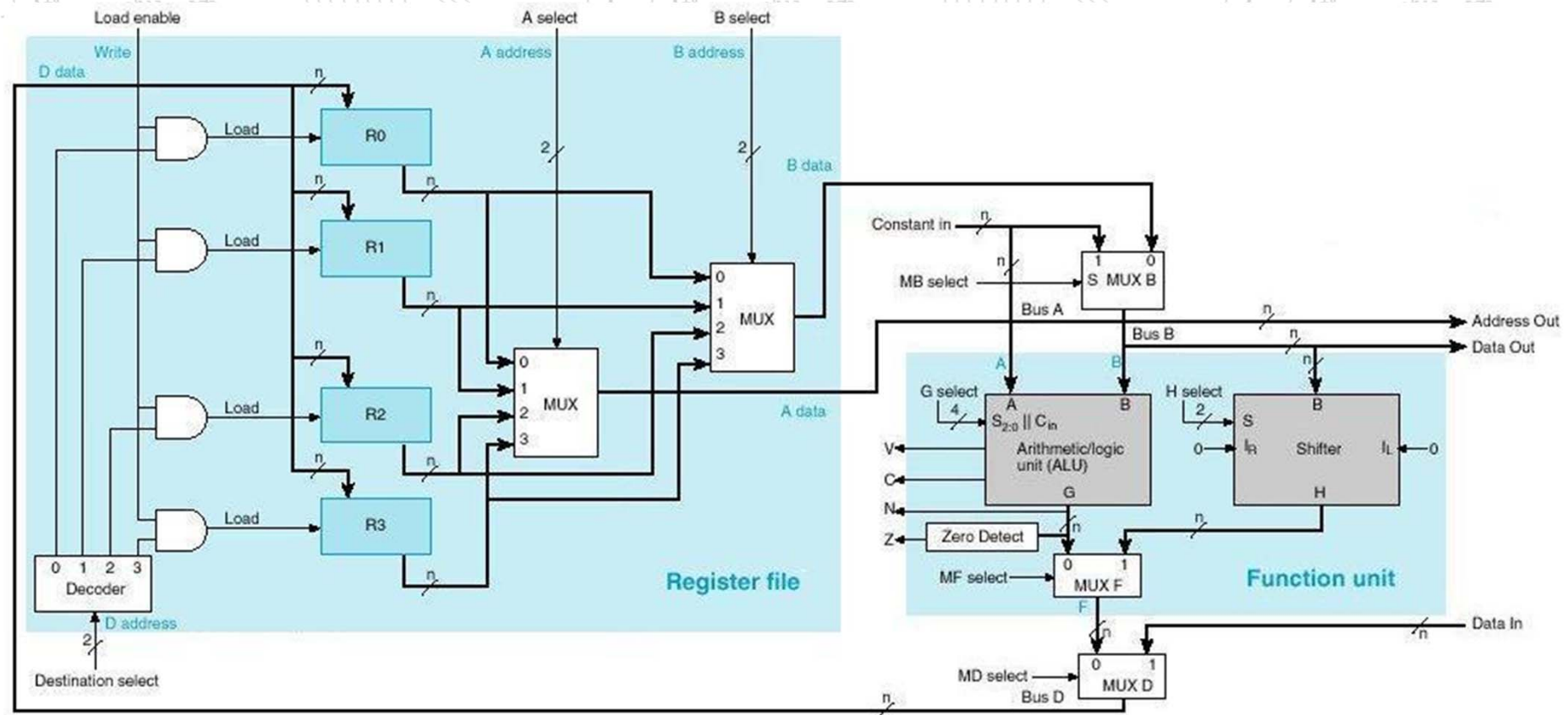
- ▶ The figure on the next slide is an updated version of our introductory datapath (4th Lecture, Page 12) where the register file has been expanded to a more realistic eight n-bit registers.
- ▶ Consequently the destination decoder and A and B bus MUX require three-bit select input.
- ▶ The Function Unit still requires five bits to select ALU/Shift micro-ops.
- ▶ Three more bits are required to control:

- ▶ Writing to the registers (RW)

- ▶ MUX B (MB)

