COS10004 Computer Systems

Lecture 2.1 – More Adders and Programmable Gates

CRICOS provider 00111D

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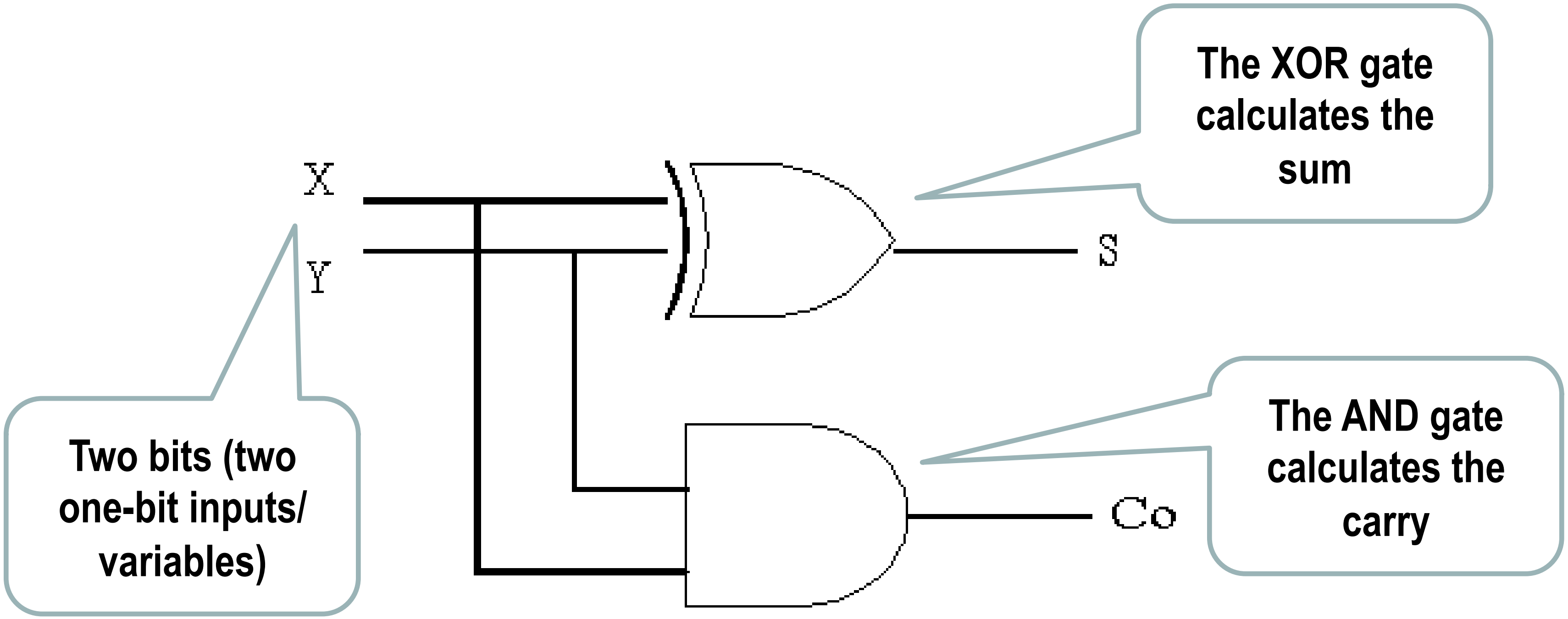
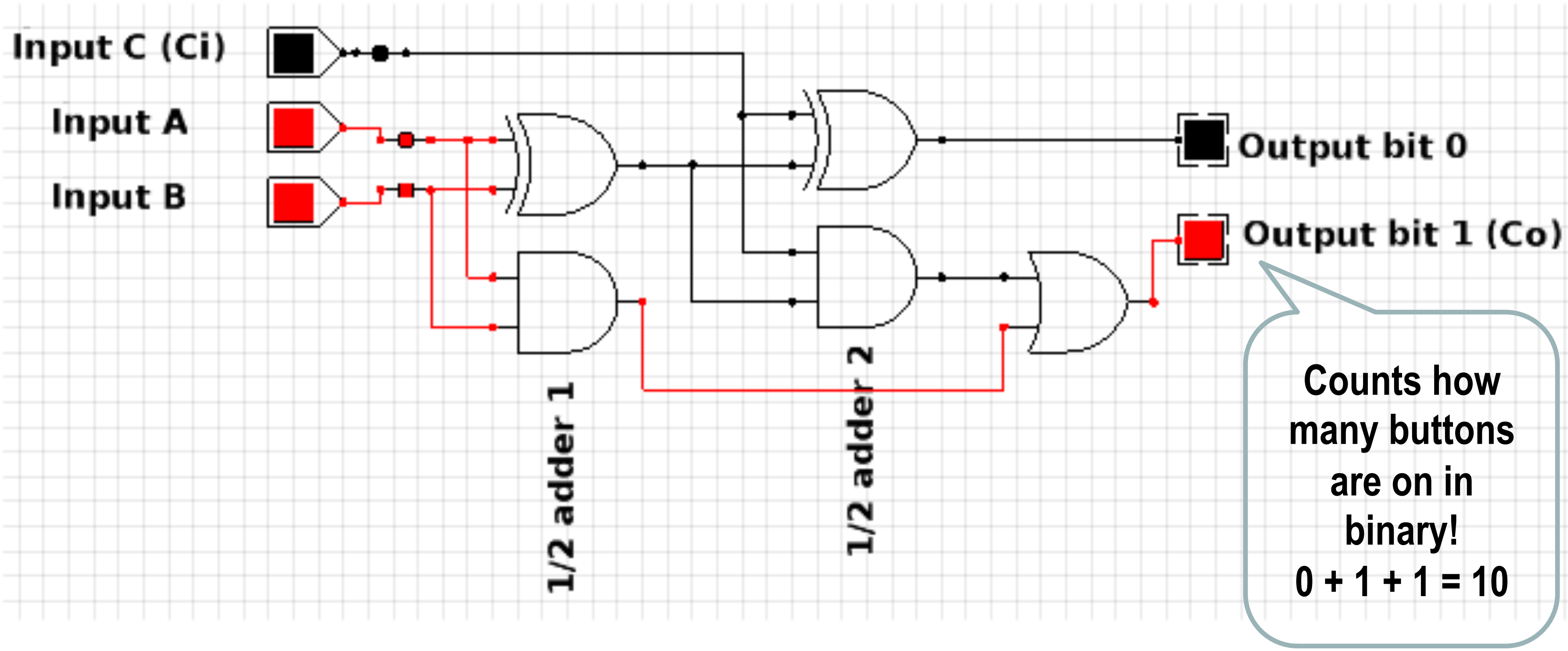
Half-adder



