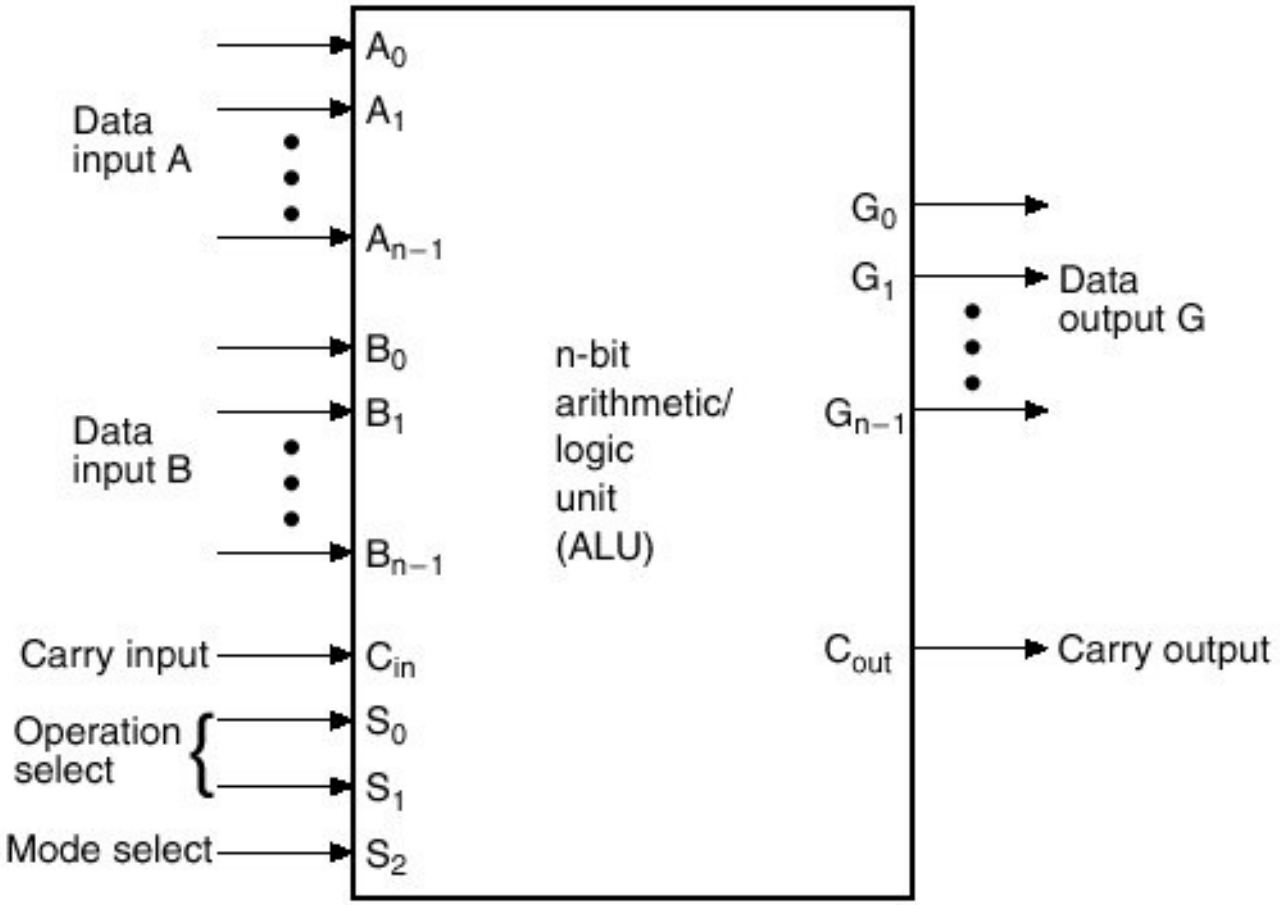
CS2022 Arithmetic Circuit

- The arithmetic circuit may implemented with the following components:
  - Parallel Adder
    - Build from a cascade of full-adder circuits
  - The data input to the parallel adder is manipulated in order to achieve a number of arithmetic operations

