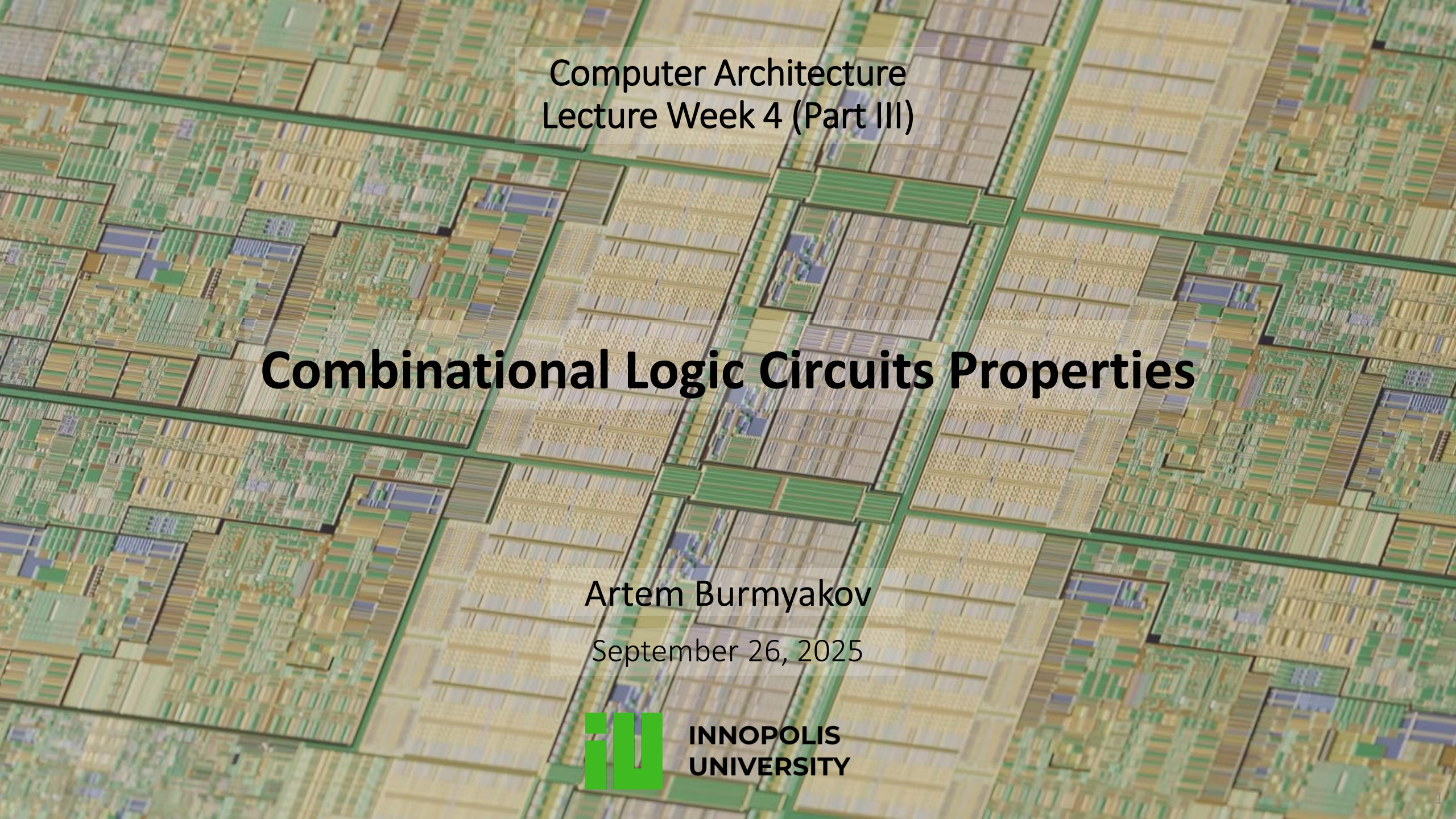


The background of the slide is a high-resolution, colorized microchip die. It shows a complex grid of rectangular blocks in various colors (yellow, green, blue, brown) representing different functional blocks and interconnects. The layout is dense and symmetrical, typical of modern integrated circuits.

Computer Architecture
Lecture Week 4 (Part III)

Combinational Logic Circuits Properties

Artem Burmyakov

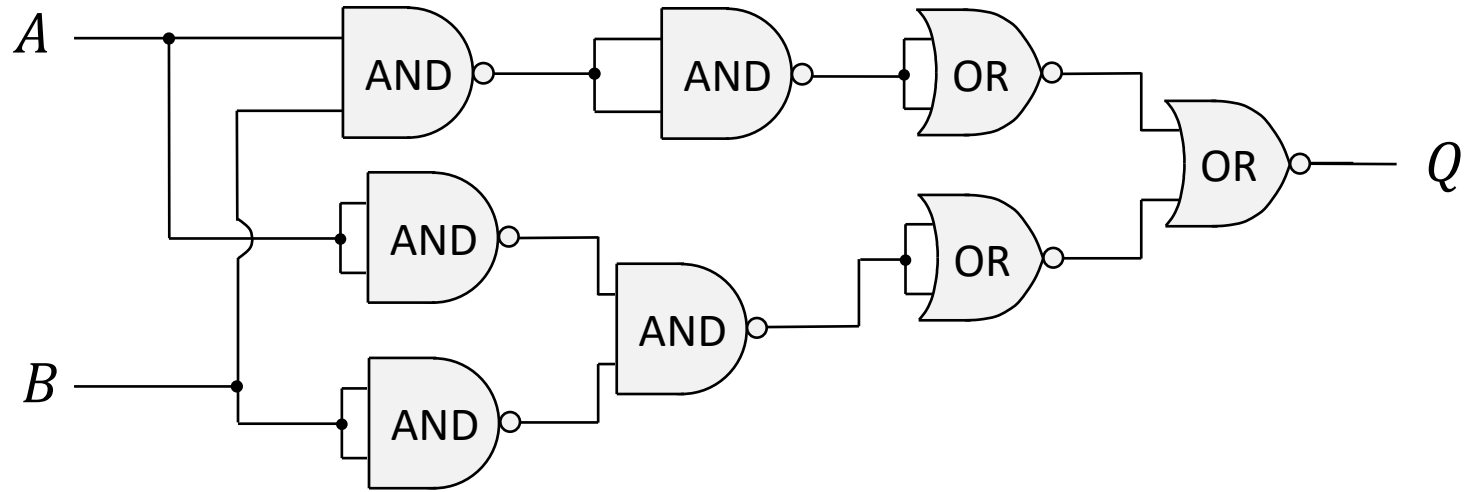
September 26, 2025



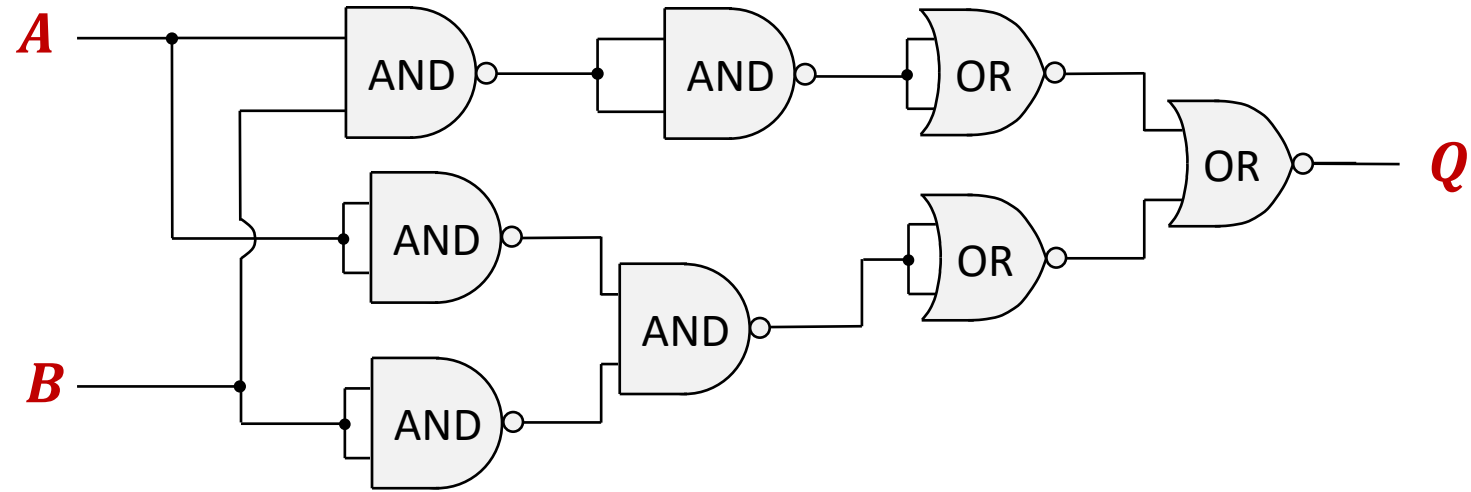
INNOPOLIS
UNIVERSITY

Recap: Characteristics of Combinational Logic Circuits

**Sample combinational
logic circuit:**

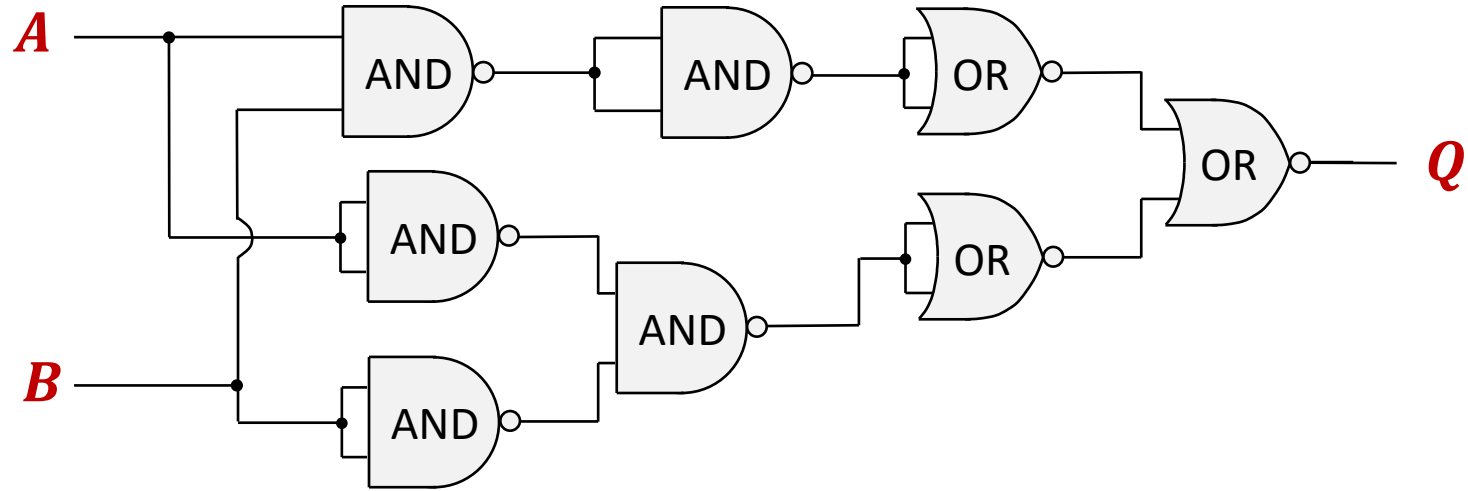


Recap: Characteristics of Combinational Logic Circuits



- 1) An output signal depends just on “current” input signals

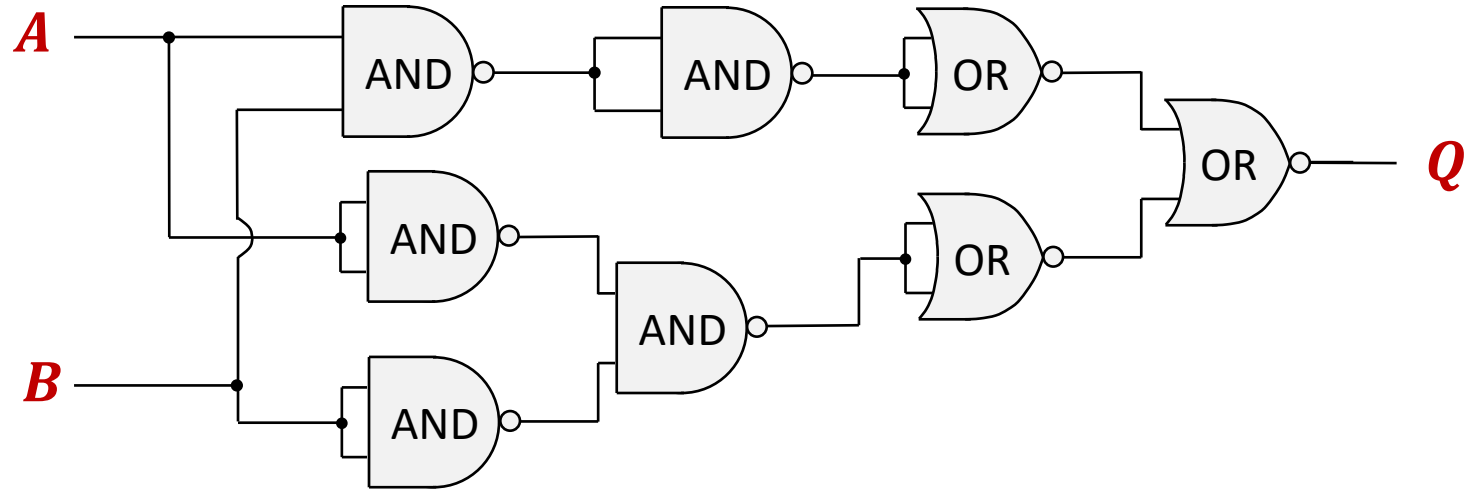
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- 1) An output signal depends just on “current” input signals