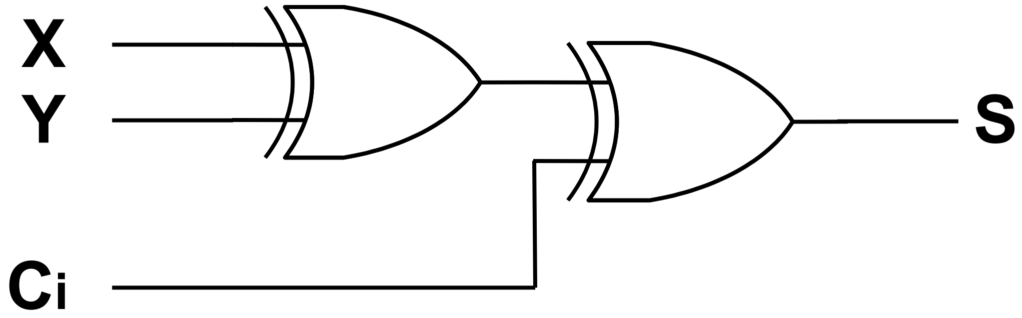
X
Y
S
Co
The XOR gate calculates the sum
The AND gate calculates the carry
Two bits (two one-bit inputs/ variables)

A full adder

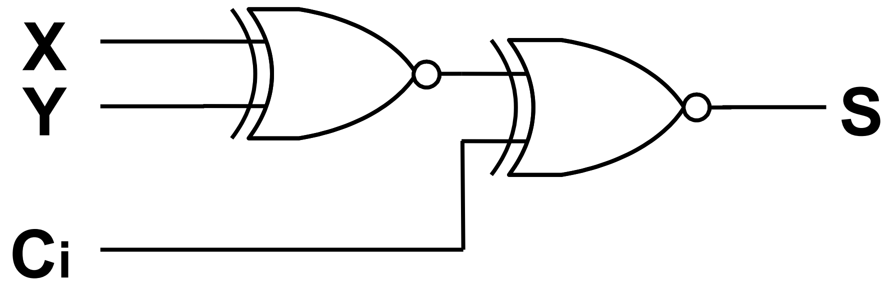
- Made from two half-adders:



Full adder sum only



The following with two XNOR gates also works – check both using the simulator.