CS2022 N-bit Arithmetic/Logic Unit(ALU)

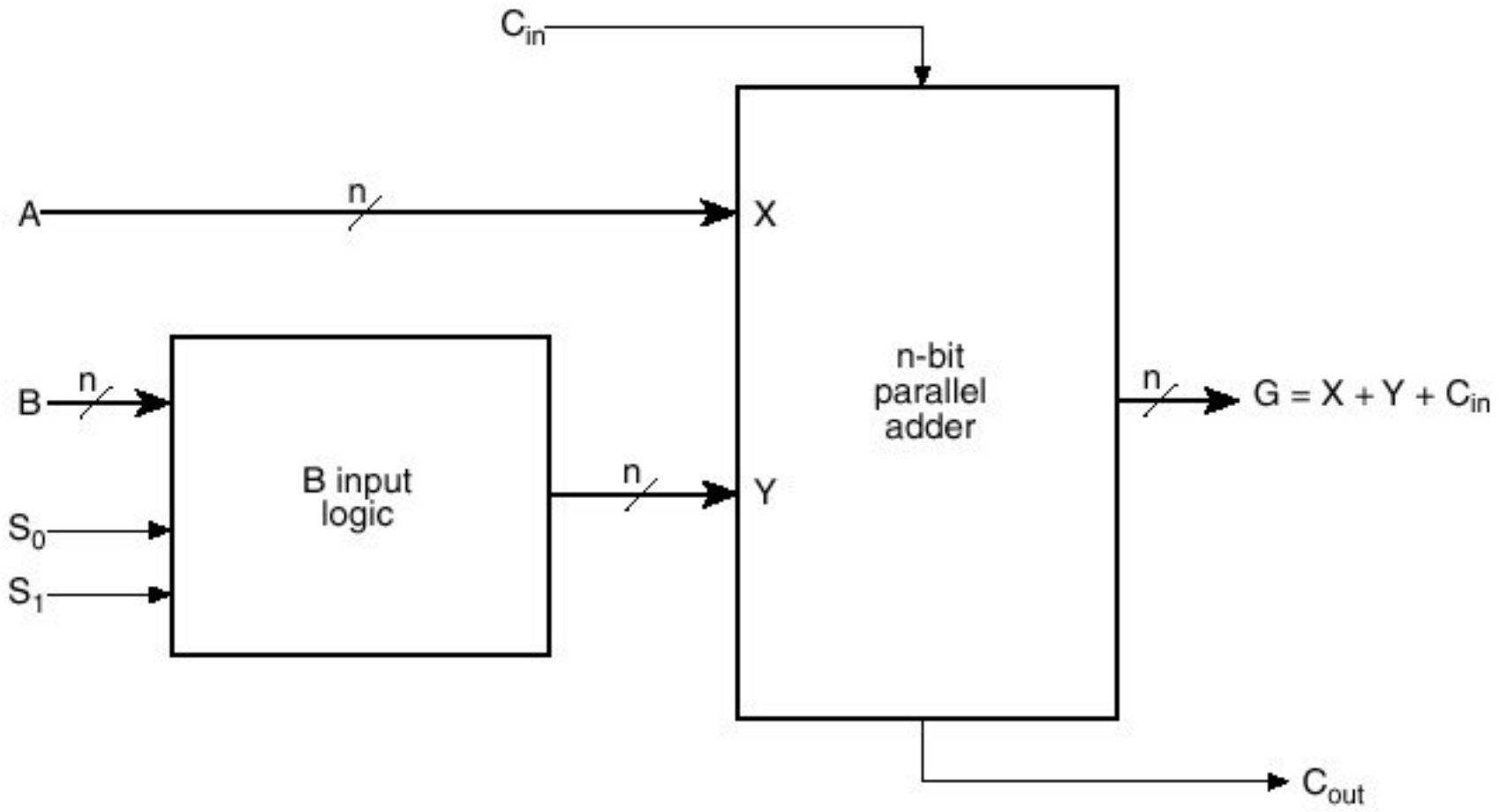


$G = A + Y + C_{in}$

- The arithmetic micro-ops can be implemented using the carry-in C_{in} and two select inputs S_1 & S_0, which condition the B input to deliver **Y** to the full-adder computing: $G = A + Y + C_{in}$.

