Digital Design and Computer Organization

Muxes, Decoders, Shifters - 3

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Department of Computer Science and Engineering

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Course Outline

- Digital Design
  - Combinational logic design
    - **Muxes, Decoders, Shifters - 3**
  - Sequential logic design
- Computer Organization
  - Architecture (microprocessor instruction set)
  - Microarchitecure (microprocessor operation)

Concepts covered

- Barrel shifter

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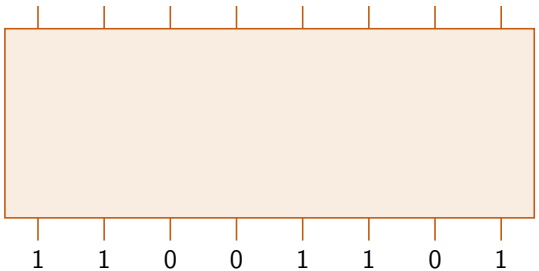
Shift Operation

- Logic circuit to left shift an 8-bit number:



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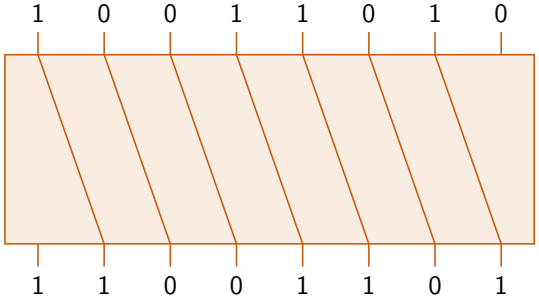

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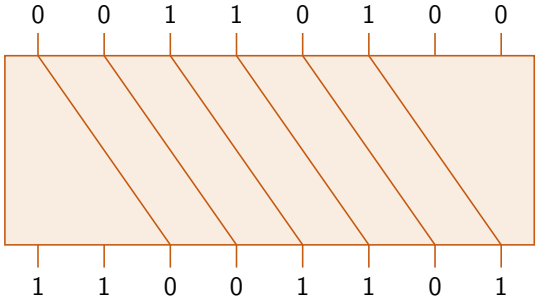

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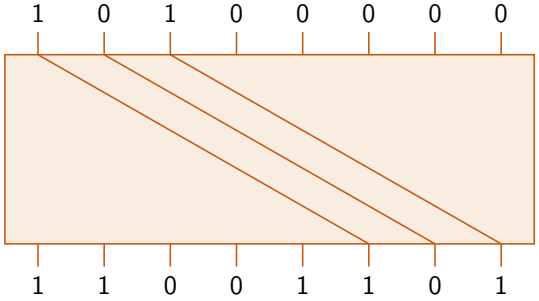

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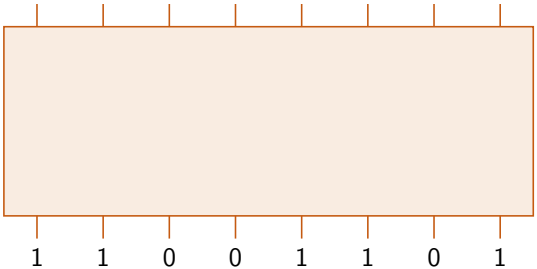

- Shift amount can range from 0 to 7

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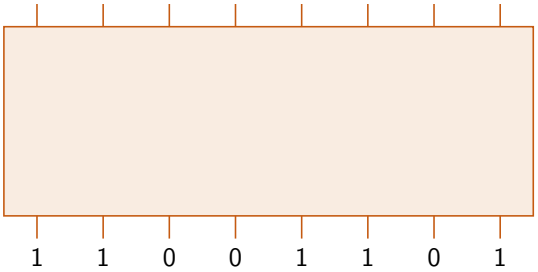

s_2	s_1	s_0	Shift by
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

- Shift amount can range from 0 to 7

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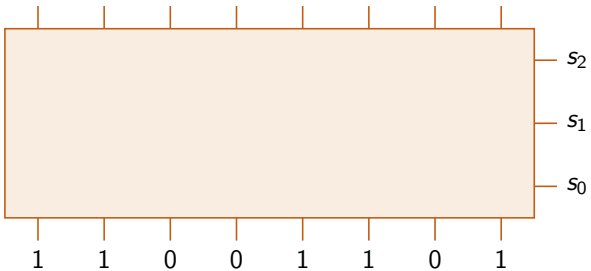

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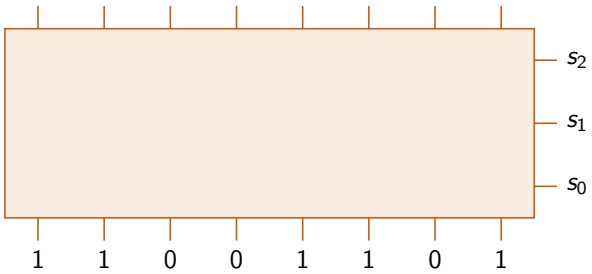

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1	0	1	5
1	1	0	6
1	1	1	7

Bit	0	1
s_0	shift by 0	shift by 1
s_1	shift by 0	shift by 2
s_2	shift by 0	shift by 4