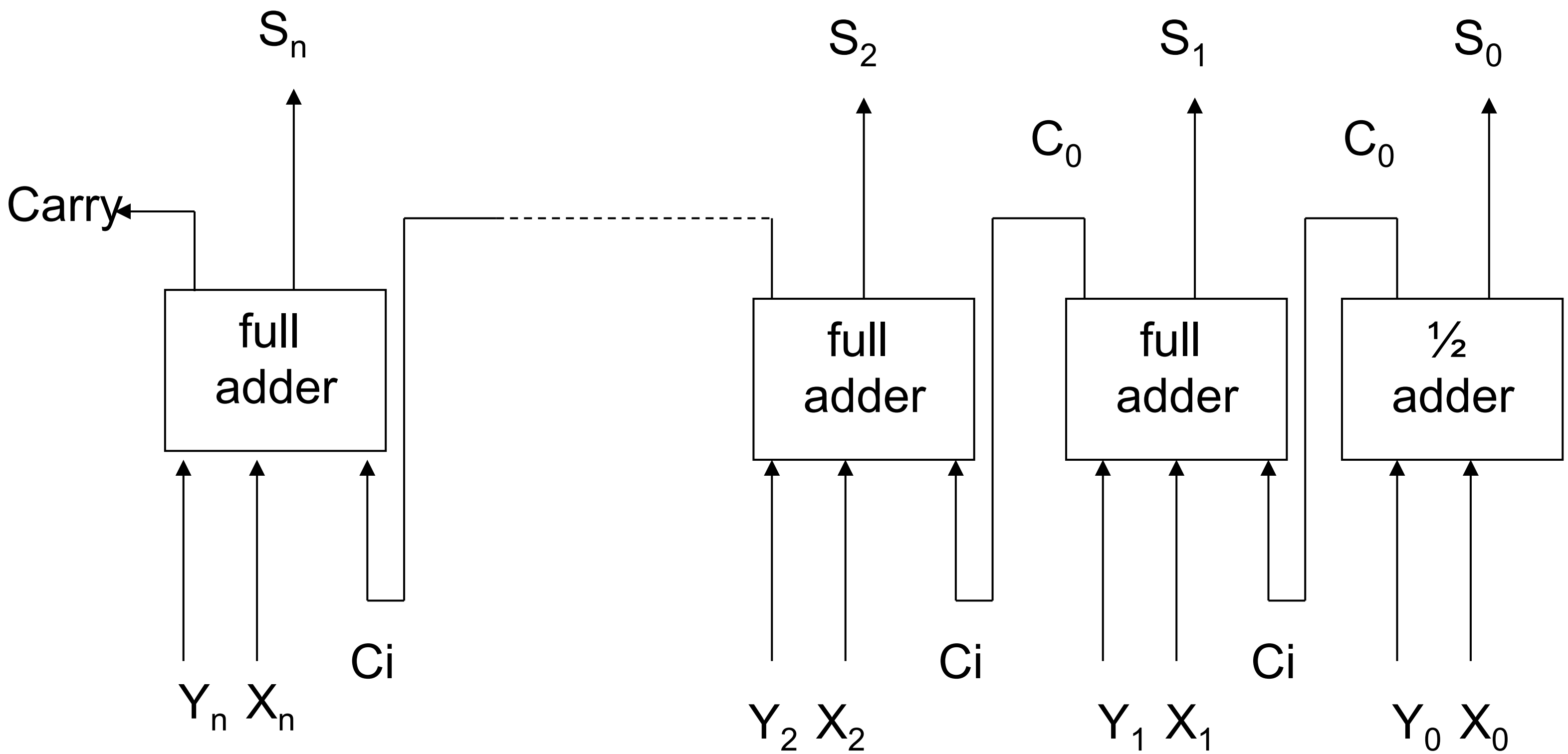


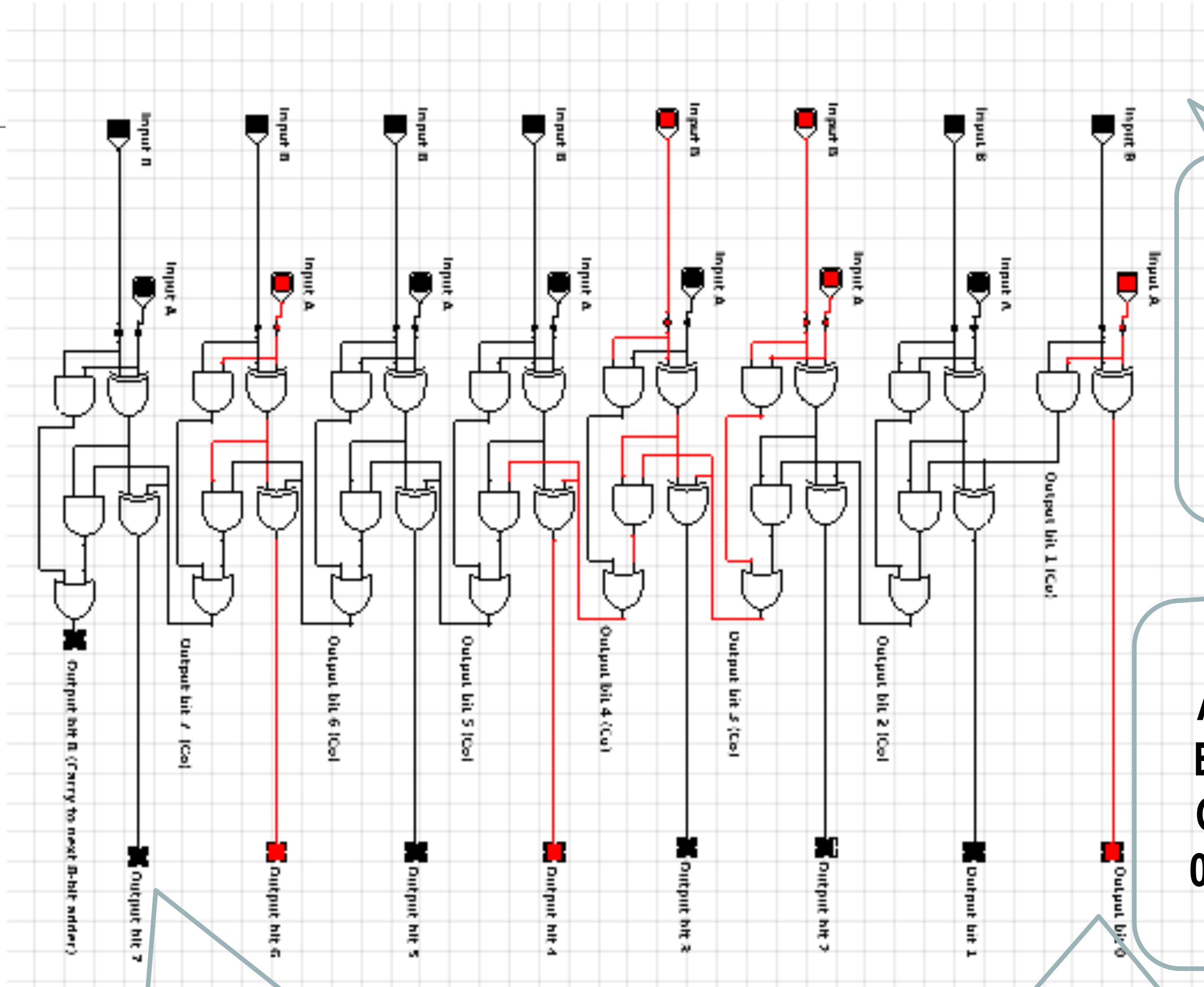
1-BIT FULL ADDER? BUT THAT'S JUST ADDING TWO BITS

To add real numbers together (8 bits, 16, 32...) we need to cascade full adders together.

Use a half adder for the first bits, full adders for the other 7 (15, 31...)

Multi bit addition - combine 8 adders with carry to get 8-bit addition (of two 8-bit numbers).





A = 69
B = 12
Output =
69 + 12 =
81

A = 0x45
B = 0x0C
Output =
0x51 = 81

Most-significant bit (2^7)