“Combinational circuit” = combine inputs and get the output

Recap: Characteristics of Combinational Logic Circuits

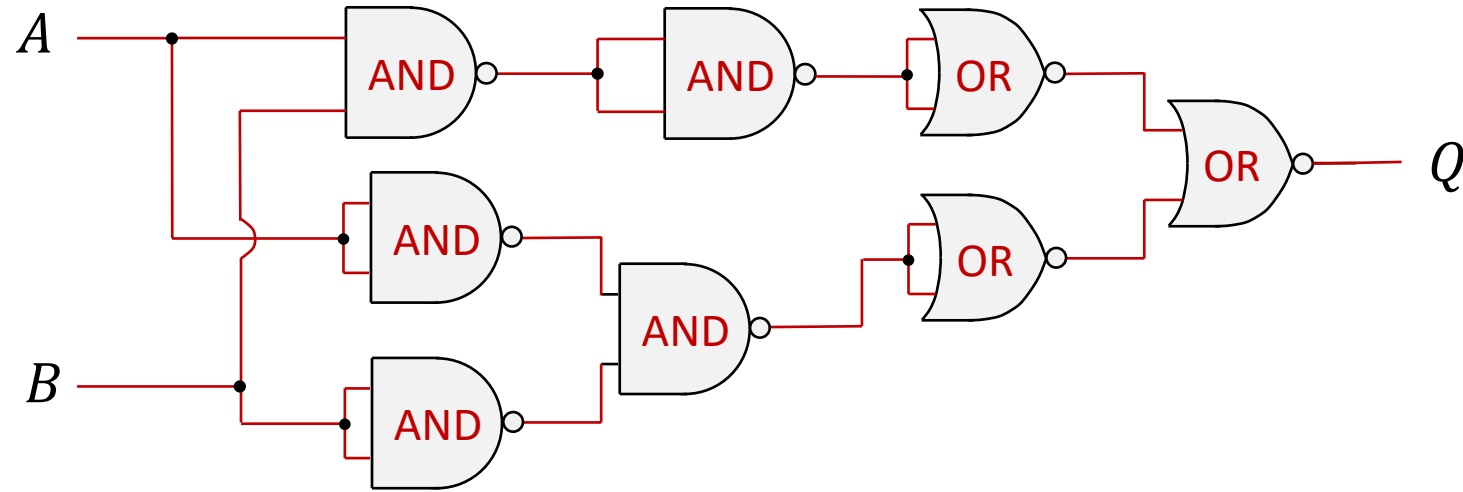


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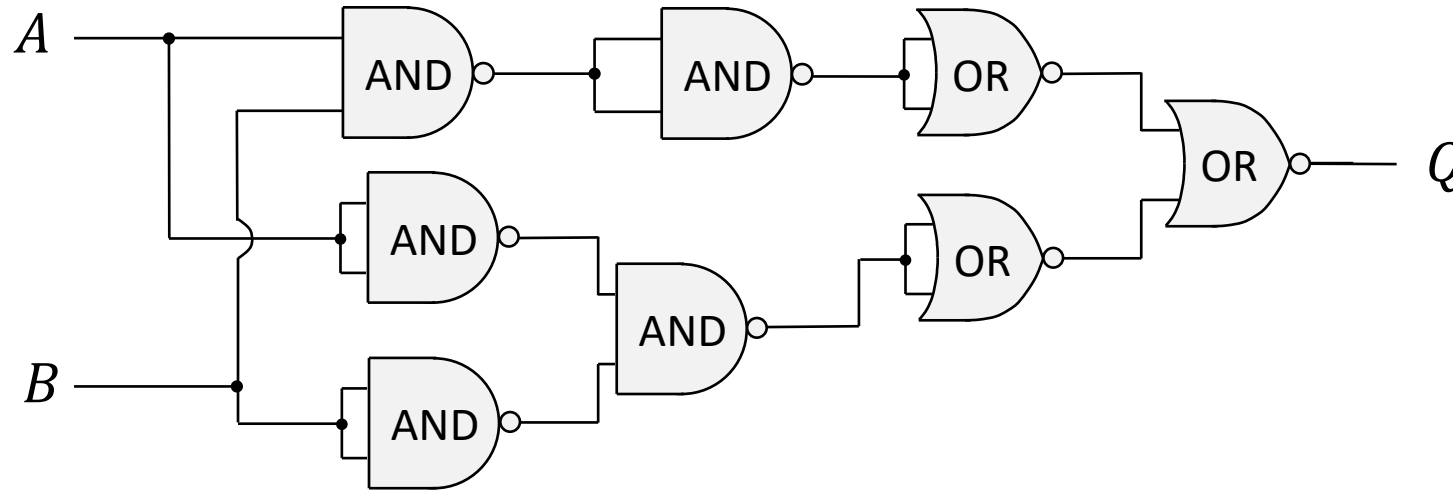
There is no dependency on previous signals or computation results

Recap: Characteristics of Combinational Logic Circuits



- 1) An output signal depends just on “current” input signals
- 2) Comprised of logic gates, such as AND, OR, etc., and wires connecting them

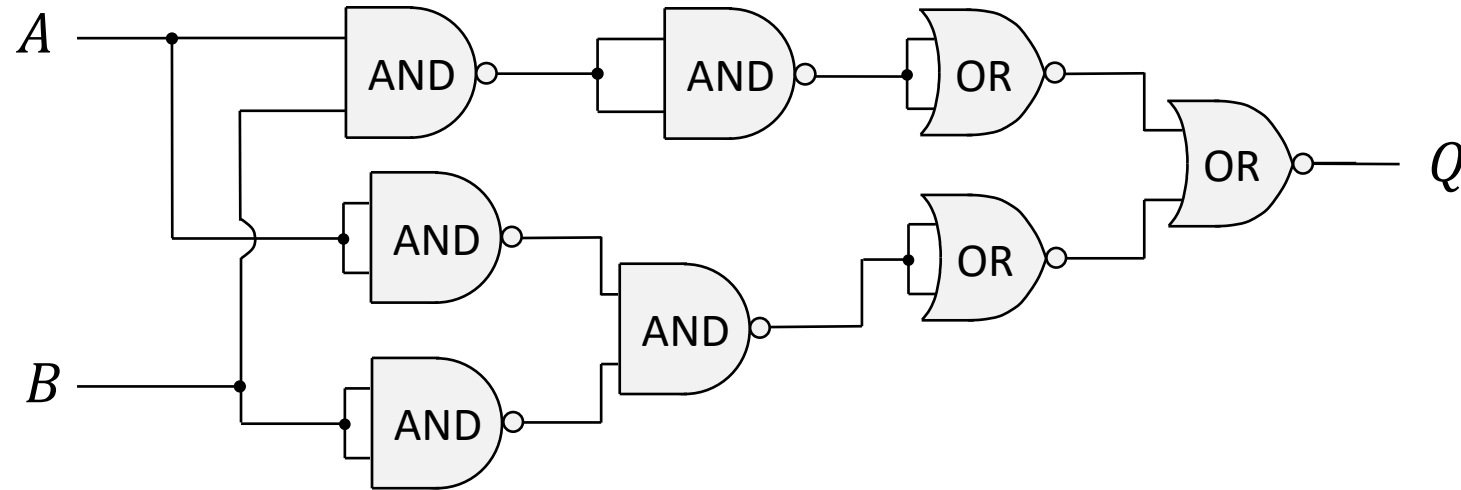
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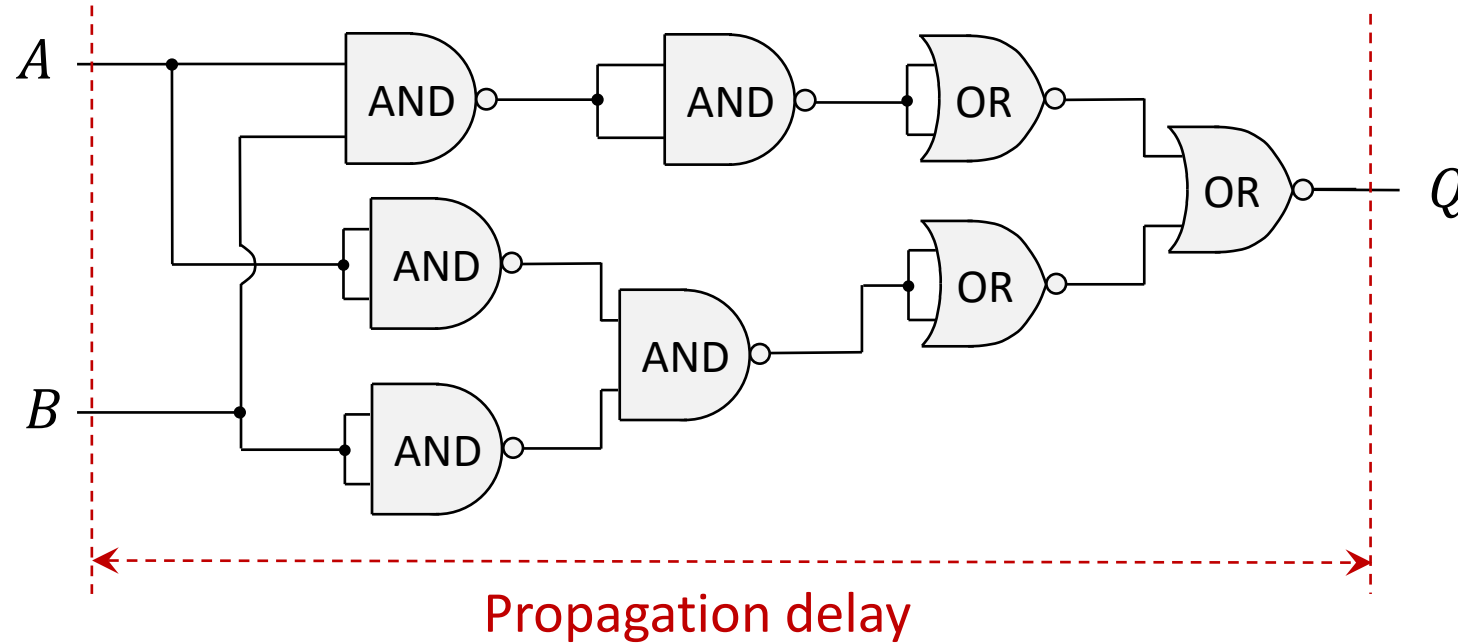
Observation: “shorter” wires are better, e.g. due to lower propagation delays
(there is some connection to Moore’s law)

Recap: Characteristics of Combinational Logic Circuits



- 1) An output signal depends just on “current” input signals
- 2) Comprised of logic gates, such as AND, OR, etc., and wires connecting them
- 3) Output signal is updated after the change of input signals, subject to propagation delay

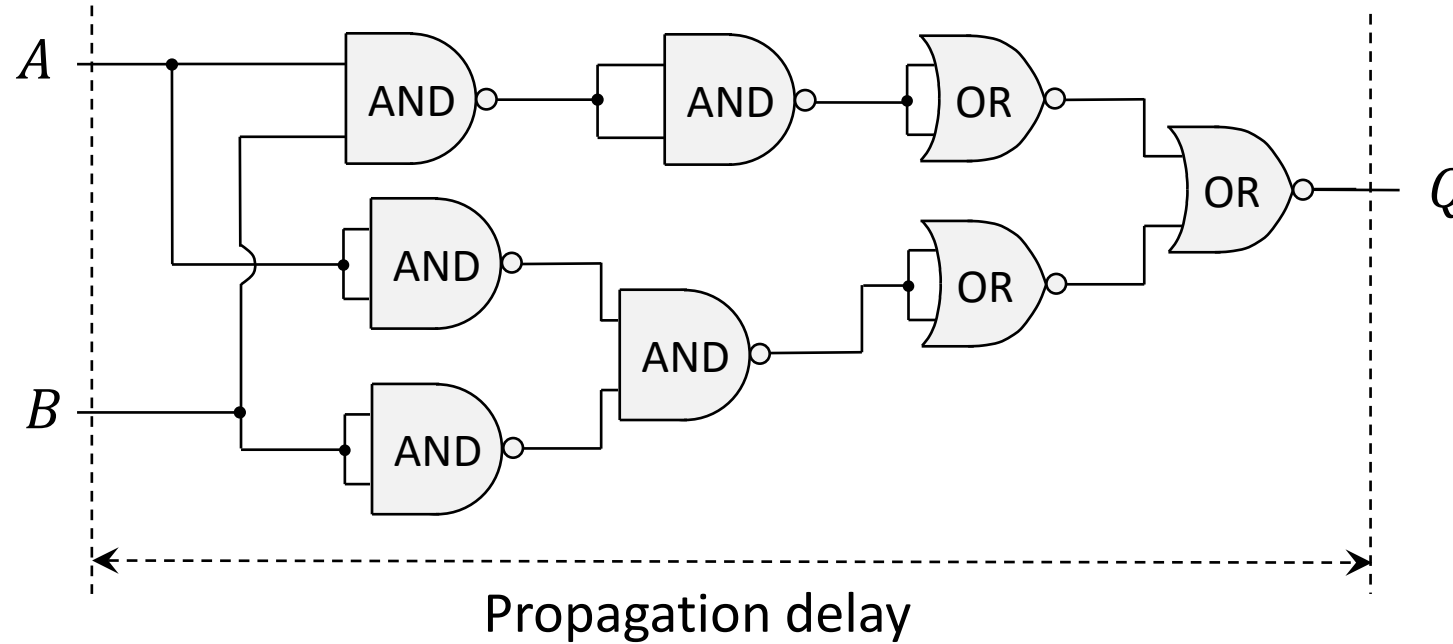
Recap: Characteristics of Combinational Logic Circuits