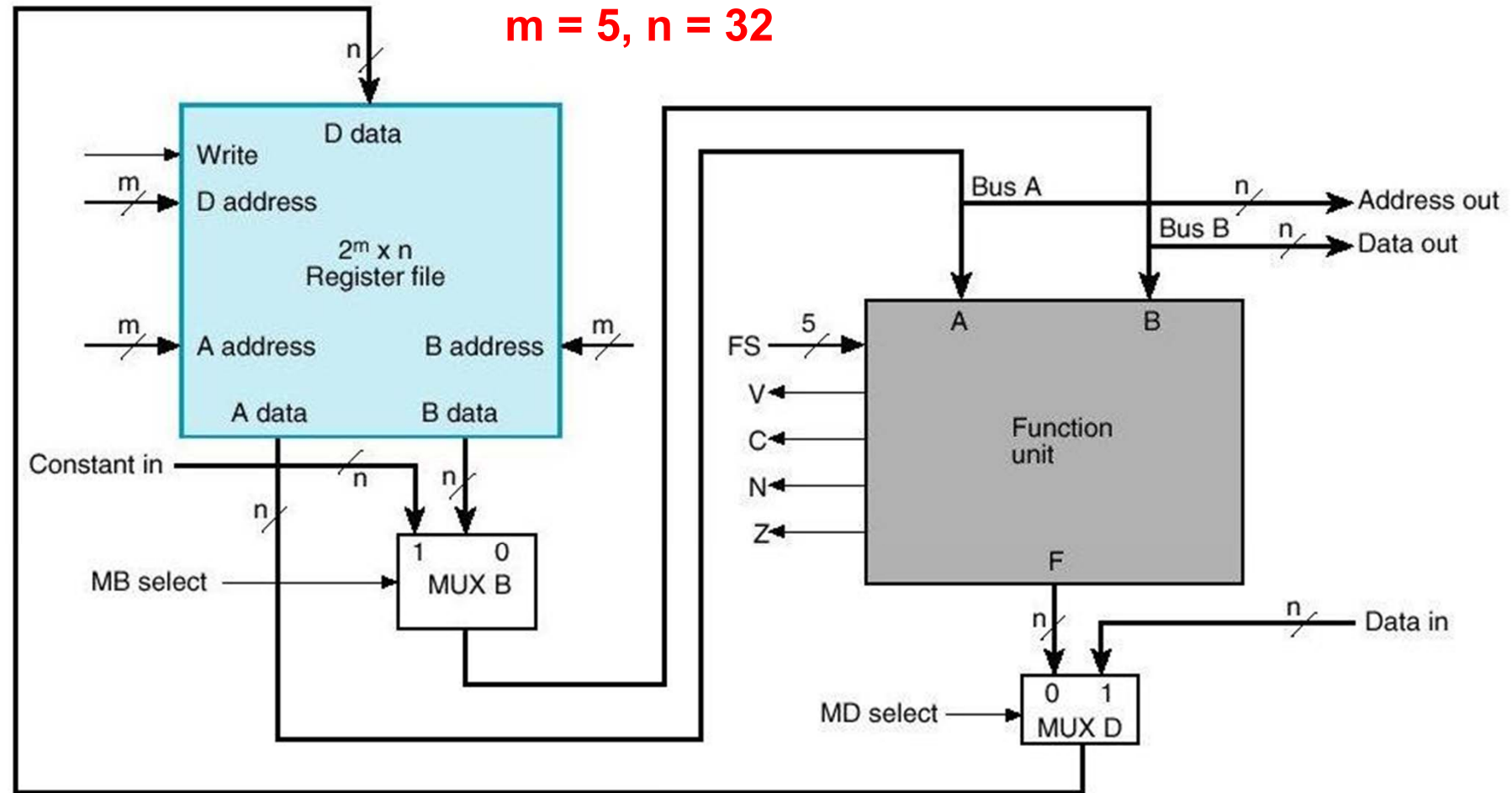
- ▶ MUX D (MD)

