ECE 2300
Digital Logic & Computer Organization

Fall 2016

Course Overview

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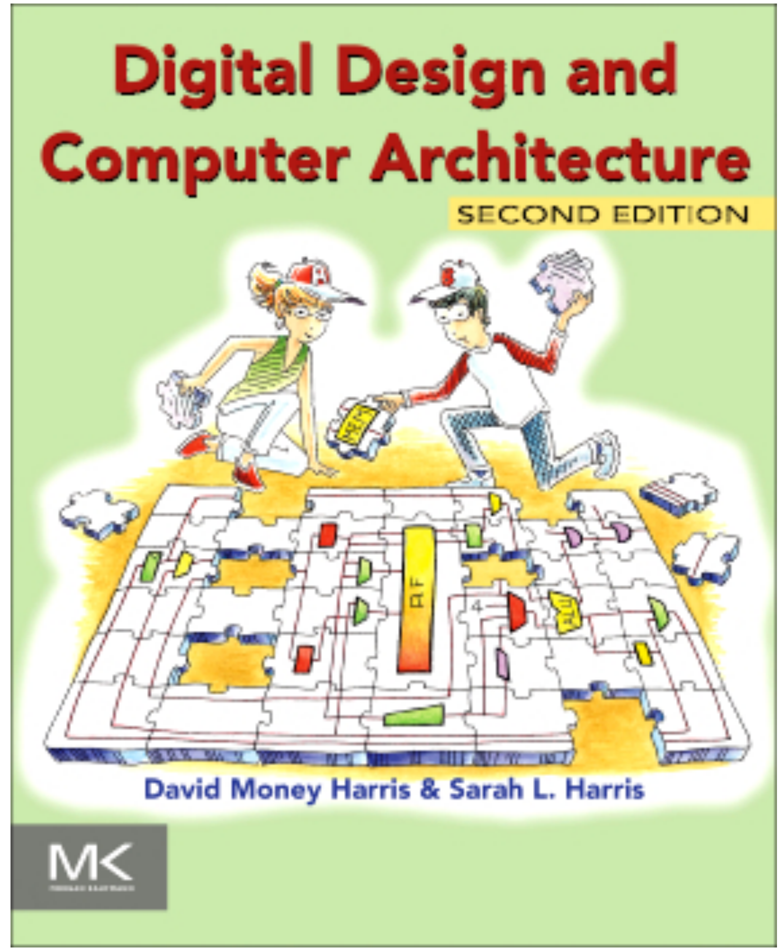
Textbook

- Get 2nd edition
- *Not* the ARM version
- Copies on reserve at Uris
- eBook available
  - Link on Blackboard
  - Up to 10 simultaneous users