- 3) Output signal is updated after the change of input signals, subject to propagation delay

Propagation delay – time delay between the change of inputs and the update of output

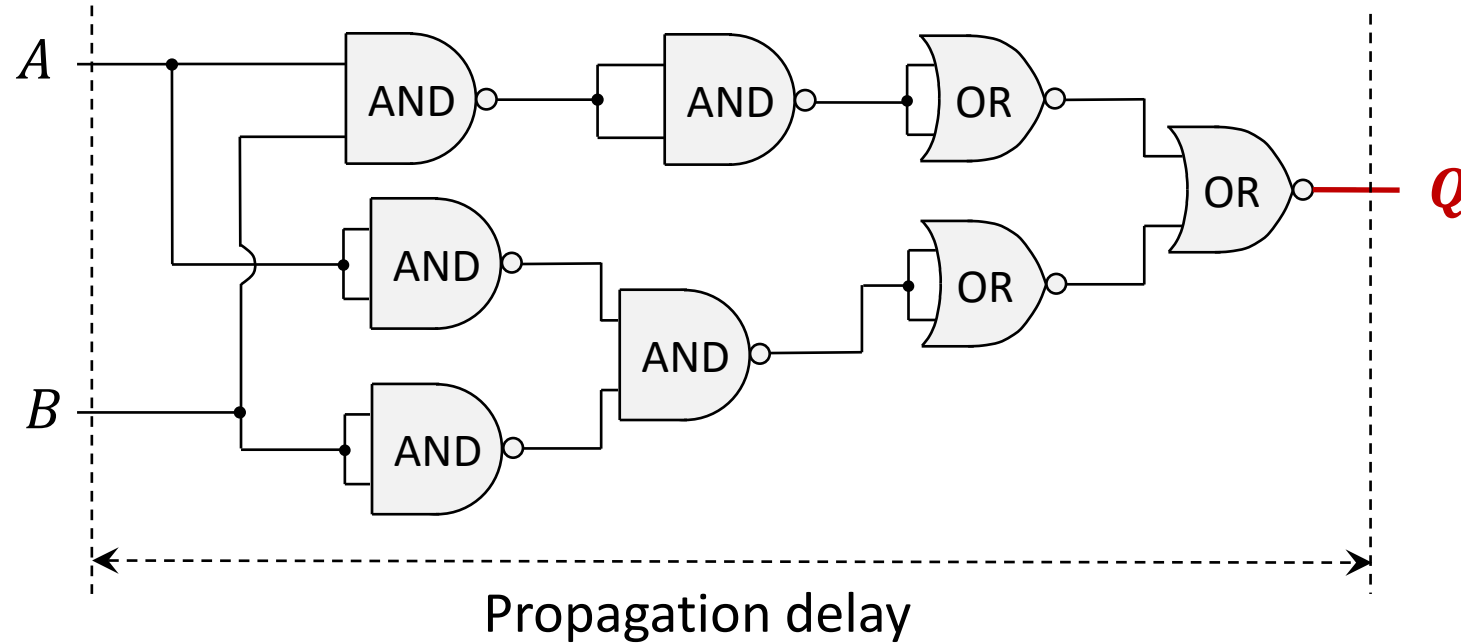
Recap: Characteristics of Combinational Logic Circuits



- 3) Output signal is updated after the change of input signals, subject to propagation delay
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Critical Path of the Integrated Circuit – the one taking the longest time
(results in the “worst case” propagation delay)

Recap: Characteristics of Combinational Logic Circuits

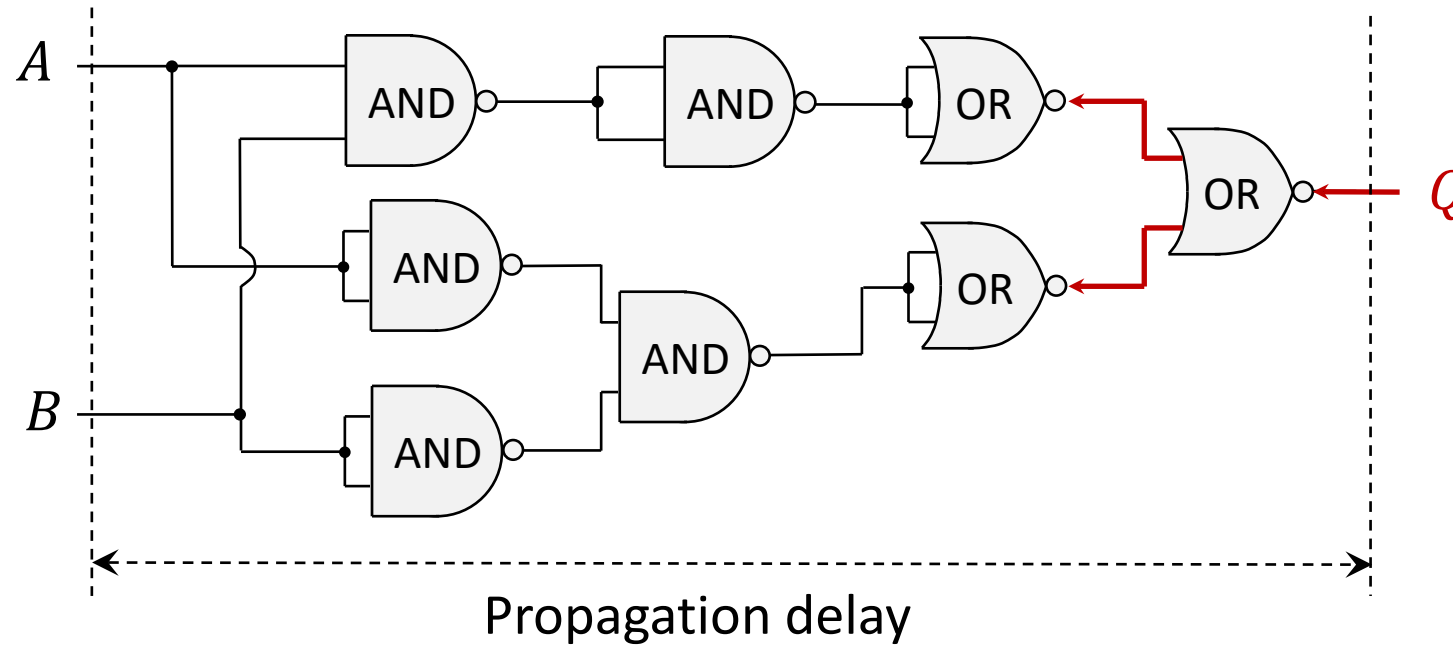


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Computed in the direction starting from the output pin(s)

Recap: Characteristics of Combinational Logic Circuits

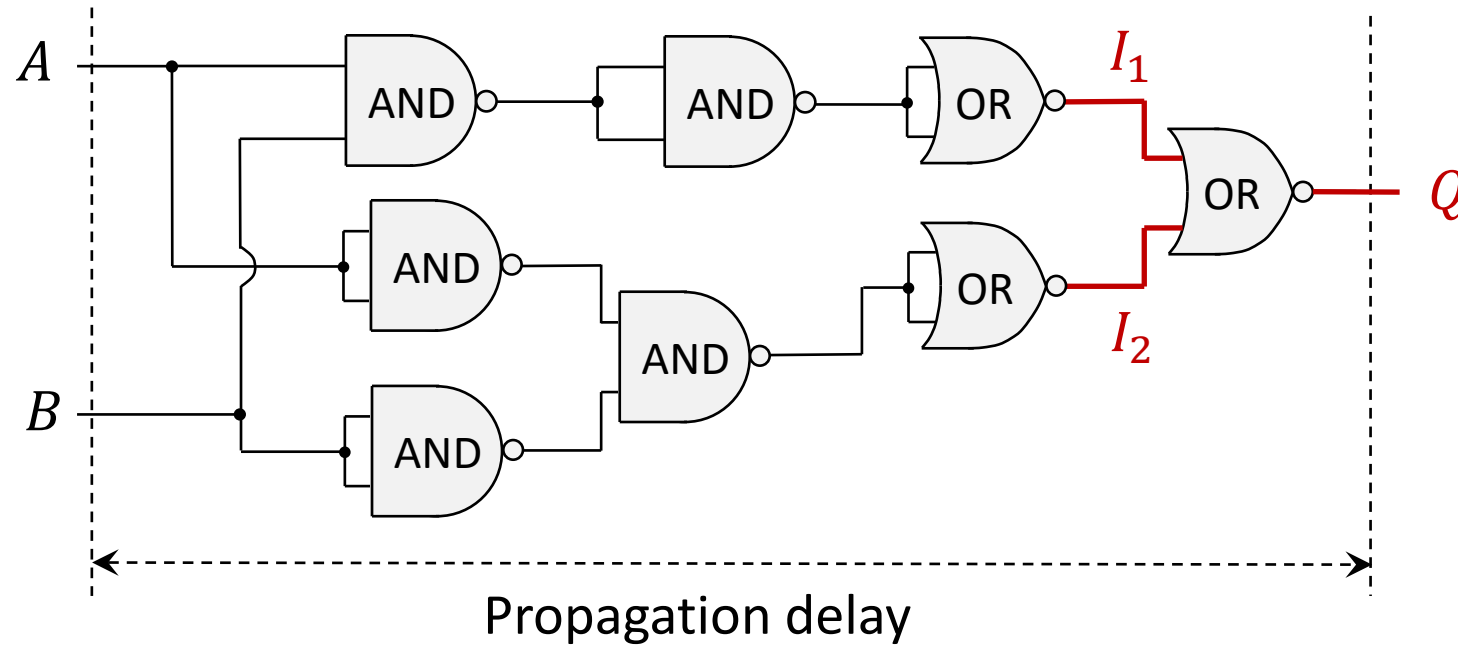


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Recap: Characteristics of Combinational Logic Circuits



Q is updated when both inputs, I_1 and I_2 , are updated;

Inputs I_1 and I_2 are in turn outputs of other logic gates;