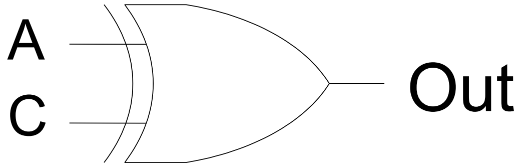
Least-significant bit (2^0)

A BIT MORE ABOUT GATES

Some gates offer useful functionality that is not immediately obvious

Lets look at a couple of examples …

USING XOR AS A CONTROLLED INVERTER



C	A	Out
0	0	0
0	1	1
1	0	1
1	1	0

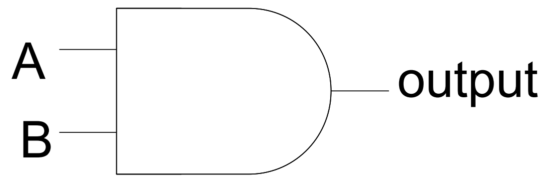
If C=0, output = A

If C= 1, output = $\overline{A}$

It's like turning **on** C enables the inverter (Out= $\overline{A}$)

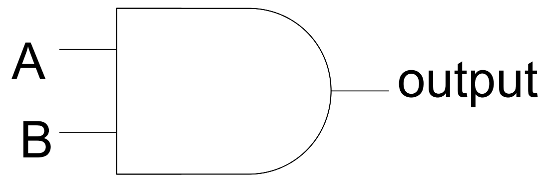
"to invert or not invert..."

