5DV008
Computer Architecture
Umeå University
Department of Computing Science

Stephen J. Hegner

Topic 3aux: Logic Design

A Ridiculously Brief Overview of Combinational Logic Design

- These slides provide a brief overview of combinational logic.

- They are limited to the ideas absolutely needed for the course.

- For a more detailed presentation consult Appendix C on the CD which comes with the course text.

Types of Logic Circuits

- *Combinational logic* is used to realize memoryless functions.

- *Sequential logic* is used to realize functions which have an internal state.

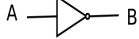- These slides focus upon combinational logic.

Basic Gates

The AND gate

A
B ──── C

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

The OR gate

A
B ──── C

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

The Inverter

A ──▷○── B

A	B
0	1
1	0

The Buffer

A ──▷── B

A	B
0	0
1	1

5DV008 t3:aux sl:4 2009-11-18

Hegner UU

Further Gates

The NAND gate

A
B ──── C

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

The NOR gate

A
B ──── C

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

The XOR gate

A
B ──── C

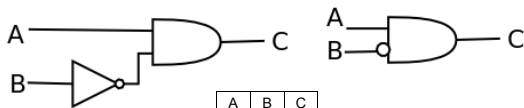| A	B	C
0	0	0
0	1	1
1	0	1
1	1	0

5DV008 t3:aux sl:5 2009-11-18

Hegner UU

Compact Representation of Negation

- Negation may be represented as a circle on another gate.
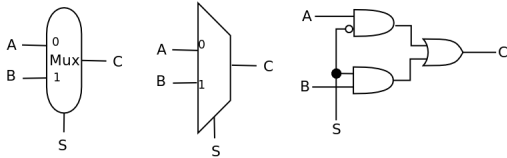- The following two circuits are equivalent.

A
B ──── C

A
B ──── C

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

5DV008 t3:aux sl:6 2009-11-18

Hegner UU

The Multiplexer

- A *multiplexer* selects between two (or more) inputs.
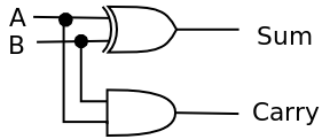- S is the *select line*.
- Shown is a two-input multiplexer.

Hegner UU

A One-Bit Half Adder

A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Hegner UU

A One-Bit Full Adder

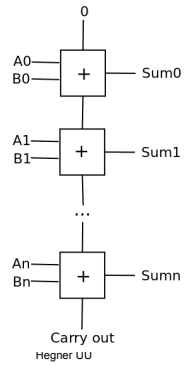| A	B	C_{in}	S	C_{at}
0	0	0	0	0
0	1	0	1	0
1	0	0	1	0
1	1	0	0	1
0	0	1	1	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	1
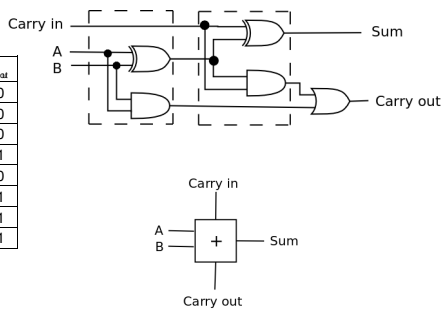
Hegner UU

A Sequential Adder

- An n-bit sequential adder may be realized by gluing n one-bit adders together.
- This is not the best design because the *critical path* is proportional to n.


```
            0
  A0 ─┐   ┌───┐
  B0 ─┤ + │   ├─── Sum0
       └───┘
  A1 ─┐   ┌───┐
  B1 ─┤ + │   ├─── Sum1
       └───┘
           ...
  An ─┐   ┌───┐
  Bn ─┤ + │   ├─── Sumn
       └───┘
       Carry out
```

5DV008 t3:aux sl:10 2009-11-18

Hegner UU