Q Repeat backtracking, to compute the worst case delay

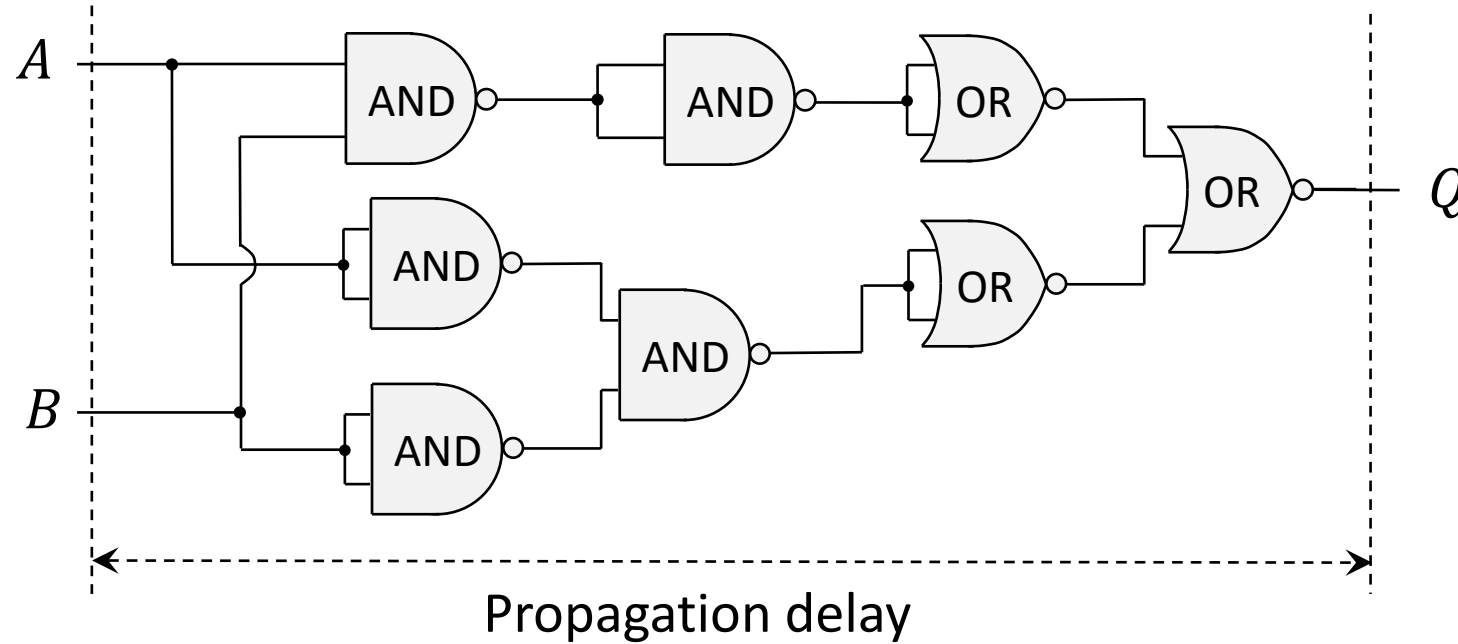
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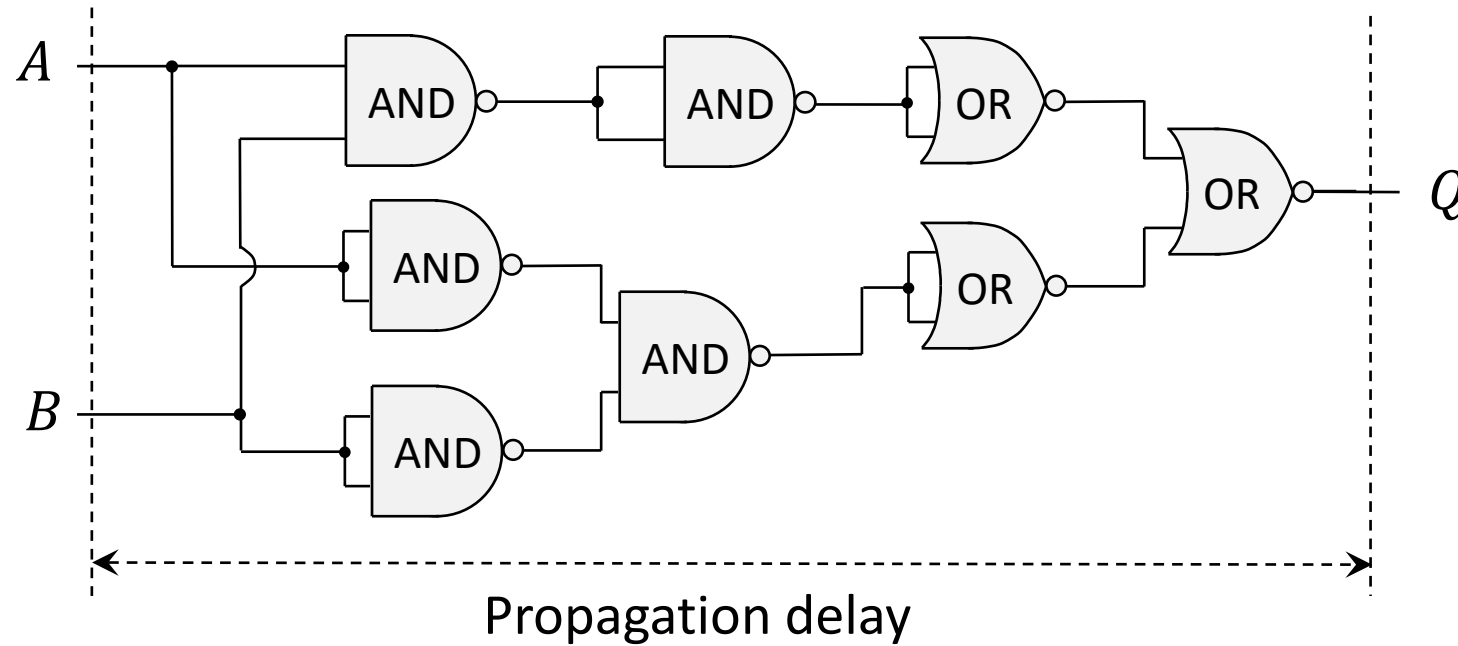
Recap: Characteristics of Combinational Logic Circuits



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Recap: Characteristics of Combinational Logic Circuits



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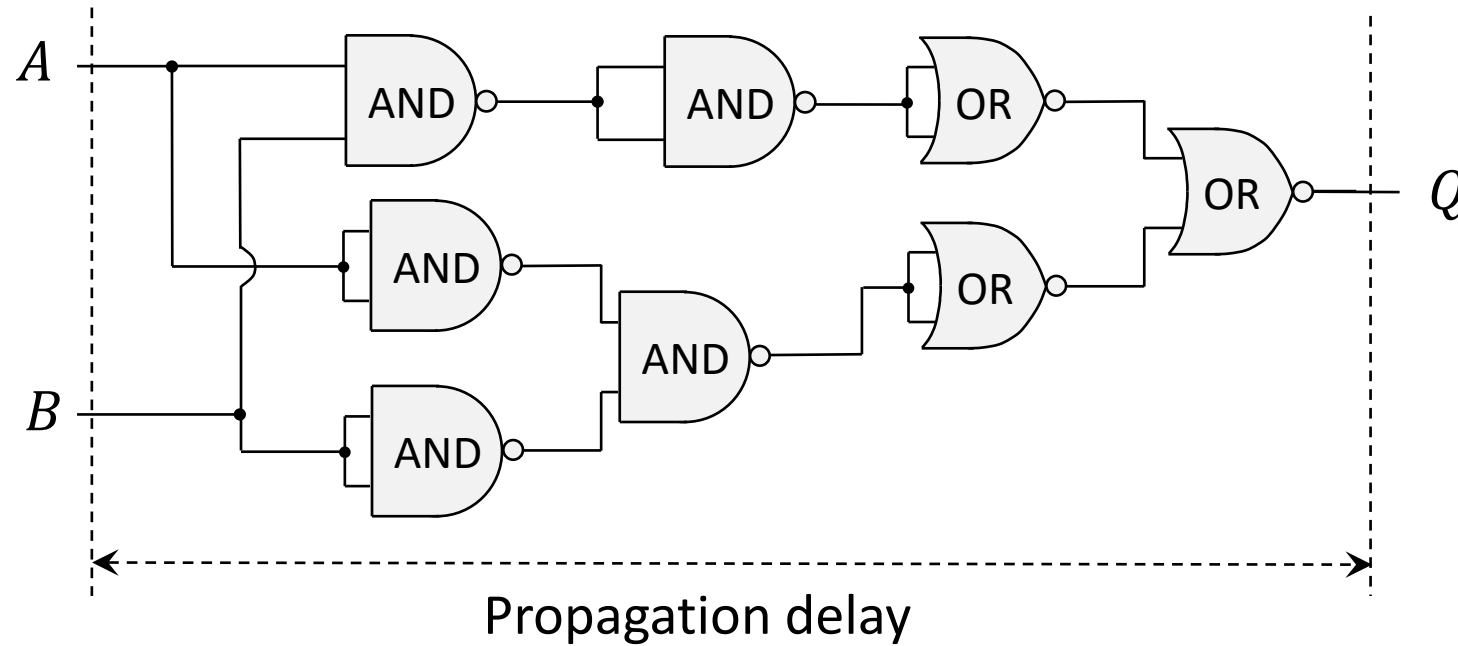
Sample timing diagram:

"0" – deasserted state;

"1" – asserted



Recap: Characteristics of Combinational Logic Circuits



3) Output signal is updated after the change of input signals, subject to propagation delay

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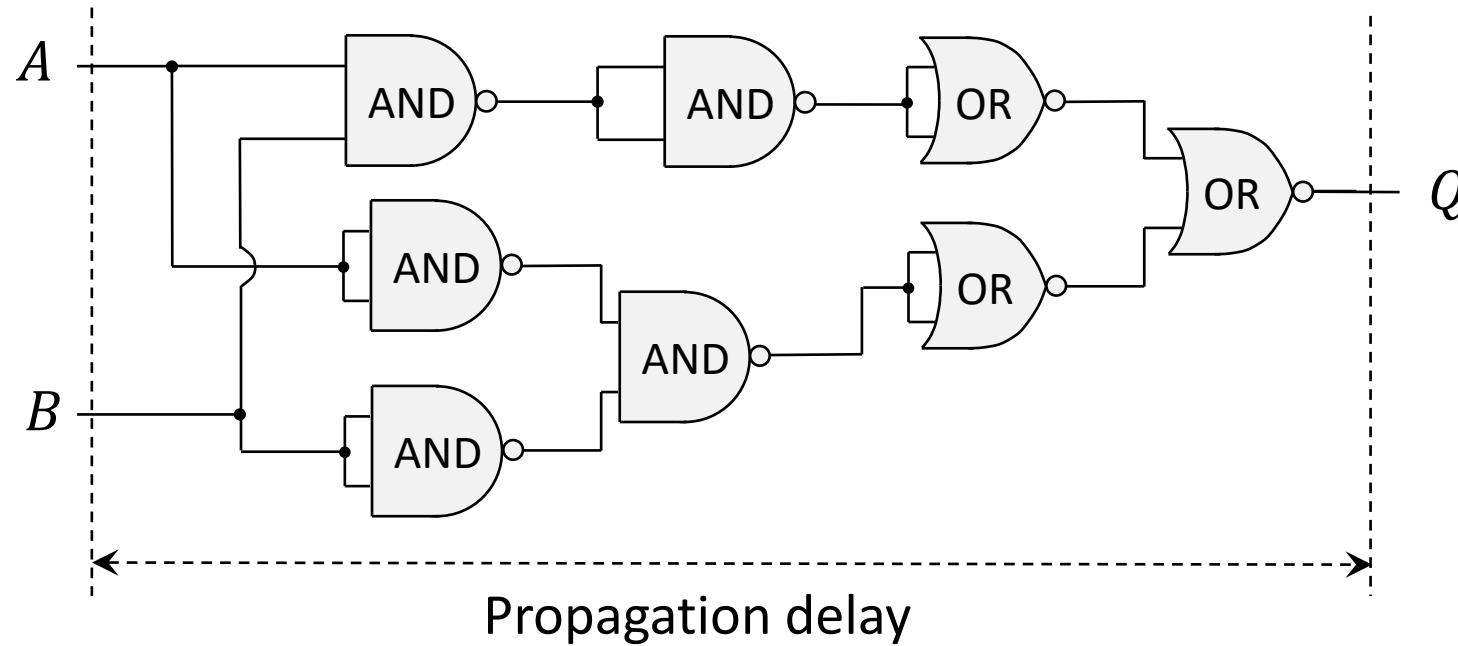
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Might not correspond
to the circuit above