4th Lecture - Page 12



Updated Datapath

$m = 5, n = 32$

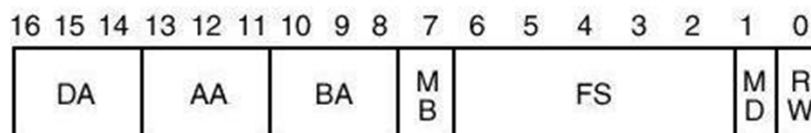
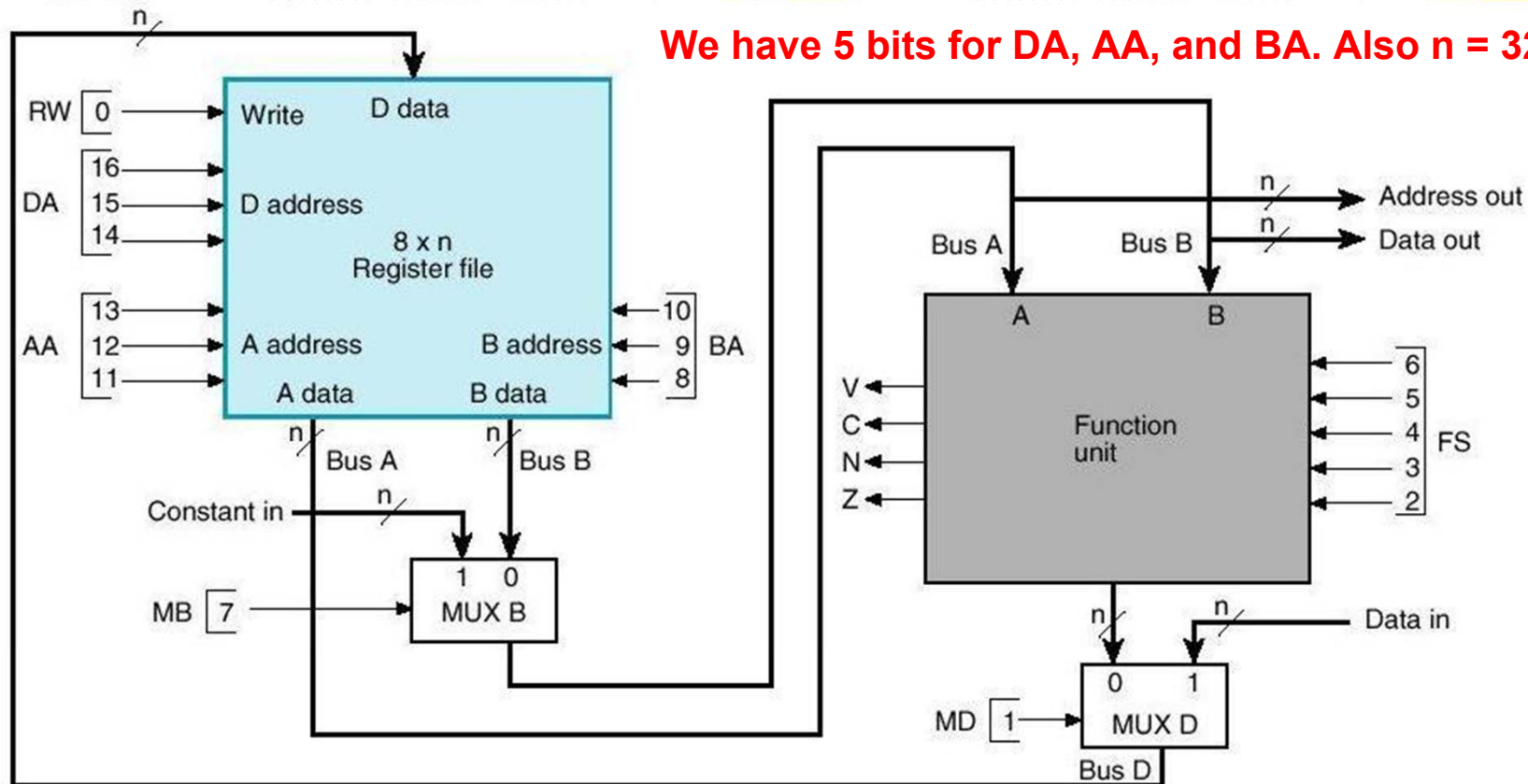


Control Word

▶ The schematic on the next slide identifies all these control inputs and arranges them in a 23-bit vector called the Control Word.