AND AS A LOGIC-CONTROLLED SWITCH



A	B	Out
0	0	0
0	1	0
1	0	0
1	1	1

AND AS A LOGIC-CONTROLLED SWITCH



A	B	Out
0	0	0
0	1	0
1	0	0
1	1	1

AND gate as a switch

If A=0, output always 0

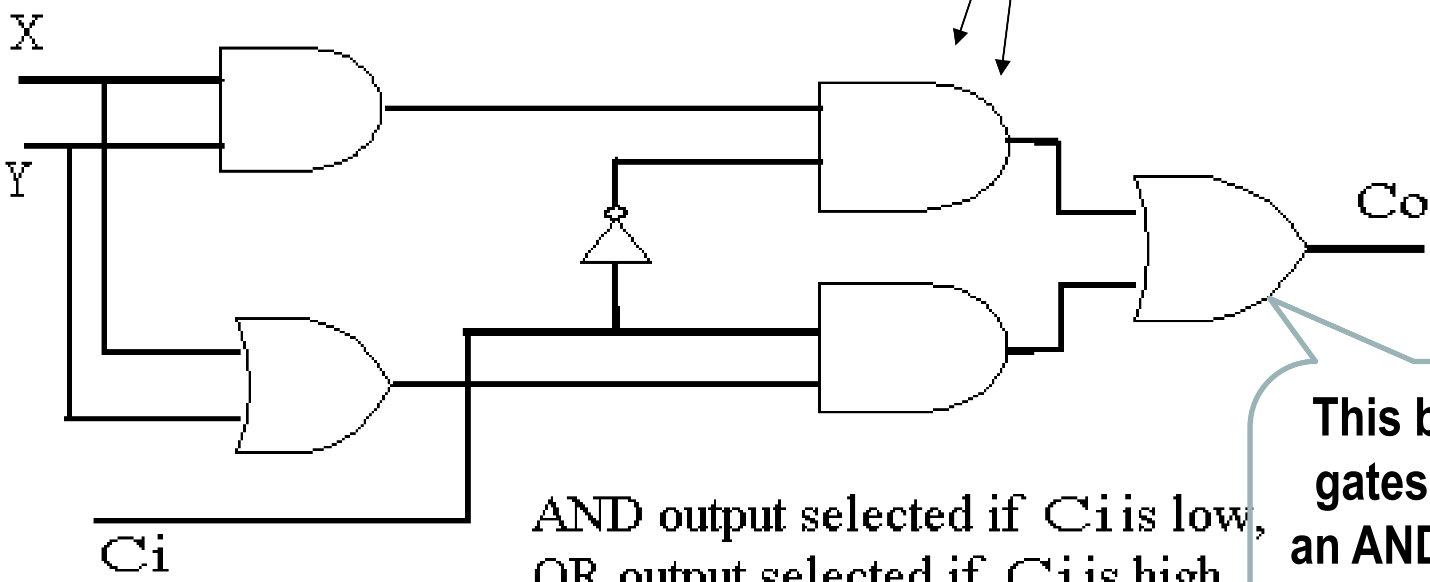
If A=1, output = B

It's like turning on A enables the output being B (O = B)

To pass through B, or not to pass through B ?
…. A is the question.

Choose which circuit forms the output

(two logic controlled switches)



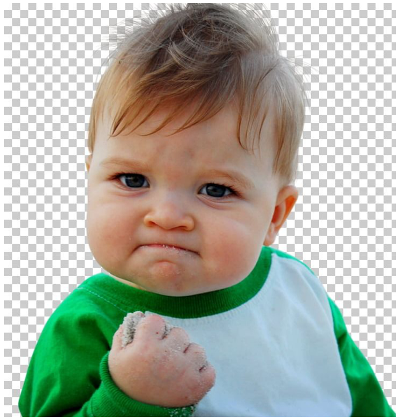
AND output selected if Ci is low,
OR output selected if Ci is high.

This block of gates can be an AND gate or an OR gate depending on Ci

WAIT A MINUTE !

… you're saying we have the capability to <u>Program</u> the behaviour of a block of gates ?

Yep



YES - Programmable Gates!

We can program a gate to be an inverter or a buffer.

We can program a gate to do AND or OR.

SUMMARY

Full Adders can combine to create full scale addition machines

Gates offer programmability using control bits

- this can be very useful for controlling data flow

Next Lecture: Clocks for synchronised.