Recap: Characteristics of Combinational Logic Circuits



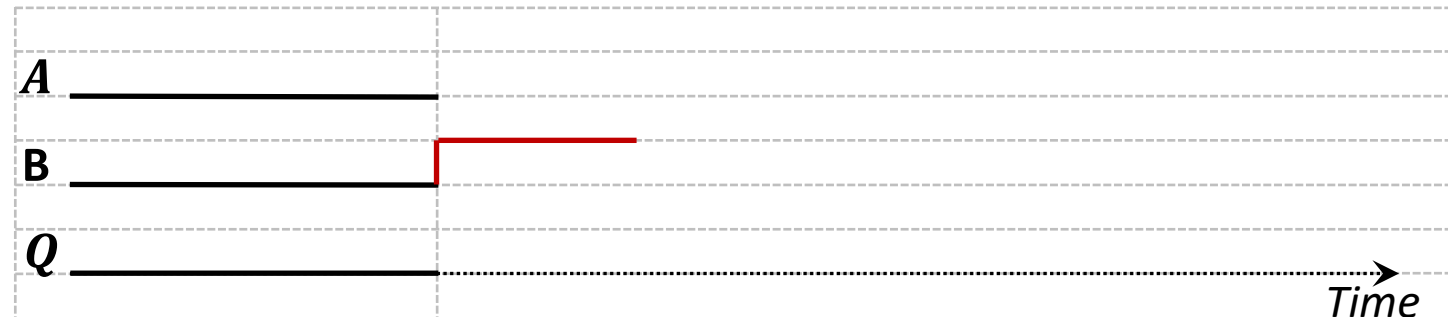
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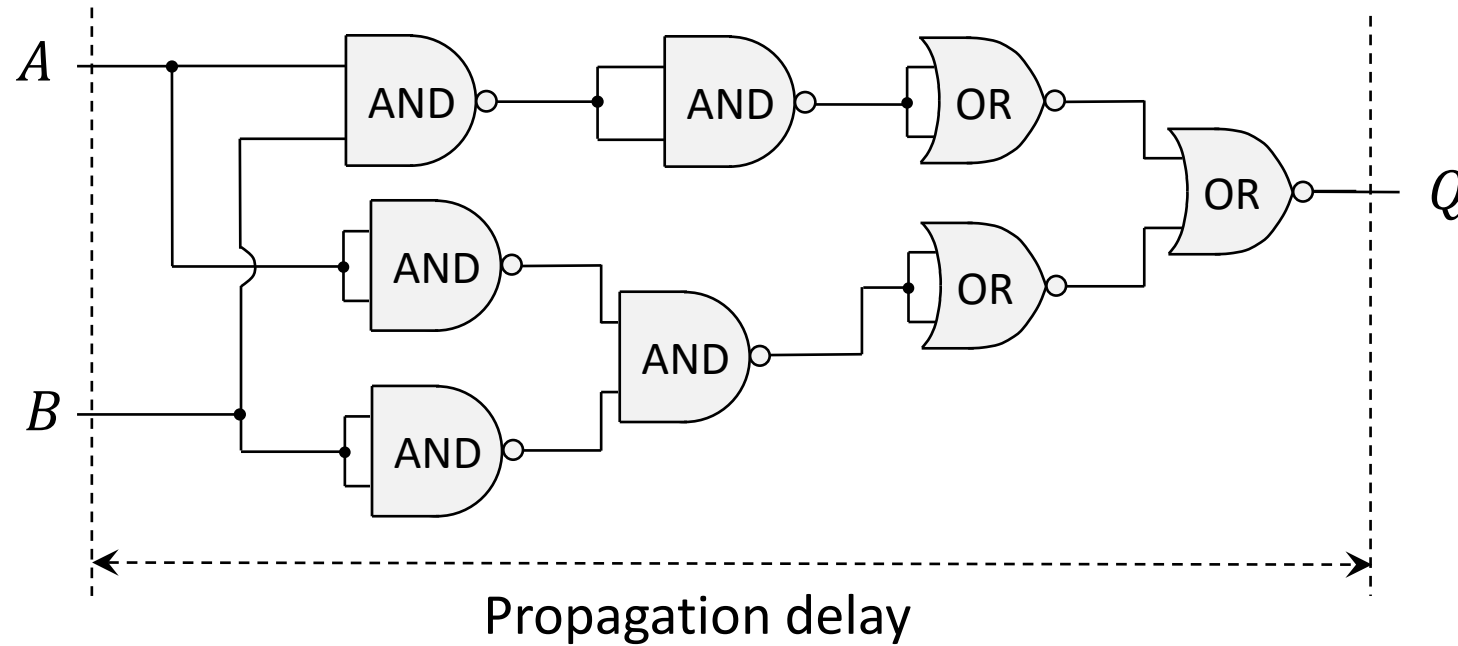
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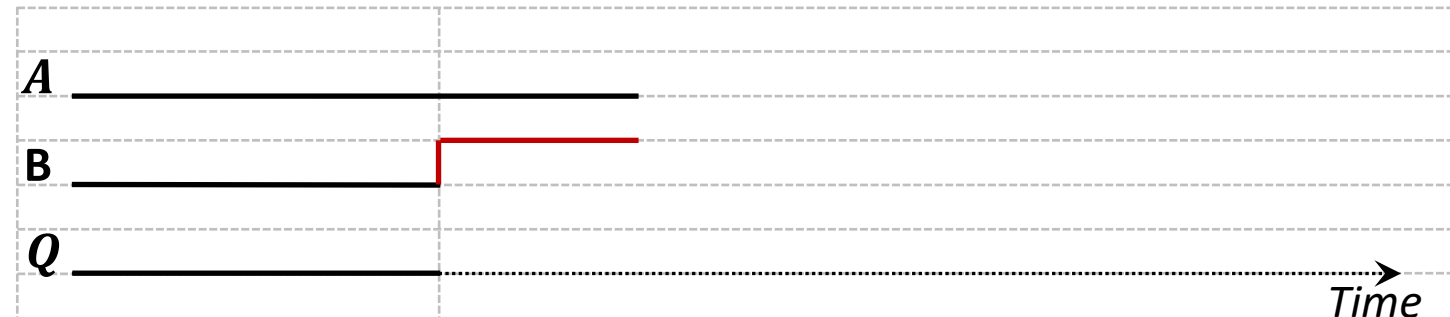
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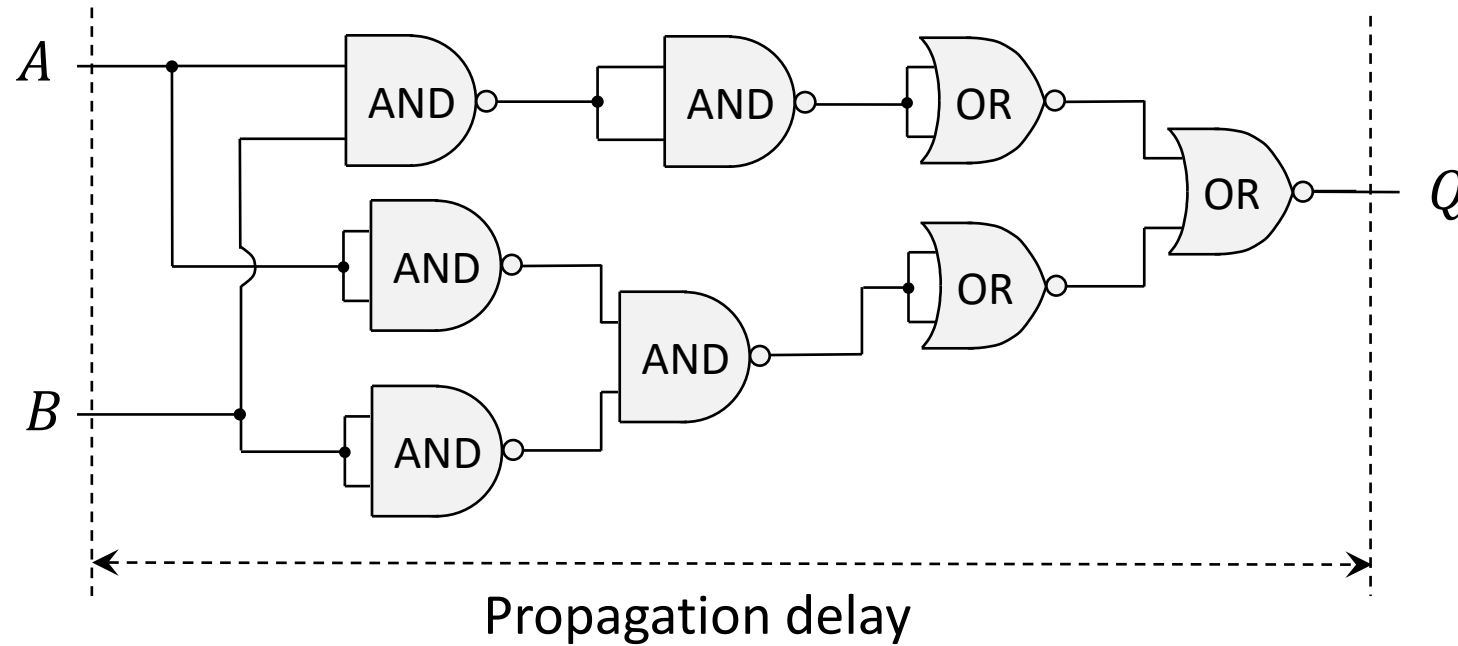
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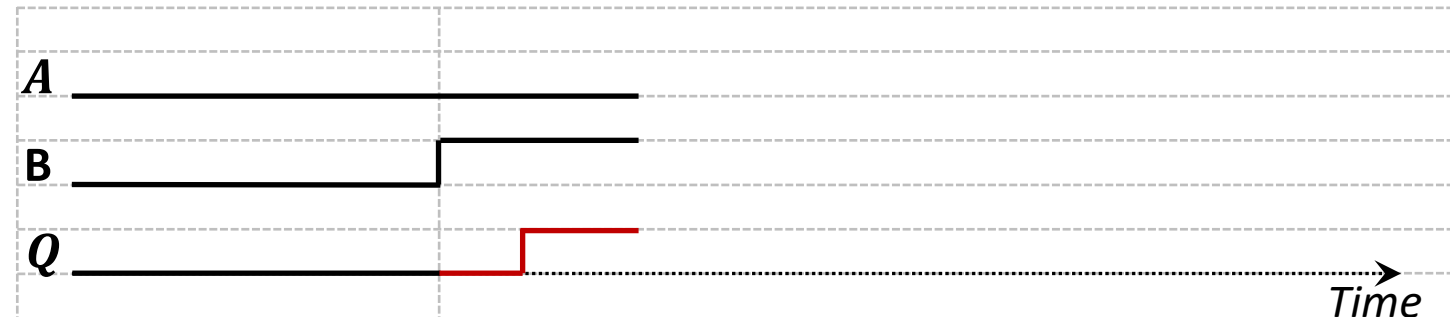
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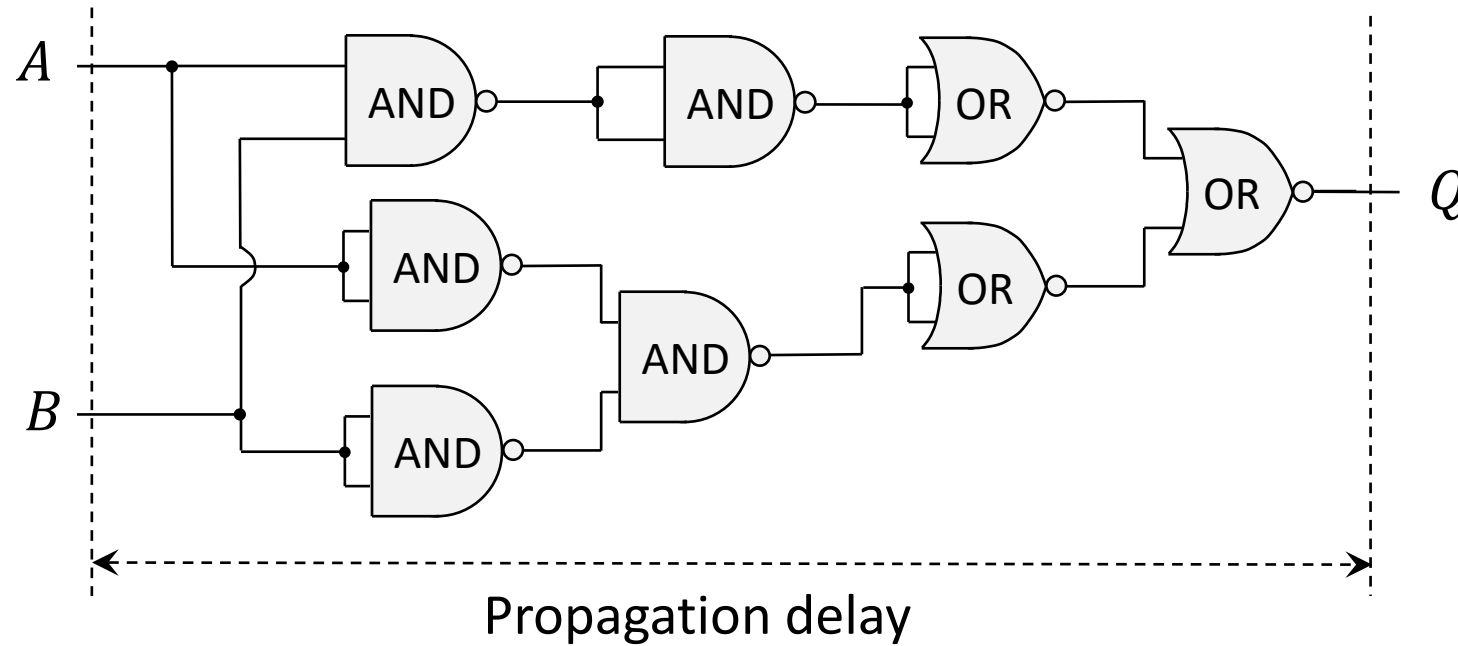
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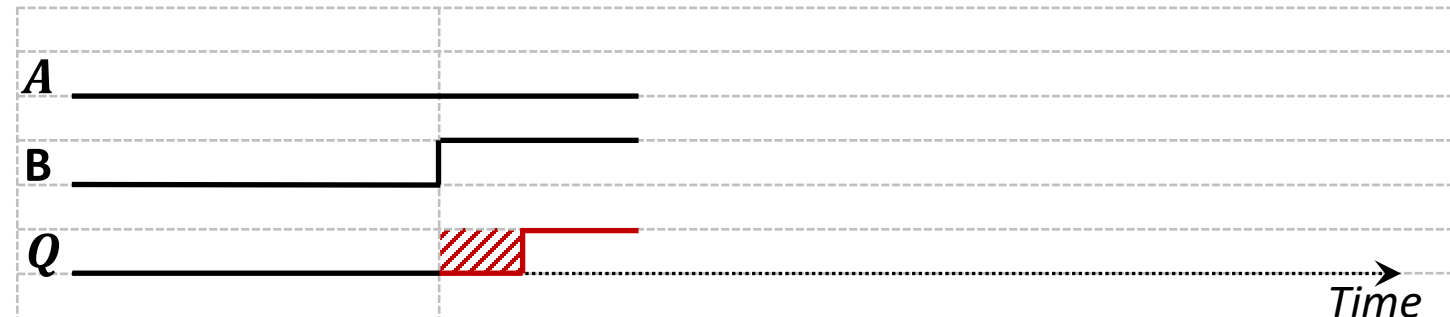
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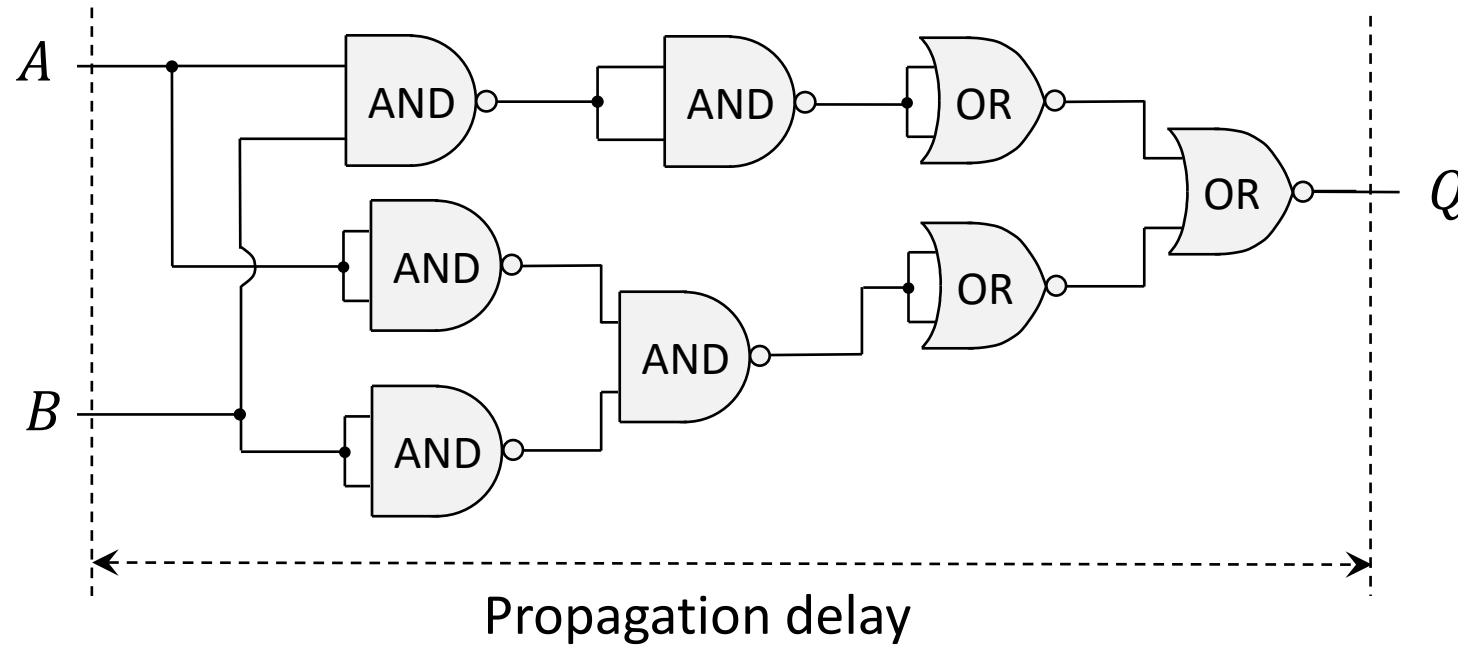
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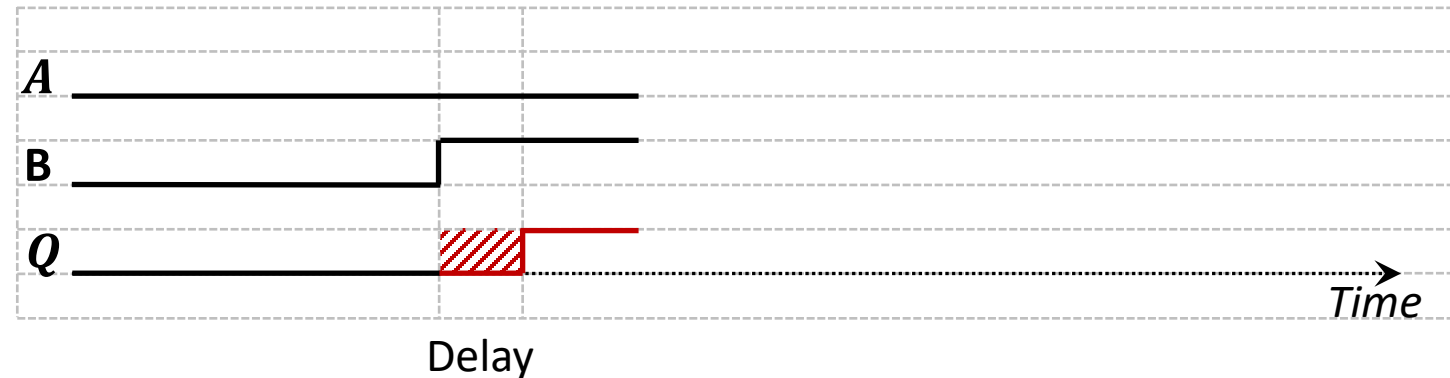
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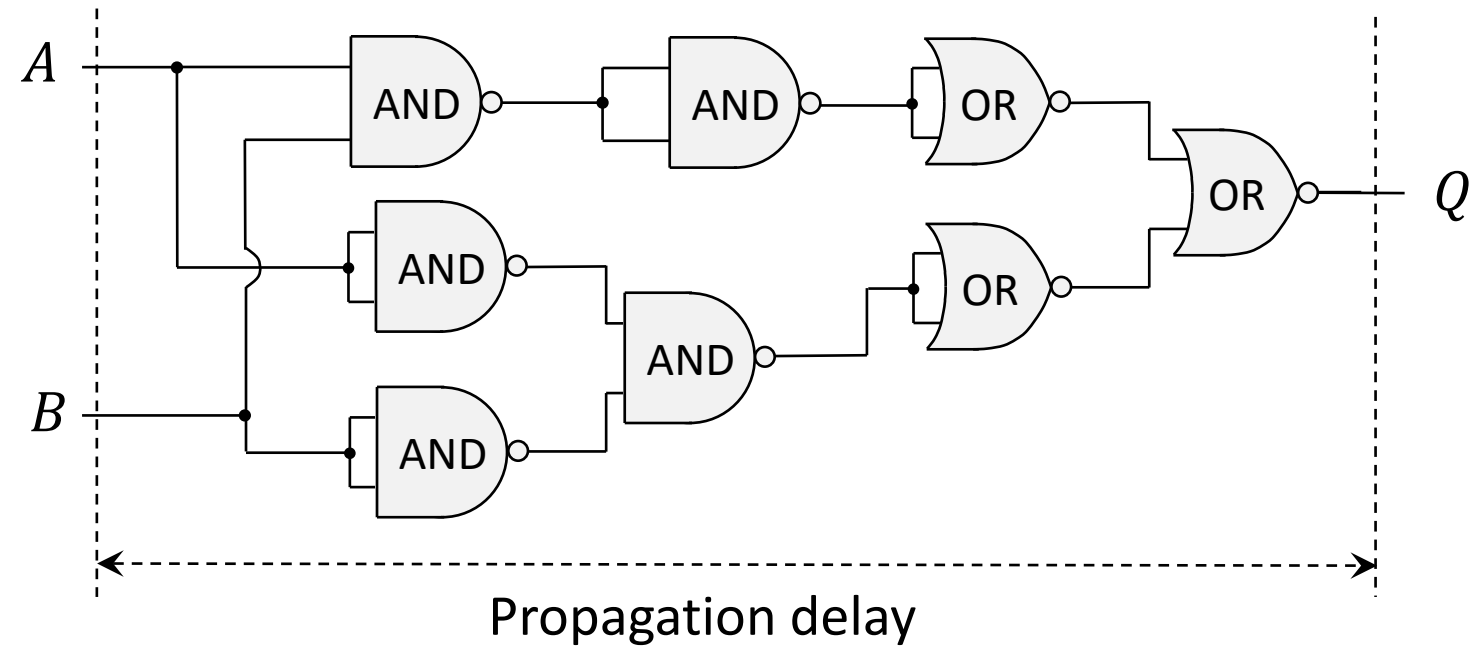
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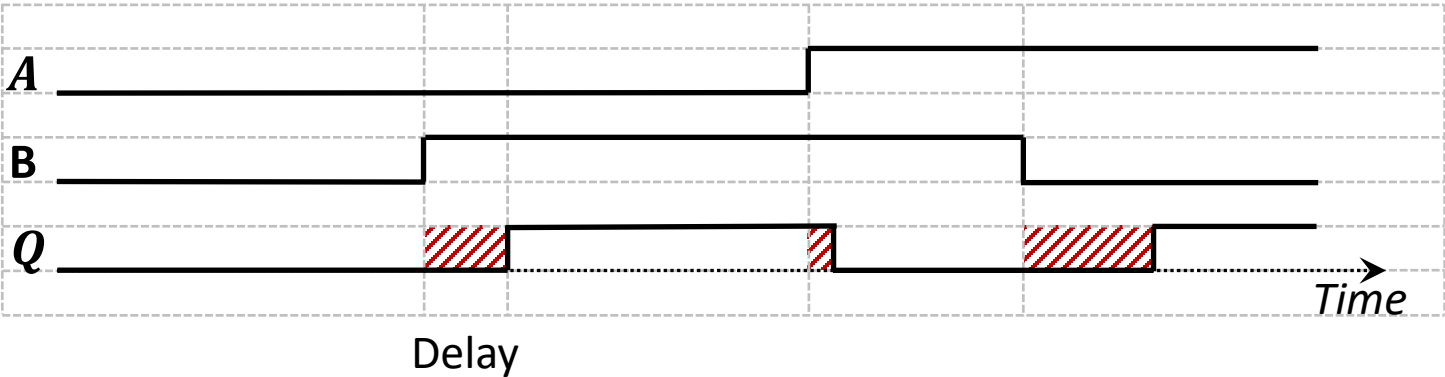