Course Content

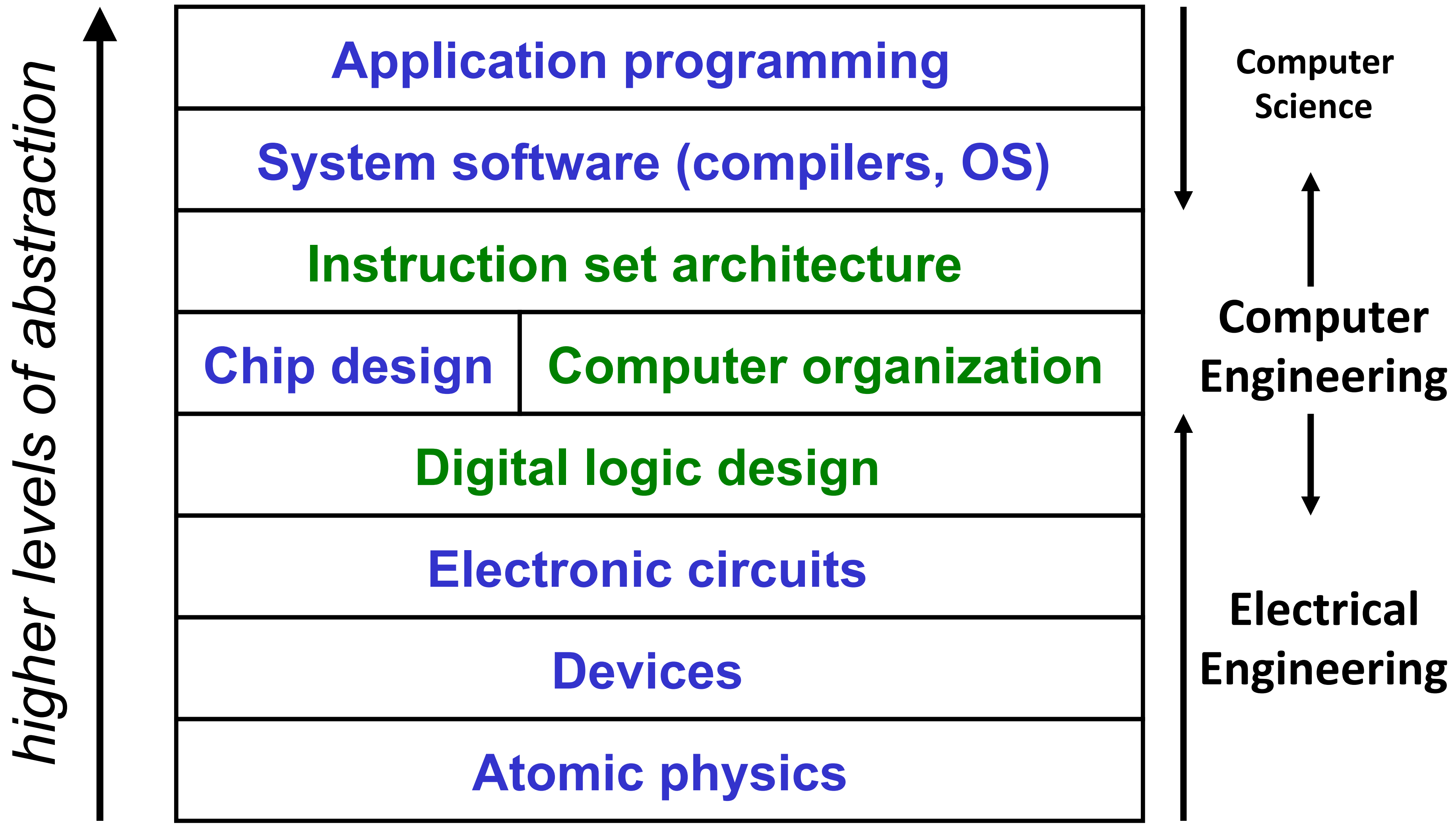
- Binary numbers and logic gates
- Boolean algebra and combinational logic
- Sequential logic and state machines
- Binary arithmetic
- Memories

Digital logic

Computer organization

- Instruction set architecture
- Processor organization
- Caches and virtual memory
- Input/output
- Case studies

Where This Course Sits in the "Stack"



Digital Logic is Everywhere







Societal Impact of Computers

- Communication
- Entertainment
- Productivity
- Personal assistance
- Disease control
- Drug design
- Health management
- Brain science
- Climate science
- Energy
- Astrophysics
- Materials science
- Ocean currents
- Chemical processes
- Weather forecasting
- Nuclear physics
- Oil and gas exploration
- Aircraft design
- Elderly assistance
- Combustion systems
- Fluid dynamics
- Finance
- Environmental research
- Genetics

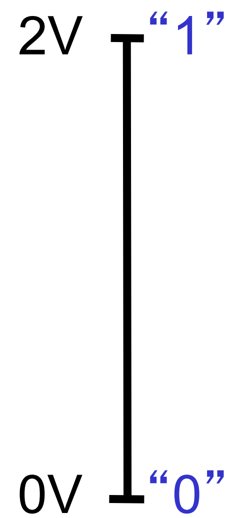
Binary Digital Systems

Digital system
•Finite number of values

Binary (base 2) system
•Uses two states: 0 and 1

- **Basic unit of information: the binary digit, or *bit***
  - **Two values: 0 and 1**

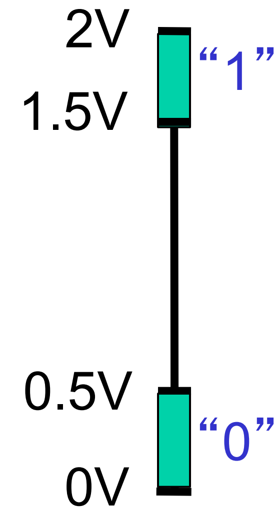
- **0 and 1 represented by voltages**



- **Other options besides voltage, such as light, magnetism, trapped electrons, …**

0 and 1 Don't Have to be Exact

- **0 and 1 represented by voltage ranges *(logic levels)***
- **Electronic circuits don't have to be perfect**
- **Can have some noise and the system still works**