- Shift amount can range from 0 to 7

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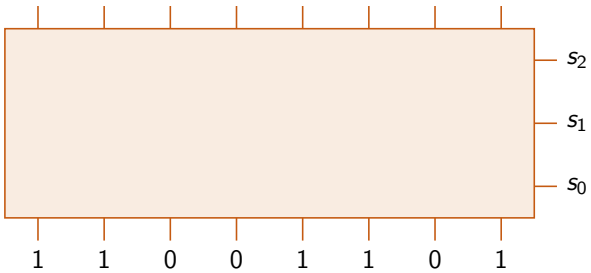
Shift Operation

- Logic circuit to left shift an 8-bit number:



- Shift amount can range from 0 to 7

s_2	s_1	s_0	Shift by
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

Bit	0	1
s_0	shift by 0	shift by 1
s_1	shift by 0	shift by 2
s_2	shift by 0	shift by 4

- So shifting can be divided into three stages which shift by 1, 2 and 4

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Barrel Shifter for $N = 8$

Let the three control inputs be s_2, s_1 and s_0. When $s_2s_1s_0 = 000$ there is no shift. When $s_2s_1s_0 = 111$ there is left shift by 7 positions, with zeores being inserted on the right

- When $s_2s_1s_0 = 101$ then:
  - Because $s_2 = 1$ shift by 4
  - Because $s_1 = 0$ shift by 0
  - Because $s_0 = 1$ shift by 1
- So in general, shift in three stages:
  - If $s_2 = 1$ shift by 4 else if $s_2 = 0$ shift by 0
  - If $s_1 = 1$ shift by 2 else if $s_1 = 0$ shift by 0
  - If $s_0 = 1$ shift by 1 else if $s_9 = 0$ shift by 0

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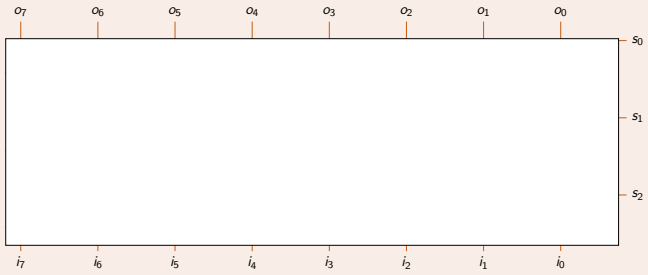
Barrel Shifter Structure



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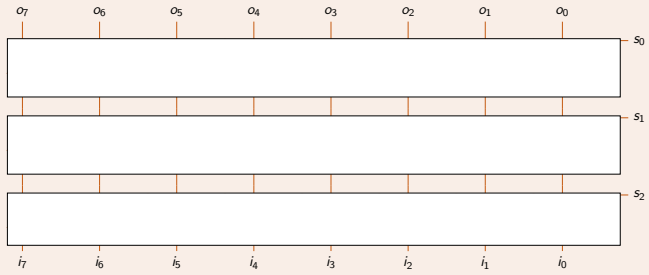

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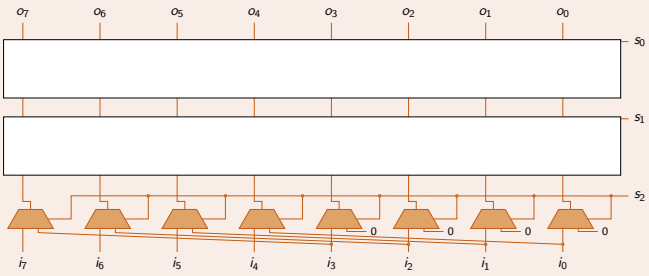

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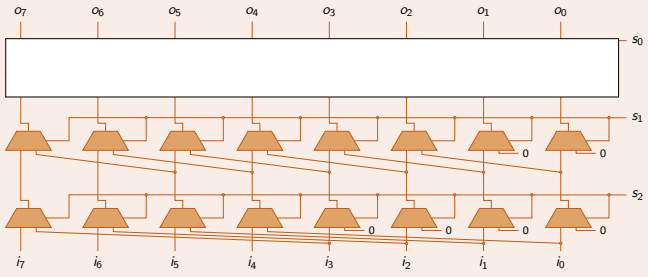

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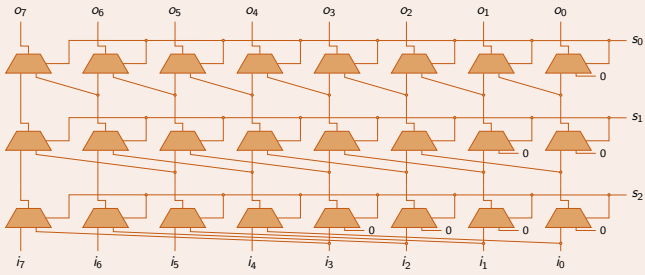

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Barrel Shifter of Size n

- A barrel shifter with a bitwidth of n,
  - Number of data inputs is n
  - Number of data outputs is n
  - Shift amout ranges from 0 to $n - 1$
  - Number of control inputs is $\lceil \log_2 n \rceil$

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Think About It

- Consider a left barrel shifter of size $n = 4$
  - How many 2:1 muxes does it contain?
  - Draw its logic circuit
  - Draw the logic circuit of right barrel shifter