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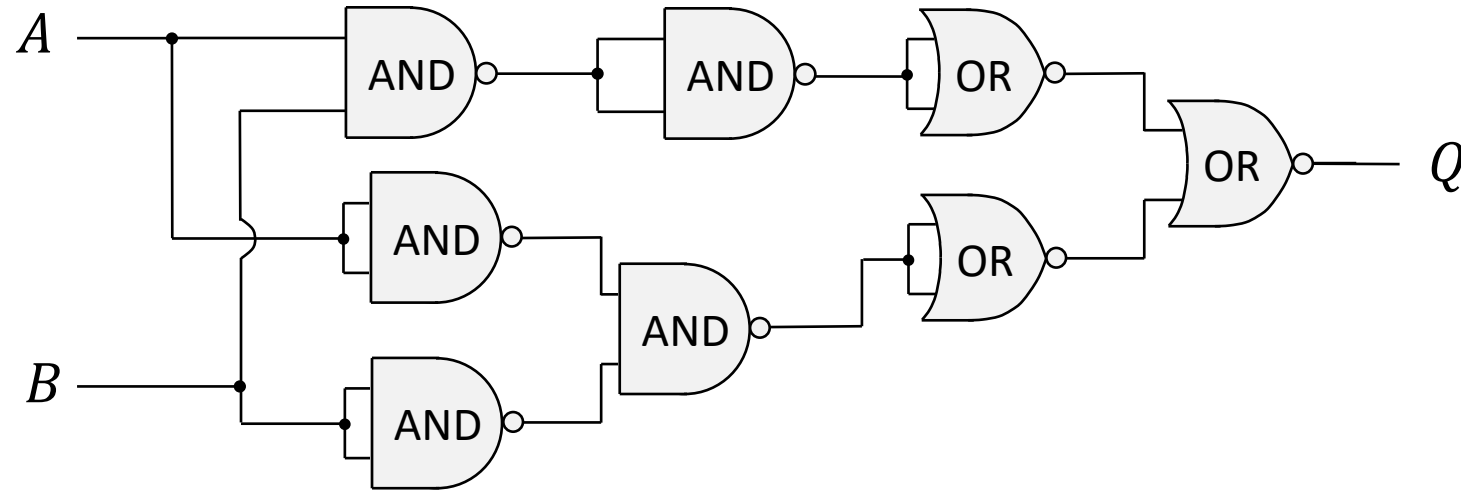
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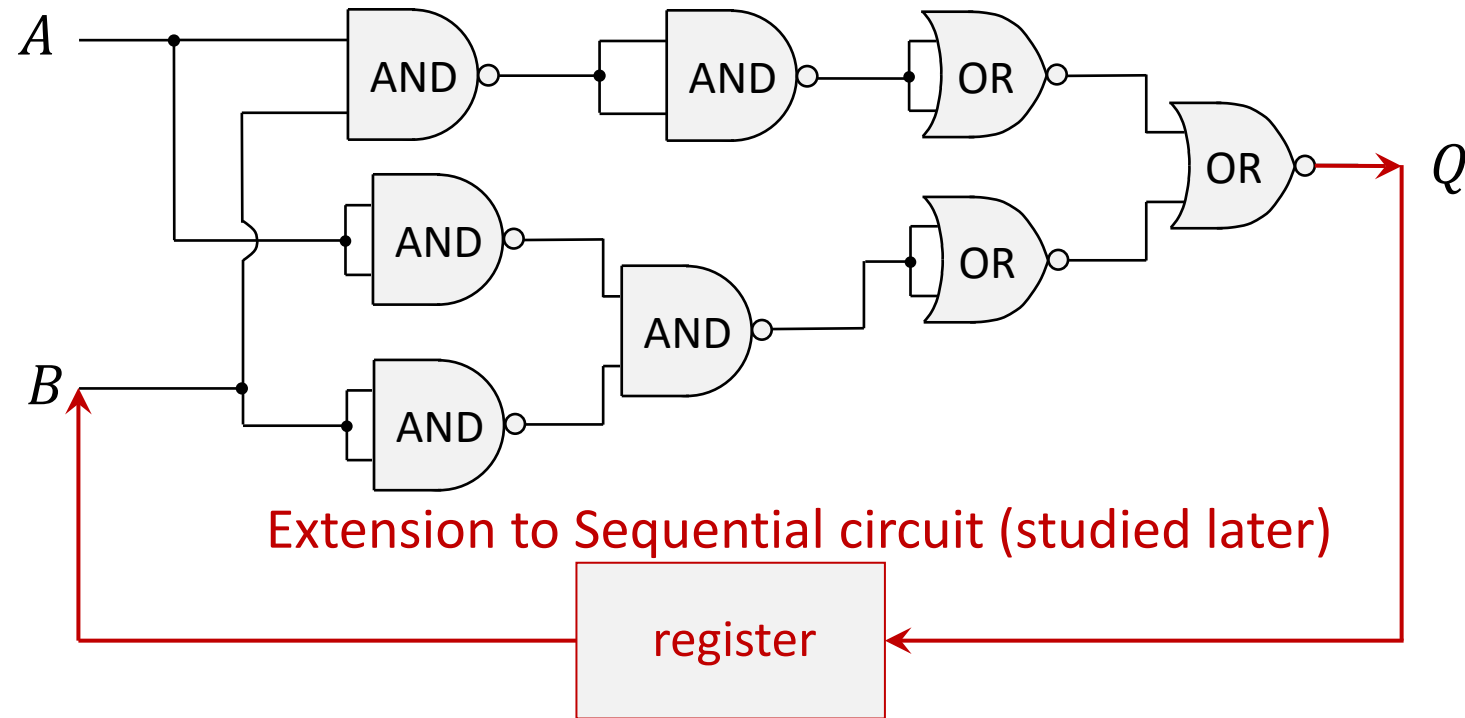