Representing >2 Values

- Use multiple bits

- A collection of 2 bits gives 4 possible values
  - 00, 01, 10, 11

- A collection of 3 bits gives 8 possible values
  - 000, 001, 010, 011, 100, 101, 110, 111

- A collection of n bits gives 2^n possible values

Positional Number Representation

- **Recall positional notation for decimal numbers**

$$\underset{10^2\ \ 10^1\ \ 10^0}{329}$$

base 10
(decimal)

3x100 + 2x10 + 9x1 = 329

- **Similar positional system for binary**

$$\underset{2^2\ \ 2^1\ \ 2^0}{101}$$

base 2
(binary)

1x4 + 0x2 + 1x1 = 5

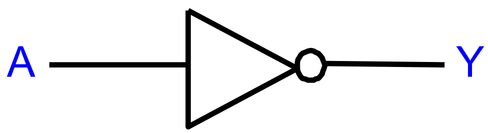
Positional Number Representation

- **An n-bit binary number represents 2^n values**
  - **From decimal 0 to 2^n-1**

2^2	2^1	2^0	decimal value
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

Logic Gates

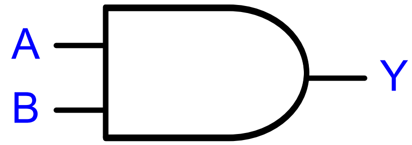
- **Take one or more binary inputs and produce a binary output**



NOT Gate

NOT X, /X, $\overline{X}$, X'