Datapath and the Control Word

We have 5 bits for DA, AA, and BA. Also $n = 32$ bits



The Control Word Specifies One Micro-ops



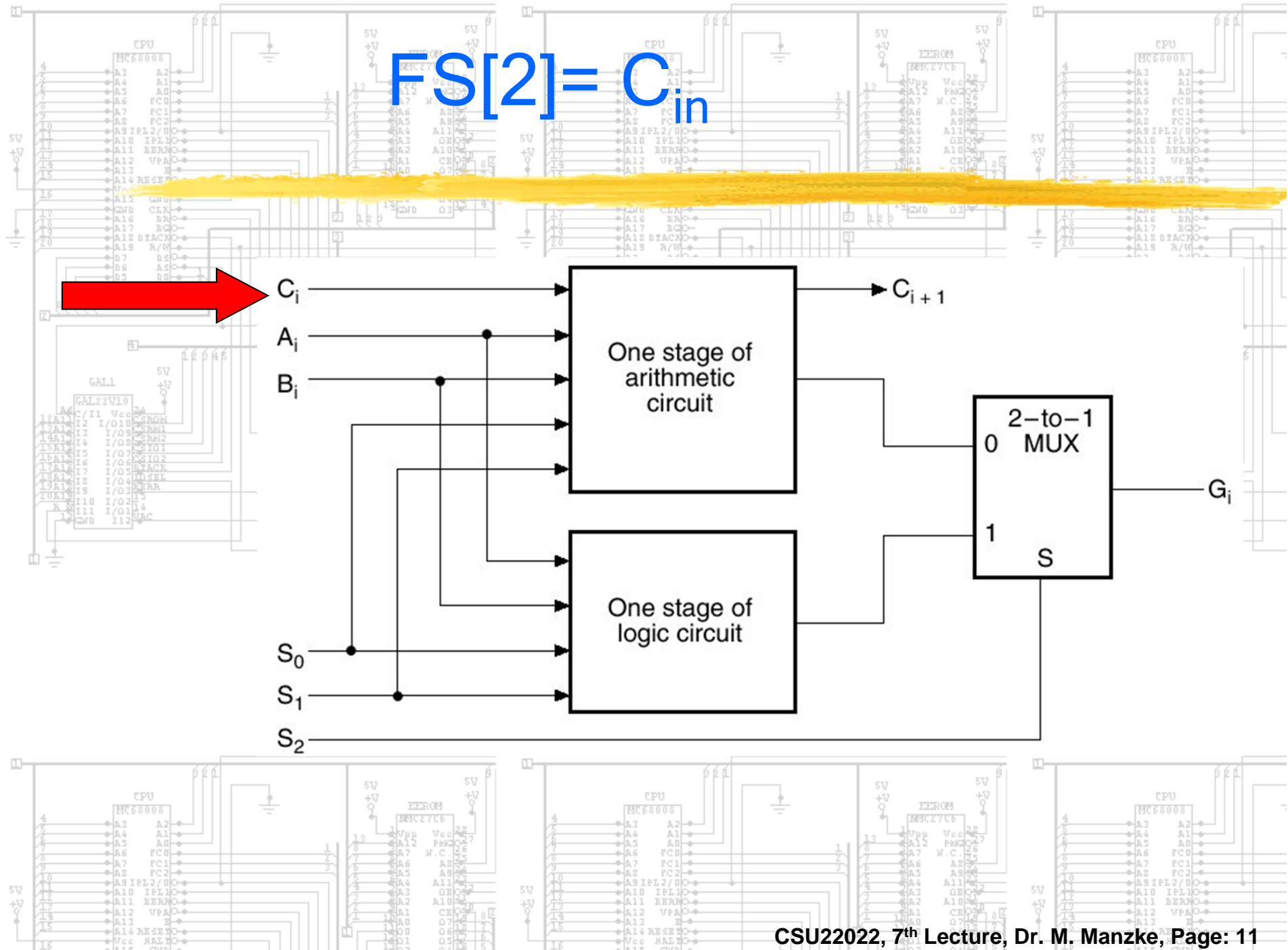
► Note that for the function select FS we need to make explicit the relationship between its value and the micro-ops.

► See next slide for details.