Recap: Characteristics of Combinational Logic Circuits



- 1) An output signal depends just on “current” input signals (“combinational” = combine inputs)
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- 4) Use no memory units, such as registers (as opposed to “sequential” circuits – to be discussed)

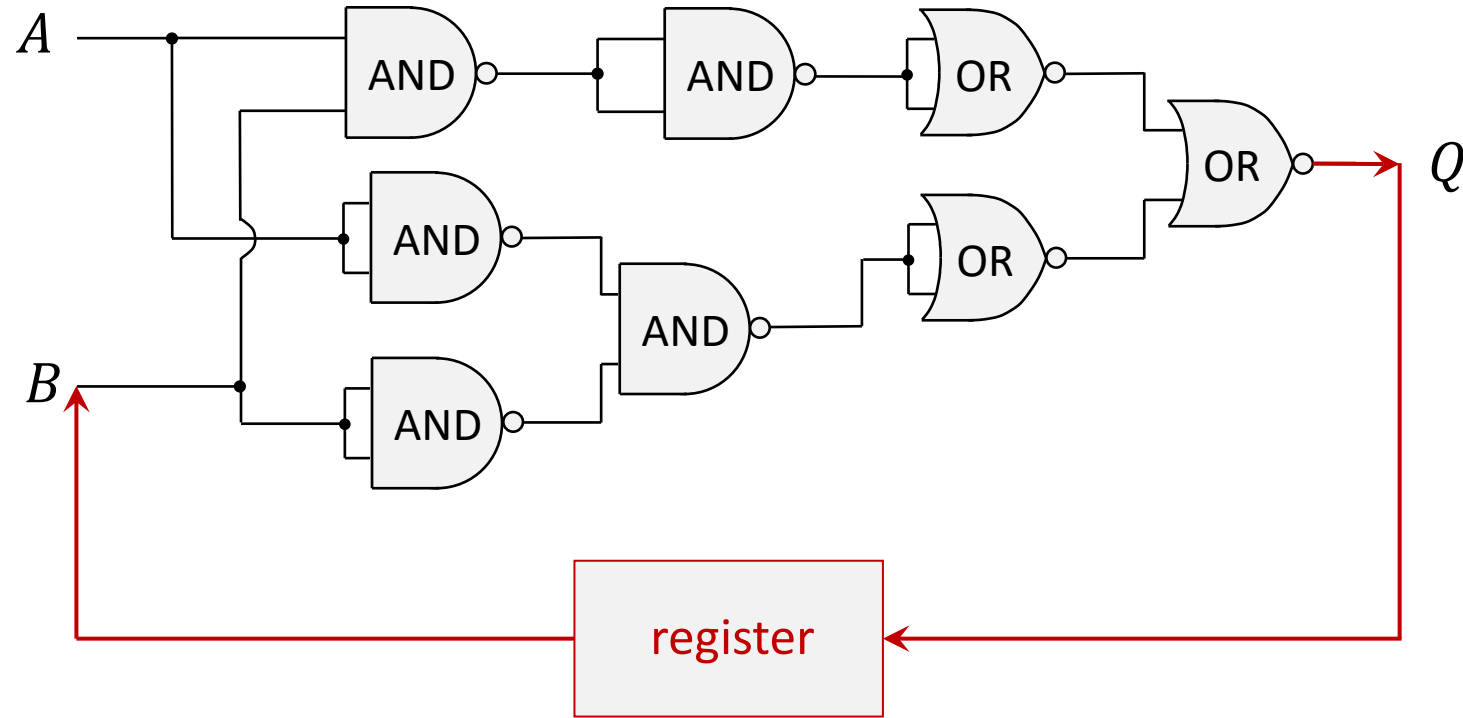
Recap: Characteristics of Combinational Logic Circuits



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Sequential circuits – the addition to combinational

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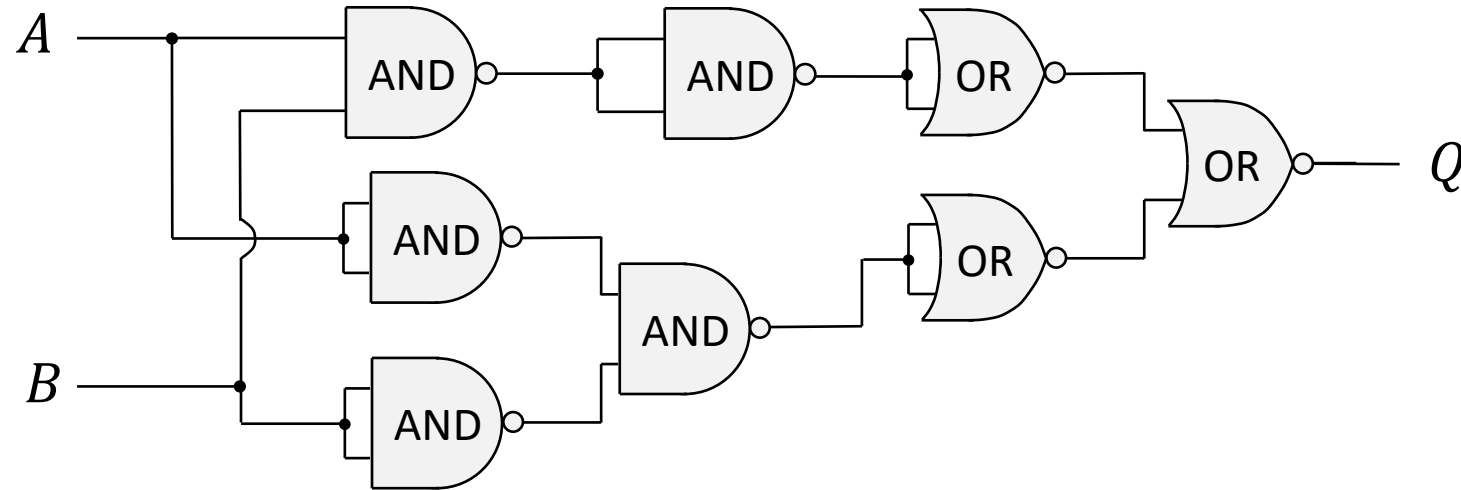


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Sequential circuits – an alternative to combinational

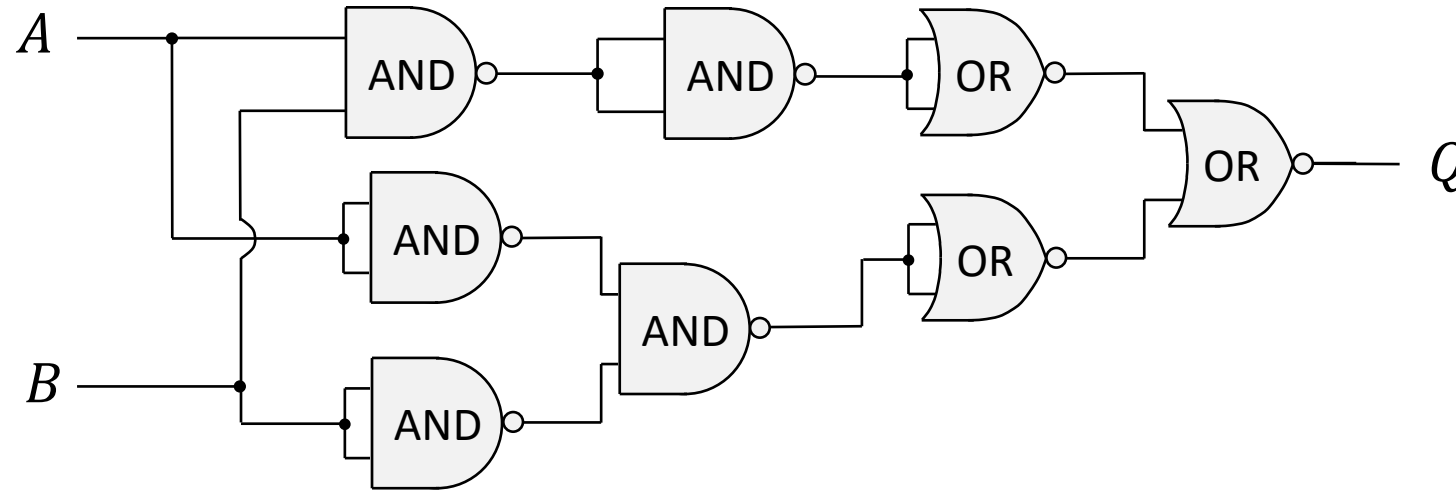
Register (from “to register” = “to remember”) – a memory element, to store an electrical charge

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- 5) Typically, no clock signal is present (exceptions might apply)

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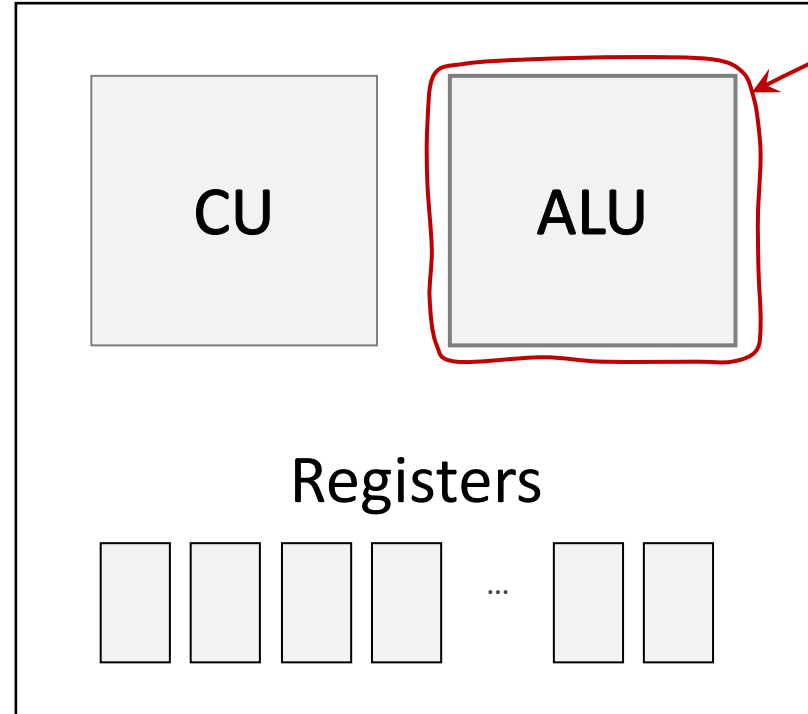


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Key advantage: Fast (thus, used in such components, as processor ALU)

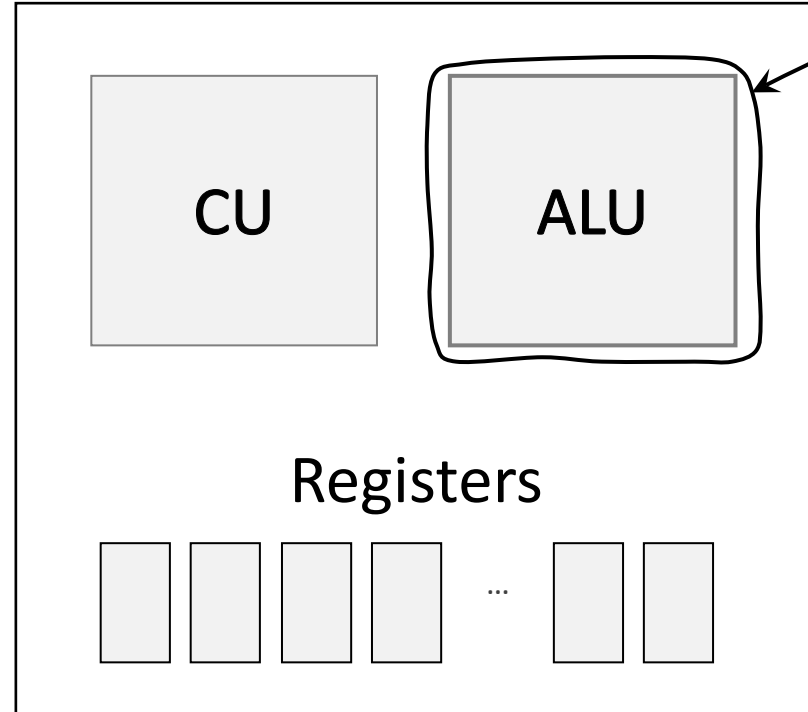
Key disadvantage: No support of inputs synchronization (will be discussed later)

