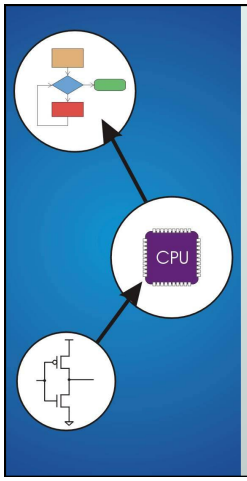
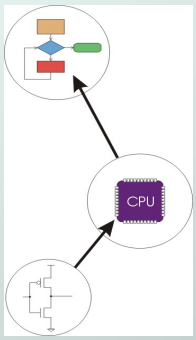


Chapter 3
Digital Logic Structures

Original slides from Gregory Byrd, North Carolina State University

Modified slides by Chris Wilcox, Colorado State University

Computing Layers



Problems

Algorithms

Language

Instruction Set Architecture

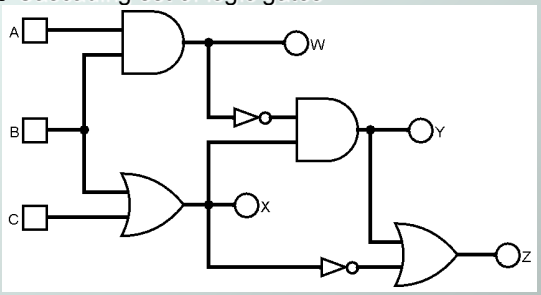
Microarchitecture

Circuits

Devices

Combinatorial Logic

- Cascading set of logic gates



What is the truth table?

Truth Table (from circuit)

- Truth table for circuit on previous slide

A	B	C	W	X	Y	Z
0	0	0	0	0	0	1
0	0	1	0	1	1	1
0	1	0	0	1	1	1
0	1	1	0	1	1	1
1	0	0	0	0	0	1
1	0	1	0	1	1	1
1	1	0	1	1	0	0
1	1	1	1	1	0	0

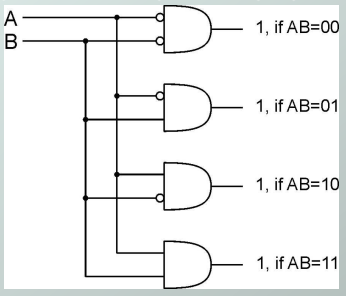
Logisim Simulator

- Logic simulator: allows interactive design and layout of circuits with AND, OR, and NOT gates
- Simulator web page (linked on class web page)
  http://ozark.hendrix.edu/~burch/logisi
- Overview, tutorial, downloads, etc.
- Windows or Linux operating systems
- Logisim demonstration

Decoder

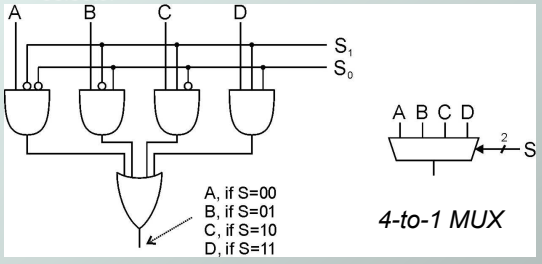
- *n* inputs, 2^n outputs
  - exactly one output is 1 for each possible input pattern

2-bit decoder



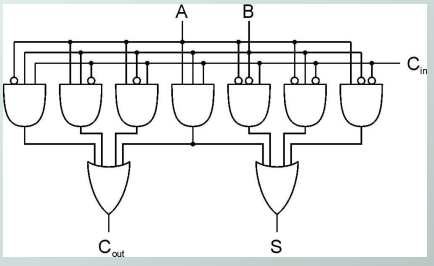
Multiplexer (MUX)

- *n*-bit selector and 2^n inputs, one output
  - output equals one of the inputs, depending on selector



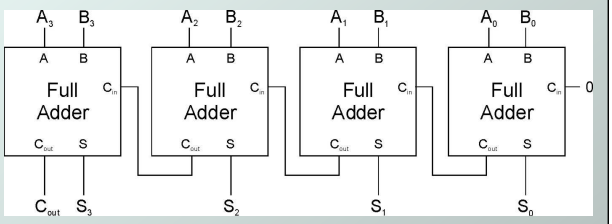
Full Adder

- Add two bits and carry-in, produce one-bit sum and 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

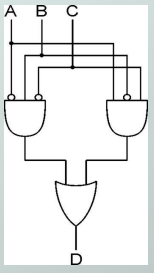
Four-bit Adder



Logical Completeness

- Can implement ANY truth table with combo of AND, OR, NOT gates.

A	B	C	D
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0



1. AND combinations that yield a "1" in the truth table.
2. OR the results of the AND gates.

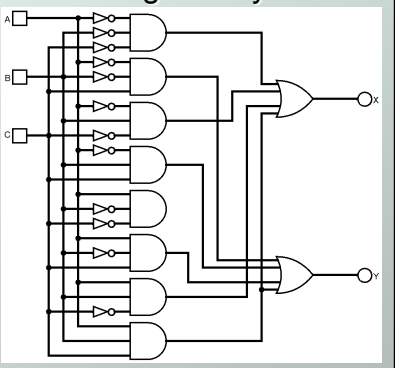
Truth Table (to circuit)

- How do we design a circuit for this?

A	B	C	X	Y
0	0	0	1	0
0	0	1	0	1
0	1	0	1	0
0	1	1	0	1
1	0	0	0	0
1	0	1	0	1
1	1	0	1	0
1	1	1	1	1

Programmable Logic Array

- Front end is a input decode
- Back end selects outputs
- Not necessarily minimal circuit!
- Logic arrays are prebuilt



Looking Ahead: C Structures

- Useful for data structures

```
struct student
{
    char *lastName;
    char *firstName;
    Date birthDate;
    …
};
struct student s;
s.lastname = (char *)malloc(80);
strcpy(s.lastname, "Smith");
```


Looking Ahead: Dynamic Memory

- Static versus dynamic memory allocation:

```
// static allocation
char name[80];
strcpy(name, "Smith");
printf("Name: %s\n", name);
// dynamic allocation
char *name = (char *)malloc(80);
strcpy(name, "Smith");
printf("Name: %s\n", name);
free(name);
```


Looking Ahead: String Tokens

- How to extract tokens from a string:

```
char *token = strtok(string, " \t");
while (token != null)
{
  tokens[numTokens] = (char *)
        malloc(strlen(token)+1);
  strcpy(tokens[numTokens], token);
  token = strtok(NULL, " \t");
  numTokens++;
}
```