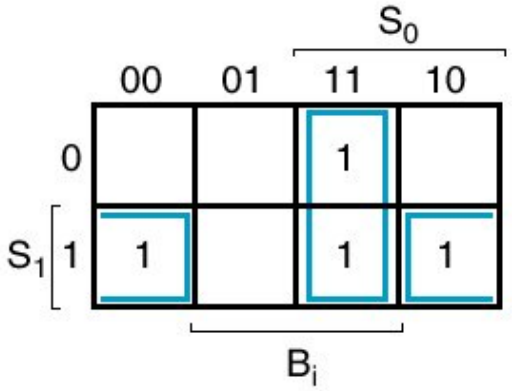
Select		Input		
S_1	S_0	Y	$C_{in}=0$	$C_{in}=1$
0	0	all 0's	G=A	G=A+1
0	1	$\overline{B}$	$G=A+\overline{B}$	$G=A+\overline{B}+1$
1	0	B	G=A+B	G=A+B+1
1	1	all 1's	G=A-1	G=A

CS2022 Arithmetic Circuit



CS2022 Y(S,B)

- The logic function **Y(S,B)** is derived as:

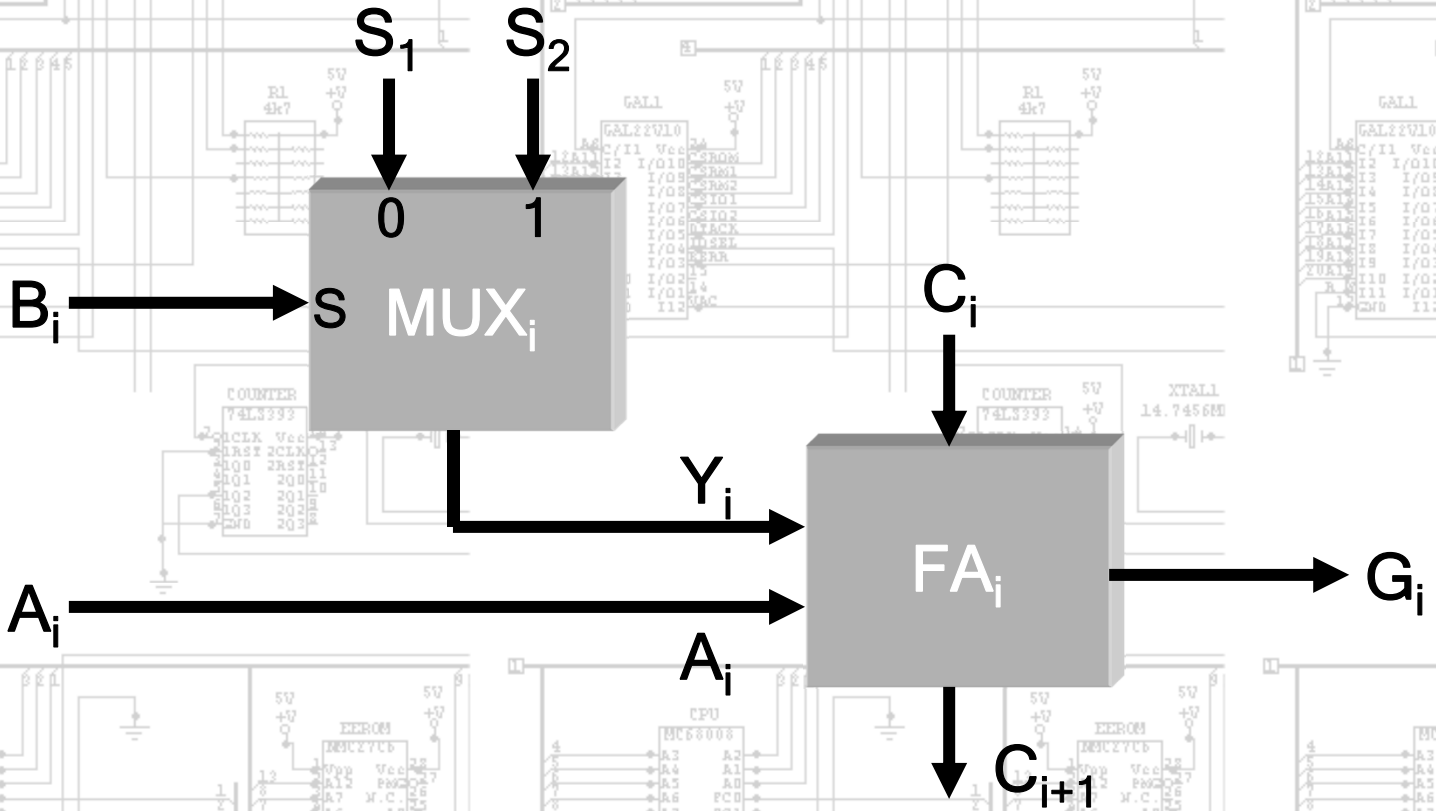


$$Y_i = S_0 B_i + S_1 \overline{B_i}$$

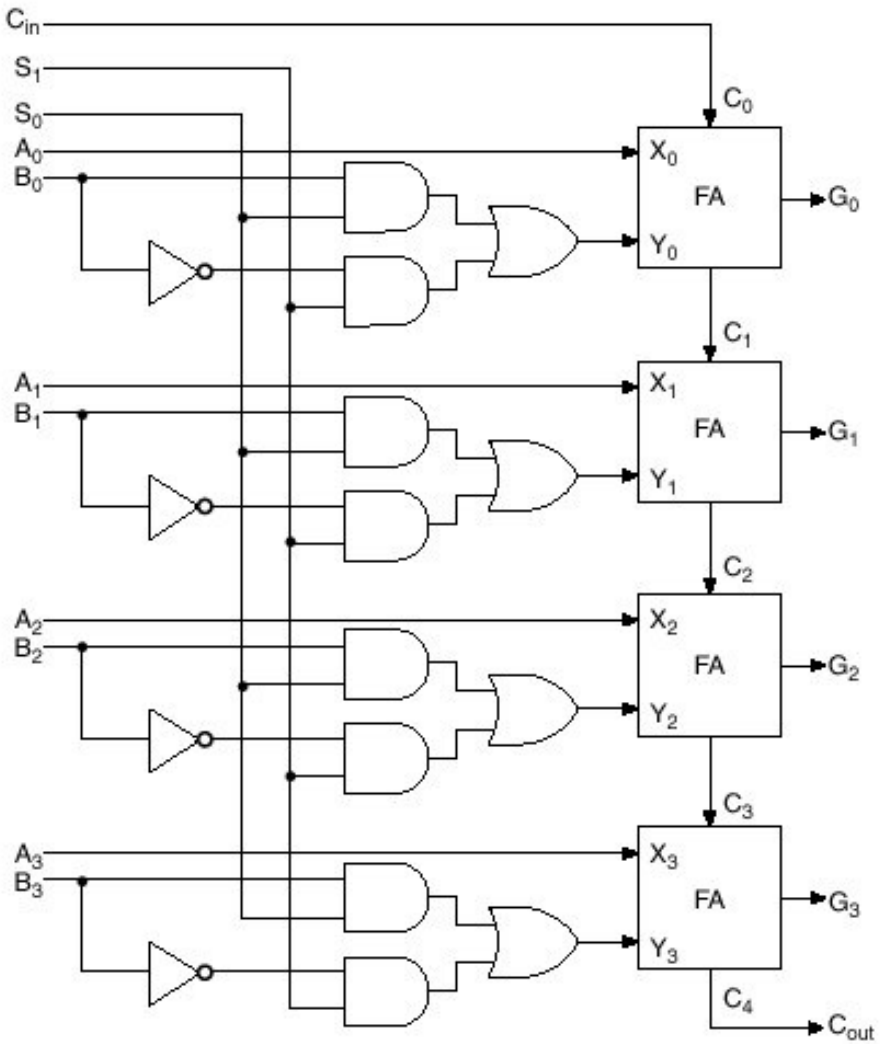
- Thus a 2:1 MUX controlled by B_i can efficiently generates Y_i