Types of Logic Circuits for CPU Components



Combinational logic circuit
for arithmetical and logic
operations

Types of Logic Circuits for CPU Components

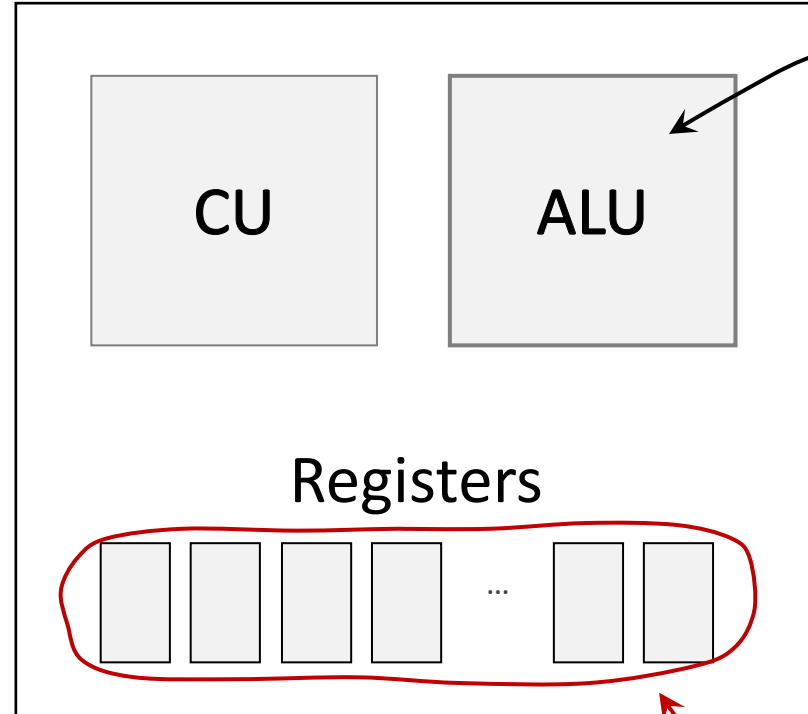


Combinational logic circuit
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operations

Fast - advantage

No synchronization support
- disadvantage

Types of Logic Circuits for CPU Components



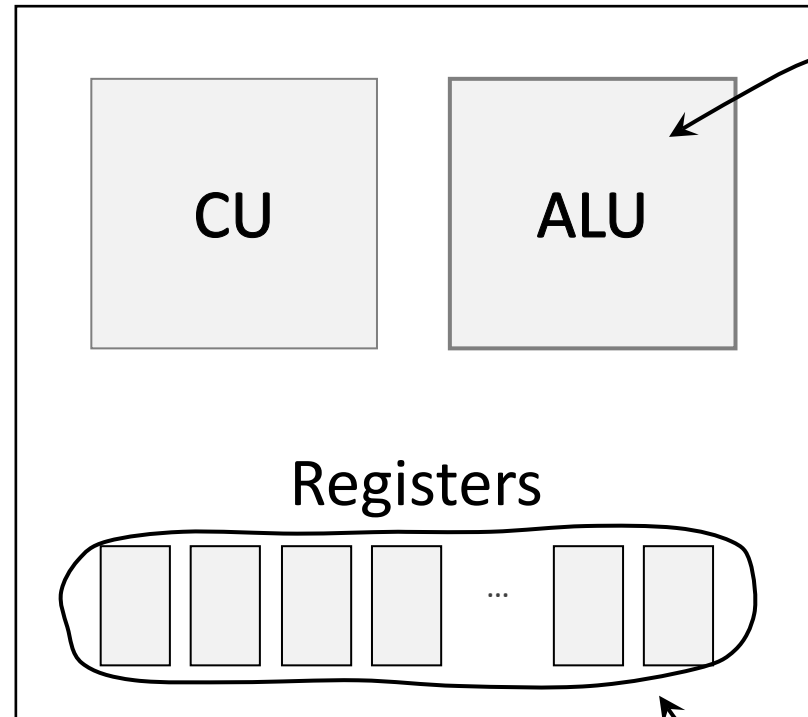
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Sequential logic circuits (clocked)

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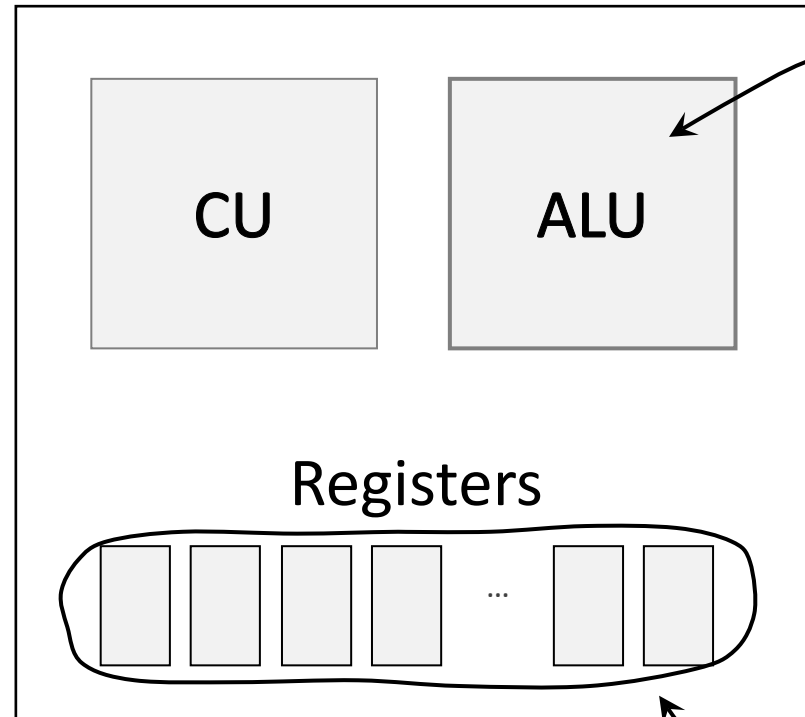
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Sequential logic circuits (clocked)

1) Capture inputs (might arrive not simultaneously);

Types of Logic Circuits for CPU Components



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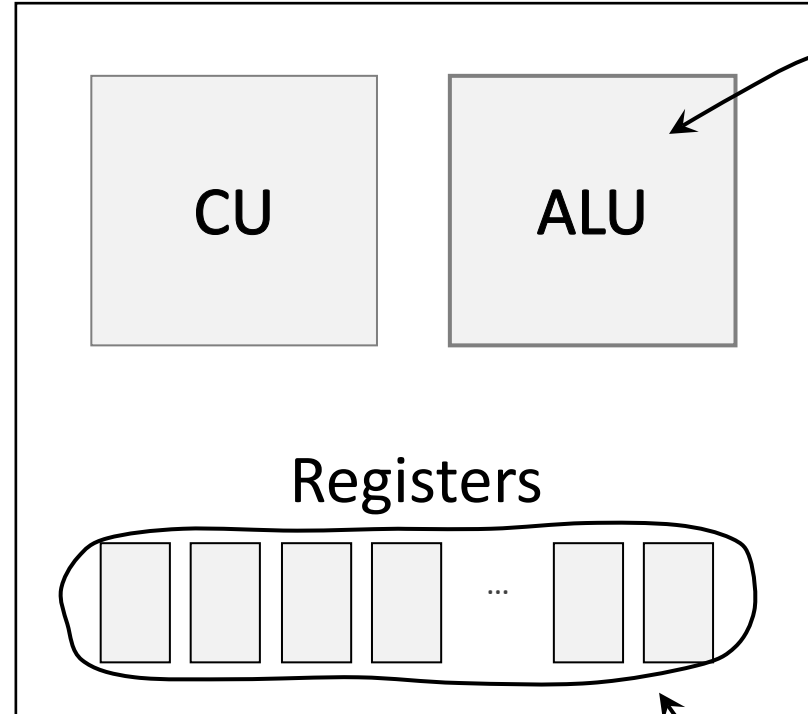
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Sequential logic circuits (clocked)

- 1) Capture inputs (might arrive not simultaneously);
- 2) Store inputs until a certain time instant;

Types of Logic Circuits for CPU Components



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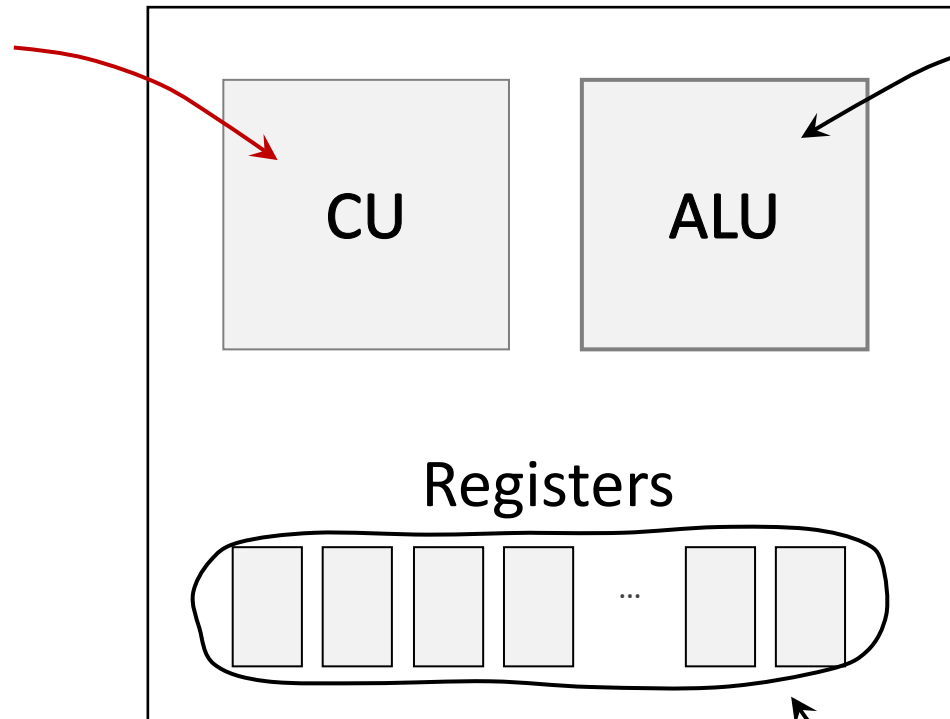
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Sequential logic circuits (clocked)

- 1) Capture inputs (might arrive not simultaneously);
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- 3) Output all inputs simultaneously to ALU

Types of Logic Circuits for CPU Components

Not a pure combinational circuit
(for example, might have IR –
instruction register)



Combinational logic circuit
for arithmetical and logic
operations

Fast - advantage

No synchronization support
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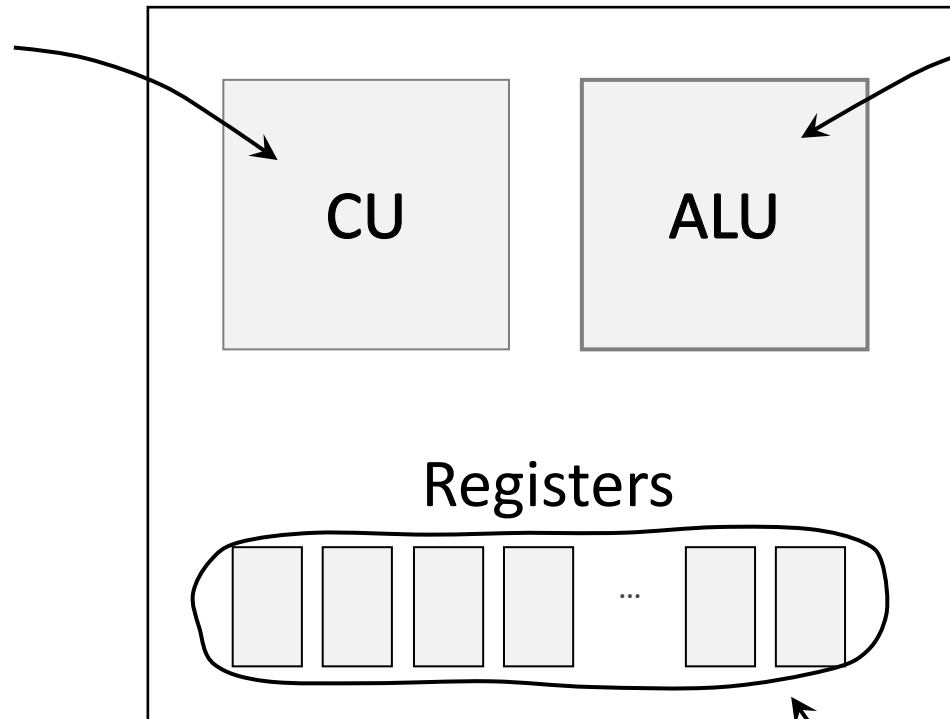
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Types of Logic Circuits for CPU Components

Not a pure combinational circuit
(for example, might have IR – instruction register)

Recall Instruction Fetch (IF)
stage of a pipelined execution
for instructions



Combinational logic circuit
for arithmetical and logic
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