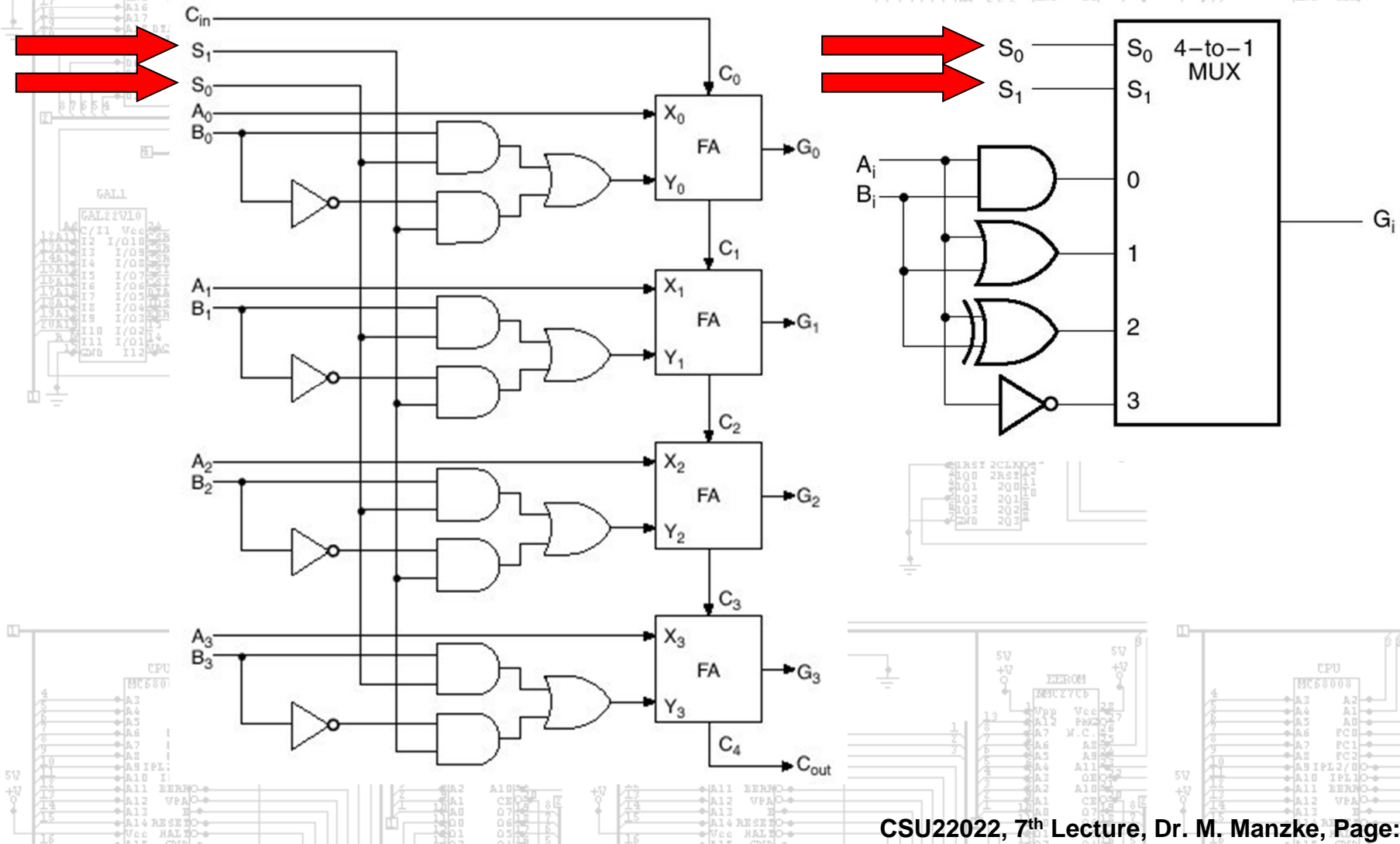
G Select, H Select and MF Select determine the FS code

FS	MF Select	G Select	H Select	Output	
00000	0	0000	XX	$G = A$	TRANSFER
00001	0	0001	XX	$G = A + 1$	INCREMENT
00010	0	0010	XX	$G = A + B$	ADD
00011	0	0011	XX	$G = A + B + 1$	ADD WITH C
00100	0	0100	XX	$G = A + \underline{B}$	A plus 1's C.B
00101	0	0101	XX	$G = A + B + 1$	SUBTRACT
00110	0	0110	XX	$G = A - 1$	DECREMENT
00111	0	0111	XX	$G = A$	TRANSFER
01000	0	1000	XX	$G = A \wedge B$	AND
01010	0	1010	XX	$G = A \vee B$	OR
01100	0	1100	XX	$G = A \oplus B$	XOR
01110	0	1110	XX	$G = A$	NOT
10000	1	XXXX	00	$G = B$	TRANSFER
10100	1	XXXX	01	$G = sr B$	SHIFT RIGTH
11000	1	XXXX	10	$G = sl B$	SHIFT LEFT

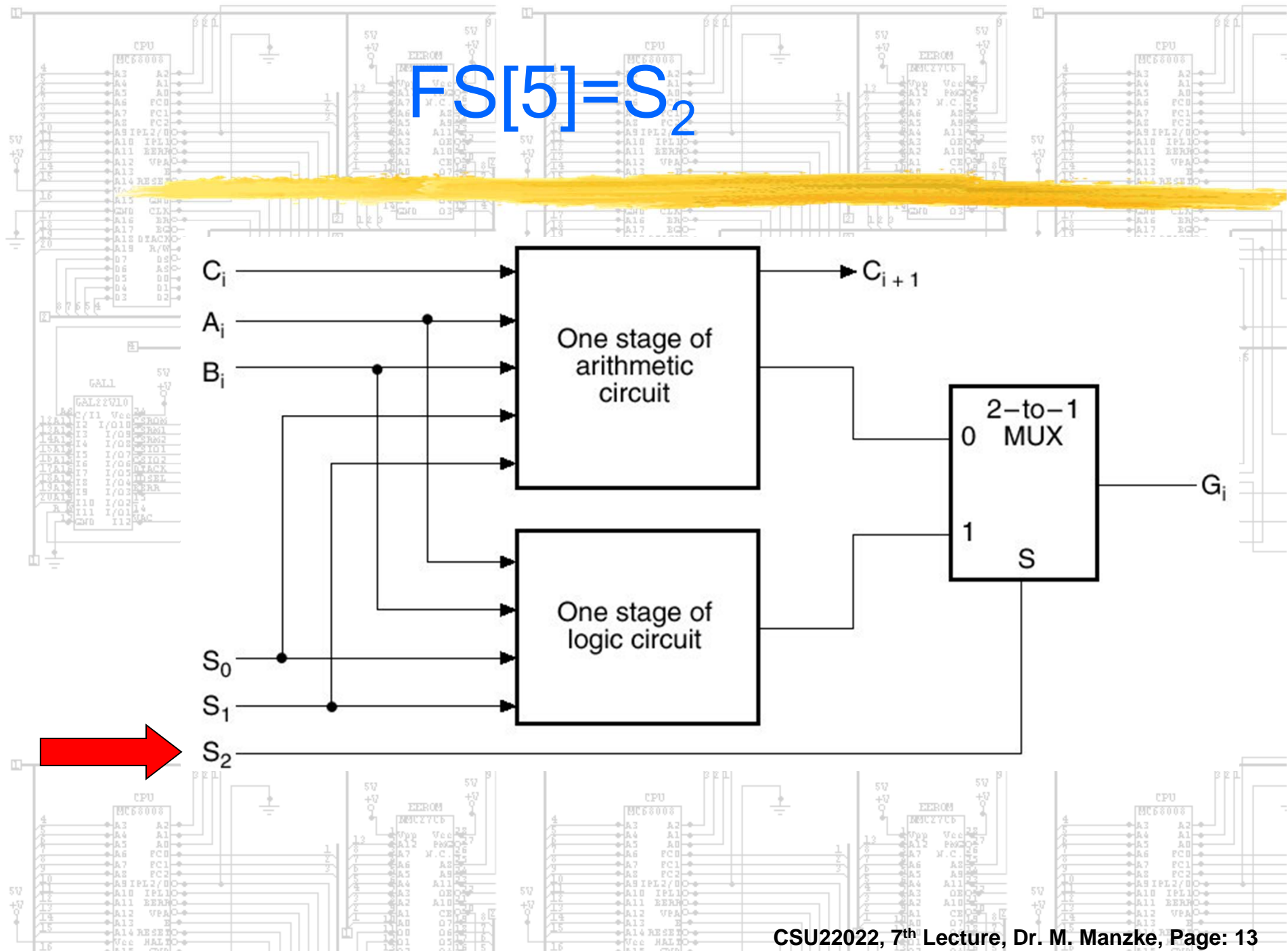
$$FS[2] = C_{in}$$



$$FS[3 \wedge 4] = S_0 S_1$$



$$FS[5] = S_2$$



FS[6]=MF select