CS2022 One Bit Slice

- One bit slice of the Arithmetic unit on the next slide.



CS2022 4-Bit Arithmetic Circuit

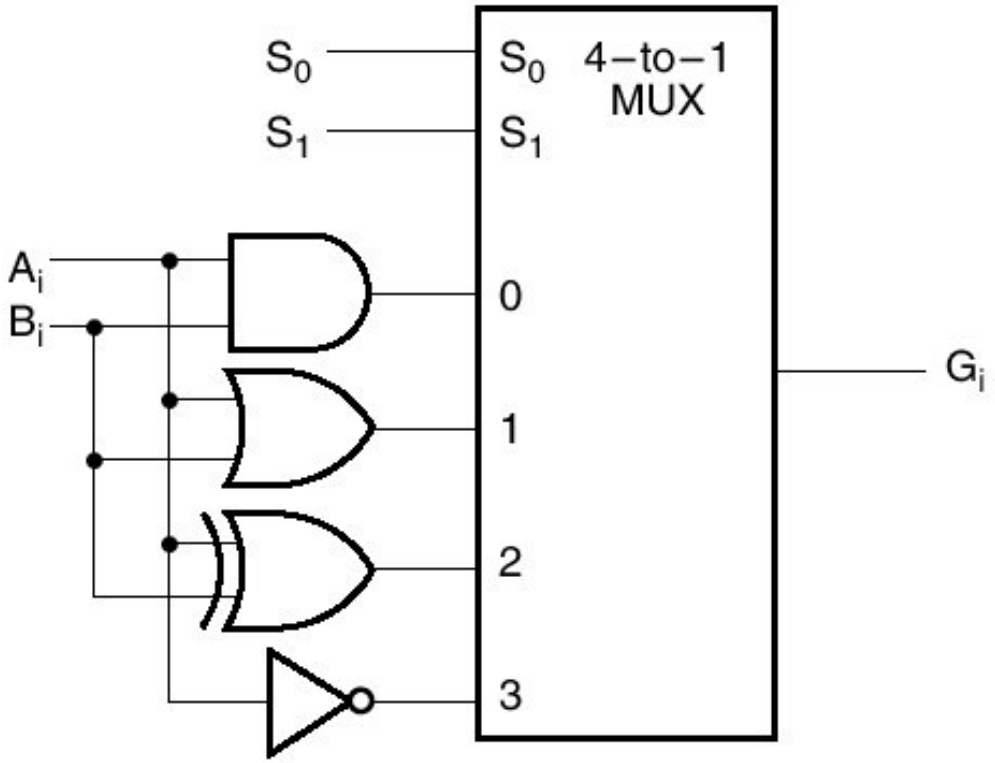


CS2022 Logic Circuit

- The logic function are similarly selected by input S_1 and S_0 :

Select		Output	
S_1	S_0		
0	0	$G = A \wedge B$	AND
0	1	$G = A \vee B$	OR
1	0	$G = A \oplus B$	XOR
1	1	$G = \overline{A}$	NOT