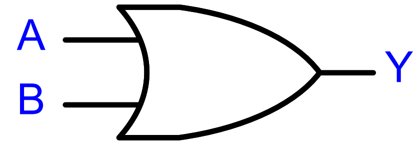
A	Y
0	1
1	0



AND Gate

A AND B, A•B

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1



OR Gate

A OR B, A+B

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

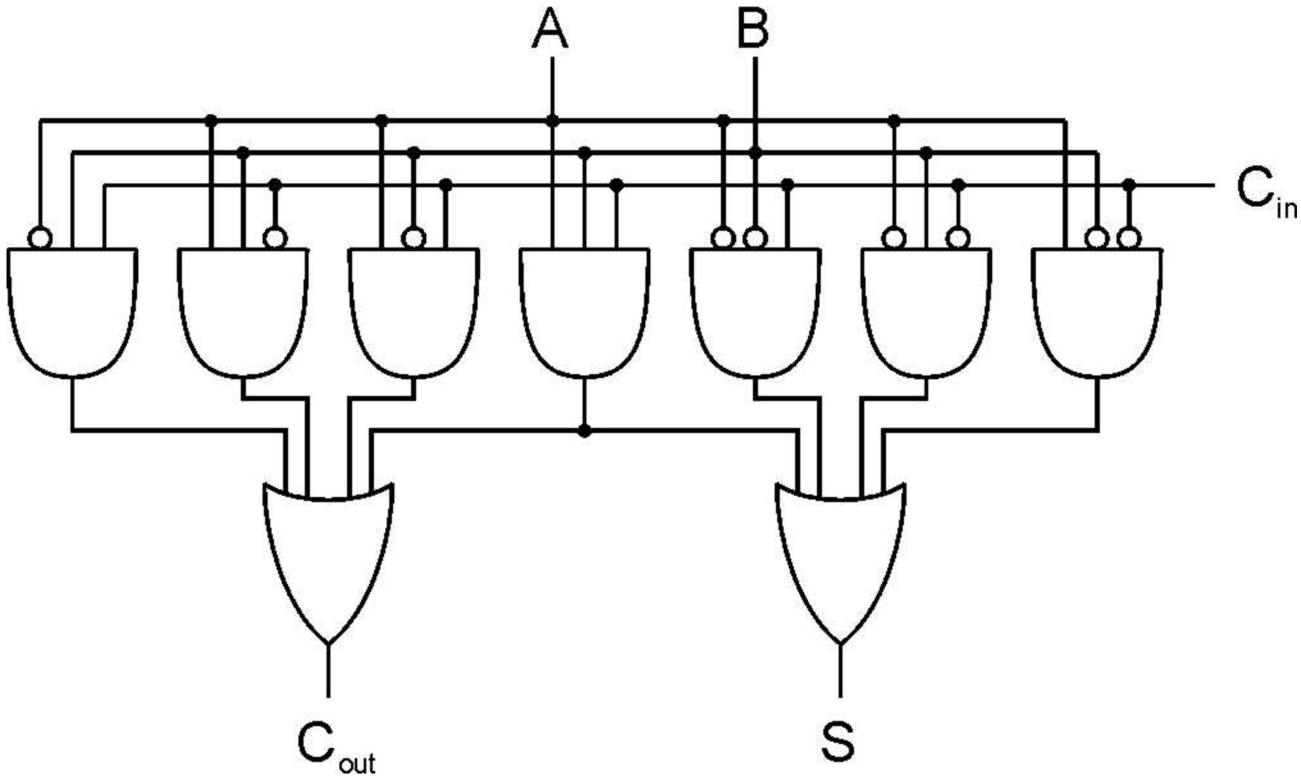
Larger Gates

- AND/OR can take any number of inputs
  - AND = 1 if all inputs are 1
  - OR = 1 if any input is 1

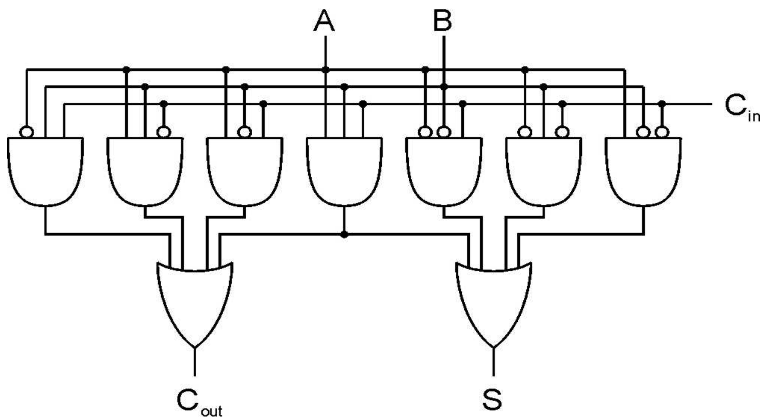
Can Use to Build a 1-bit Adder…

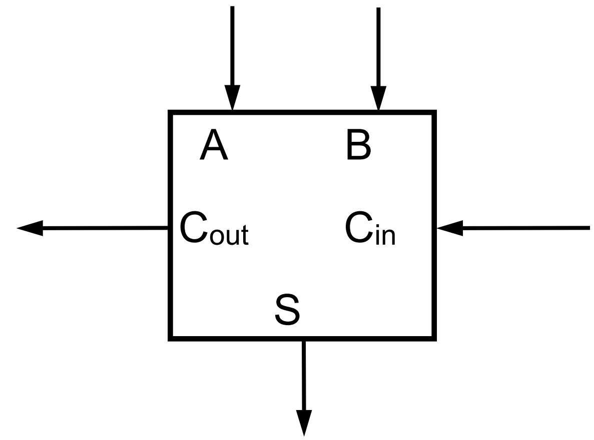
- **Inputs: A, B and C_{in} (carry-in)**
- **Outputs: S (sum) and C_{out} (carry-out)**

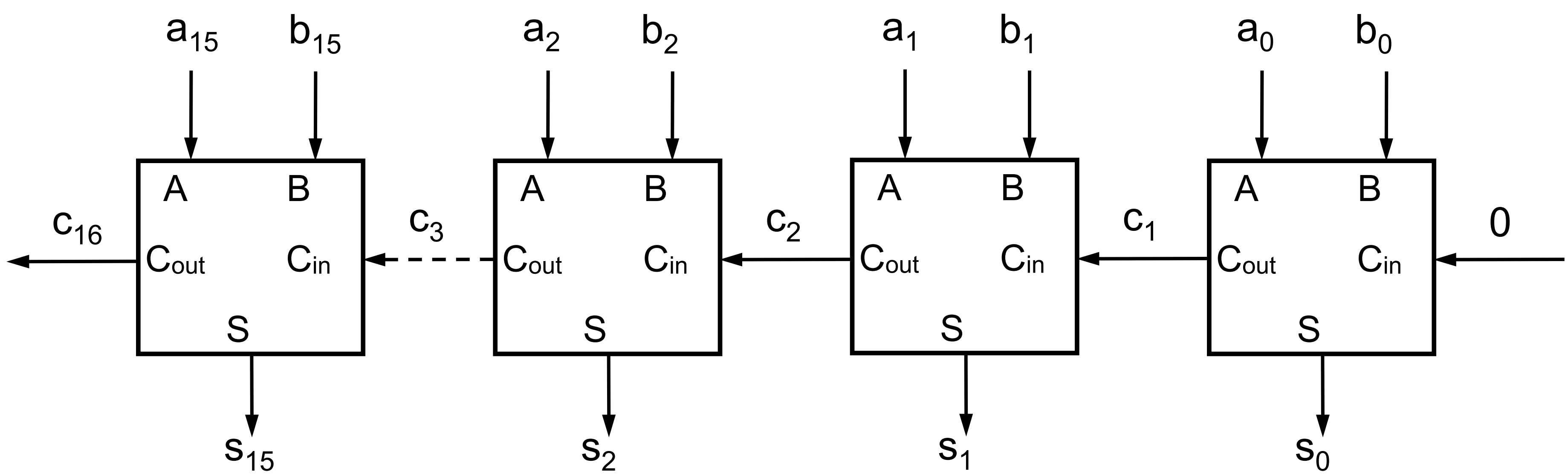
A	B	C_{in}	S	C_{out}
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1



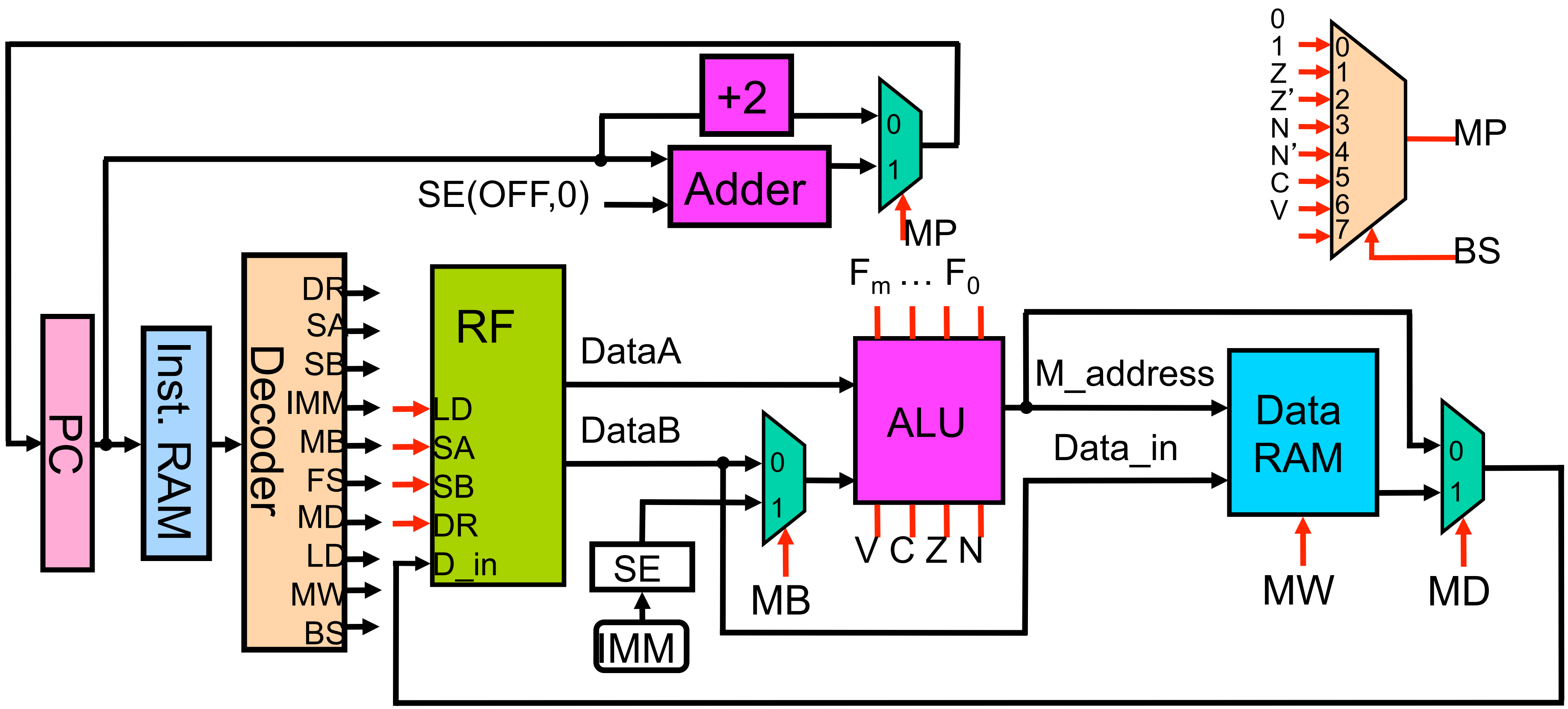
A Larger Adder…



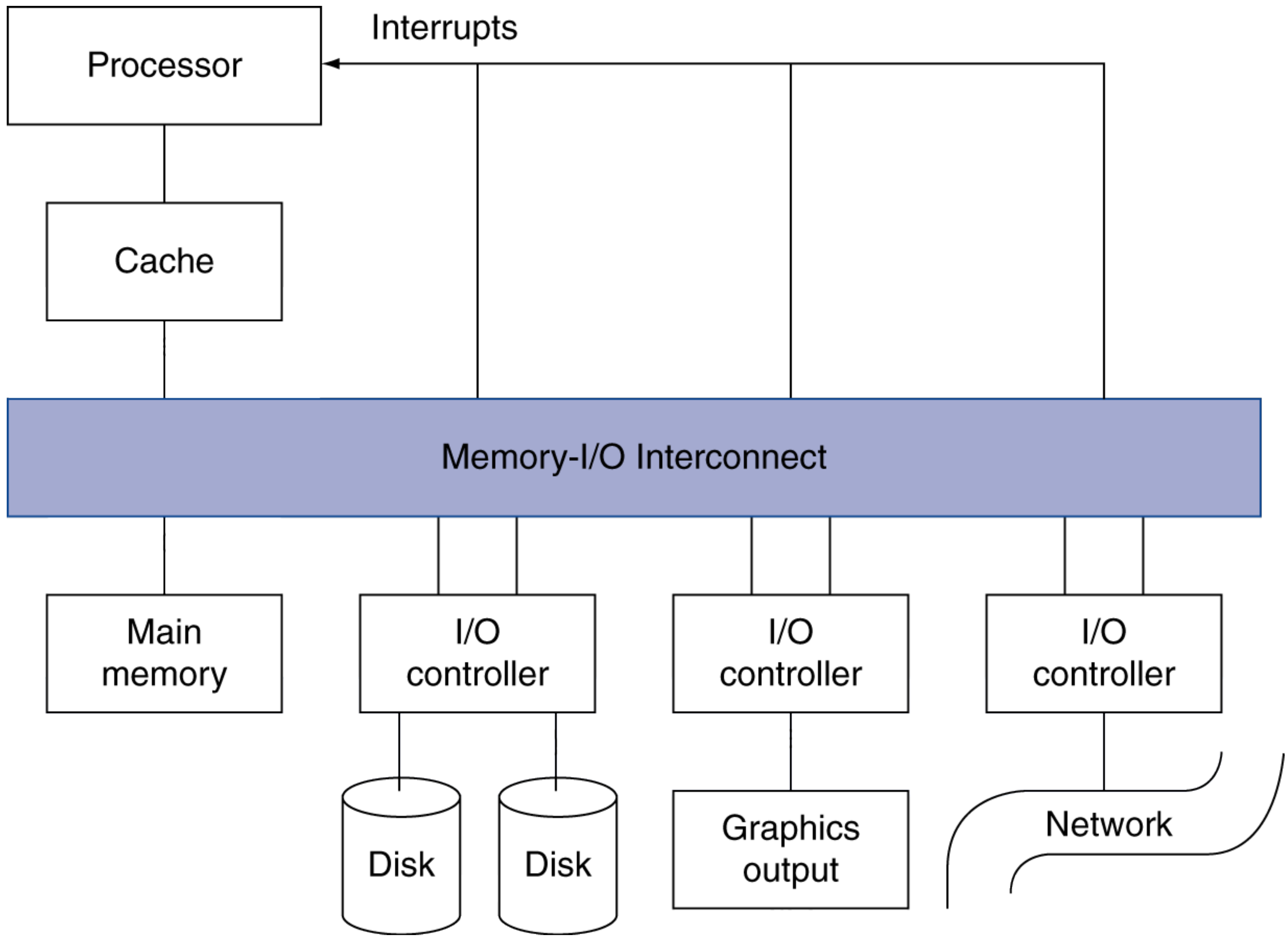




A Programmable Processor…



A Complete Computer



Before Next Class

- H&H 1.1-1.4.2, 1.5-1.6.2, 2.1-2.3

Next Time

Switching Algebra