Chapter 3
Digital Logic Structures

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Computing Layers

Problems
Algorithms
Language
Instruction Set Architecture
Microarchitecture
Circuits
Devices

Combinational Logic

Cascading set of logic gates

What is the truth table?

Truth Table (from circuit)

Truth table for circuit on previous slide
Logisim Simulator

- Logic simulator: allows interactive design and layout of circuits with AND, OR, and NOT gates
- 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

Decoder diagram:

```
A
B
1, if AB=00
1, if AB=01
1, if AB=10
1, if AB=11
```

2-bit decoder

```
A
B
C
D
S
```

Multiplexer (MUX)

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

4-to-1 MUX

```
A
B
C
D
S
```

```
A
B
C
D
S
```

```
A
B
C
D
S
```

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
```
Logical Completeness

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

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
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</table>

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

Programmable Logic Array

- Front end reacts to specific inputs
- Back end defines the outputs
- Any truth table can be built
- Not necessarily minimal circuit!

Requires (at least) ten gates.