CS2022 Logic Circuit Implemented with a 4:1 MUX

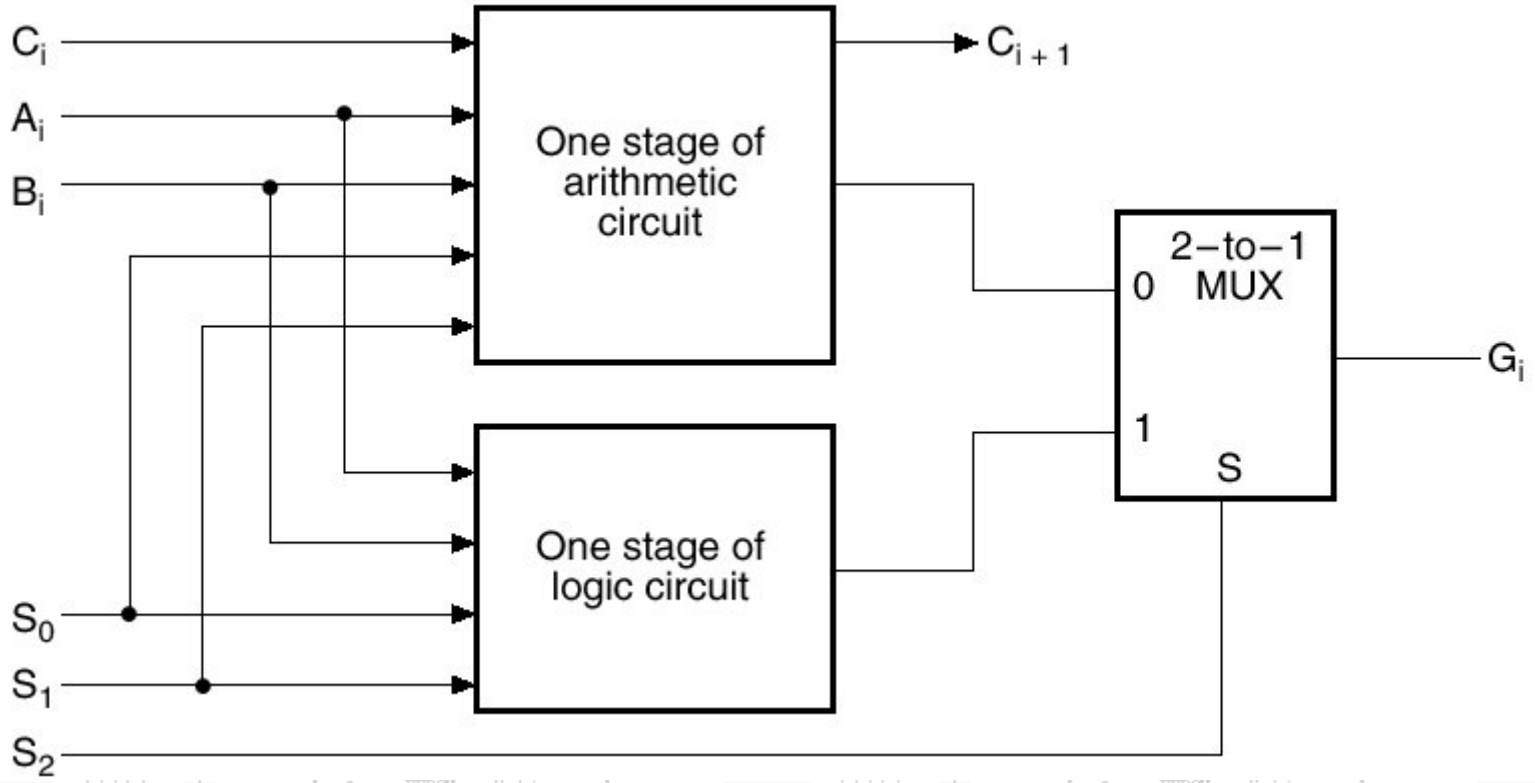


- One bit slice of the logic unit.

CS2022 ALU (Arithmetic/Logic)

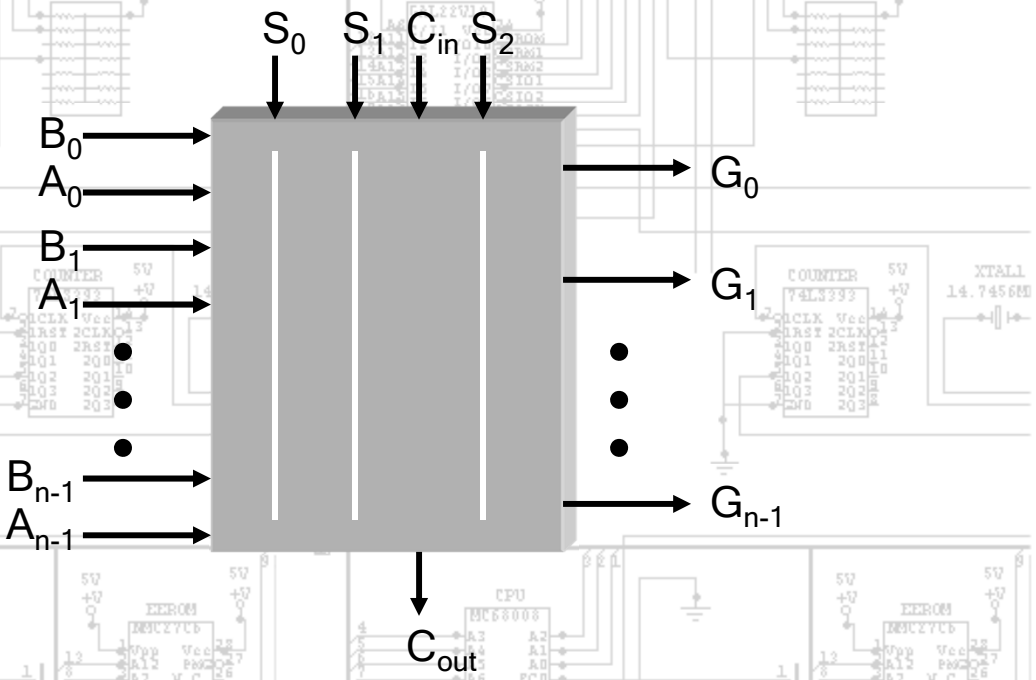
- We next use an additional 2:1 MUX controlled by S_2 to select either the arithmetic output bit or the logic output bit as shown on the next slide.

CS2022 One bit slice ALU



CS2022 N-bit ALU

- To construct an n-bit ALU we concatenate n-bit slices together:



CS2022 Physical Implementation

- Physical schematic of an n-bit ALU assembled from a bit slices as shown on the previous slide.

1. Note the control signals, because they apply to the whole word, tend to cross the datapath.
2. This geometry results in very efficient VLSI chip implementation.

CS2022 Carry-Lookahead Adder

- With a carry-lookahead adder this gives us a fast combinational ALU with the following functionality:

Select				Output	
S_2	S_1	S_0	C_{in}		
0	0	0	0	G = A	TRANSFER
0	0	0	1	G = A + 1	INCREMENT
0	0	1	0	G = A + B	ADD
0	0	1	1	G = A + B +1	ADD WITH C
0	1	0	0	G = A + B	A plus 1's C.B
0	1	0	1	G = A + B +1	SUBTRACT
0	1	1	0	G = A - 1	DECREMENT
0	1	1	1	G = A	TRANSFER
1	0	0	X	G = A $\wedge$ B	AND
1	0	1	X	G = A $\vee$ B	OR
1	1	0	X	G = A $\oplus$ B	XOR
1	1	1	X	G = A	NOT

CS2022 4-Bit SR/SL Shifter Unit

- For speed of execution the shifter unit is always implemented as a combinational circuit based on a MUX: