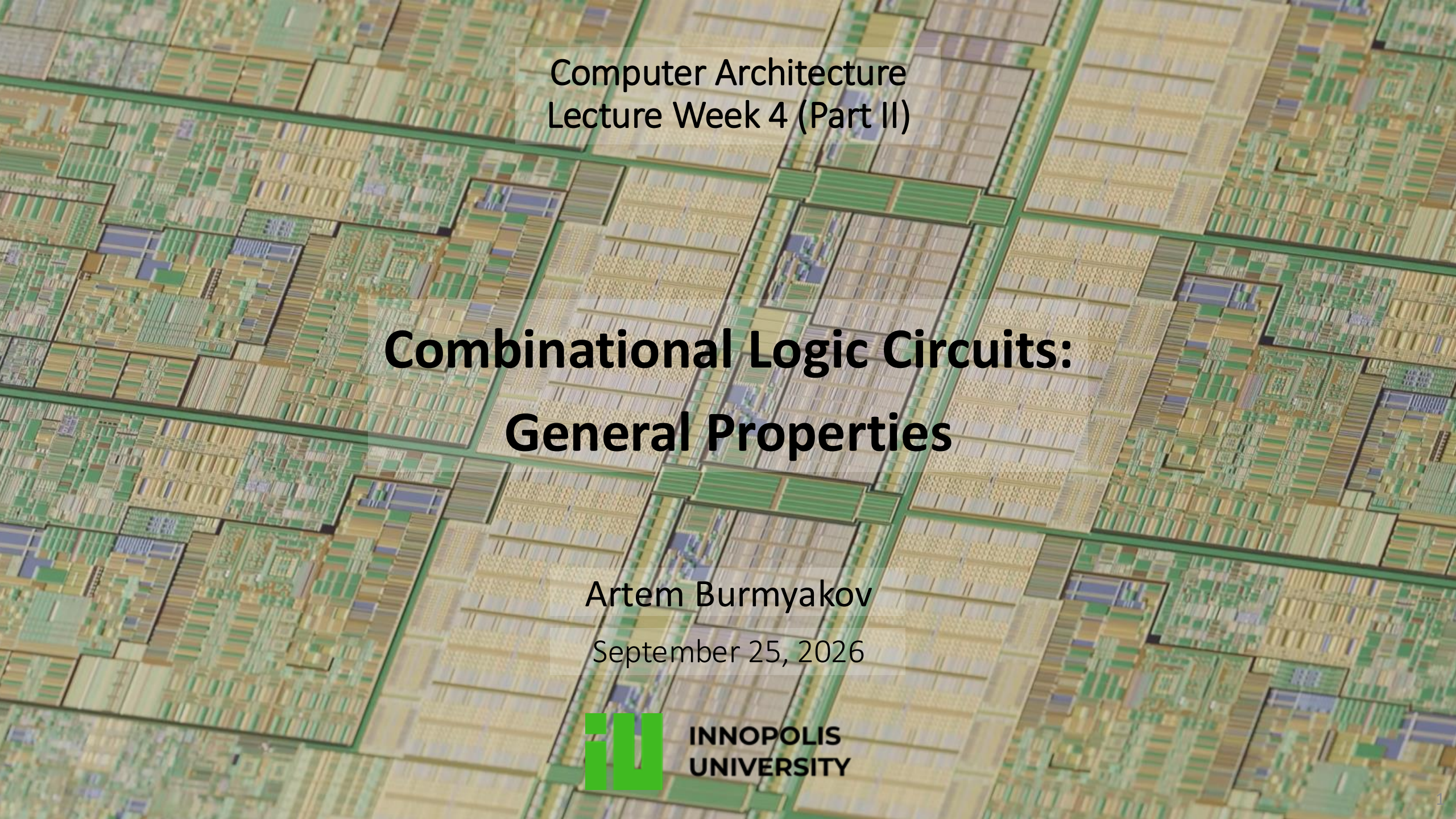




Computer Architecture
Lecture Week 4 (Part II)

Combinational Logic Circuits: General Properties

Artem Burmyakov

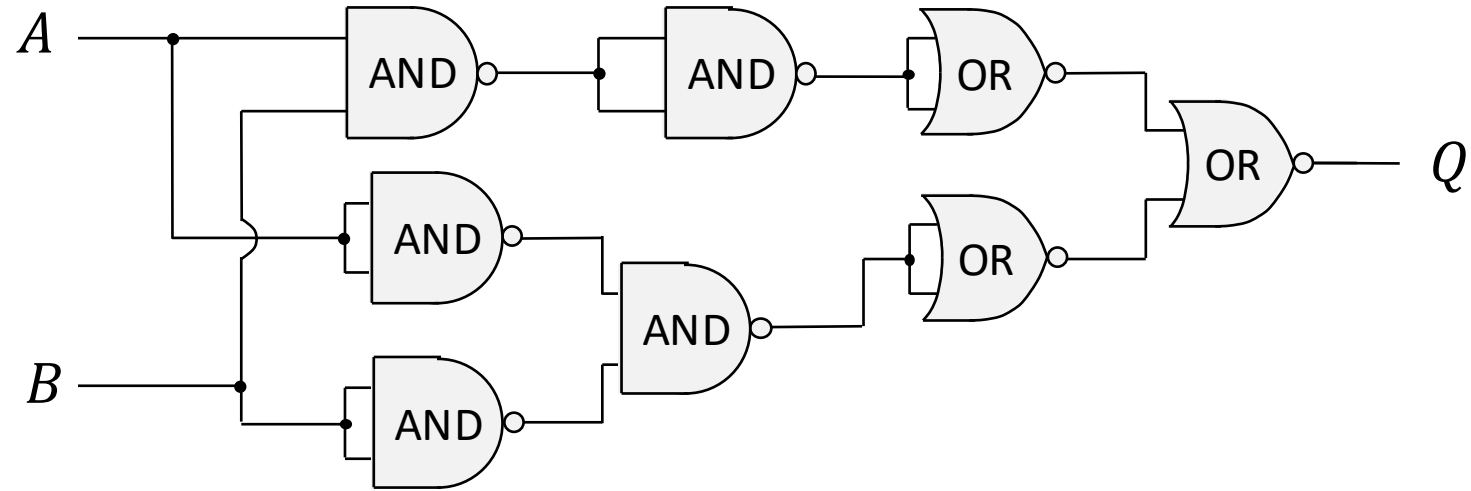
September 25, 2026



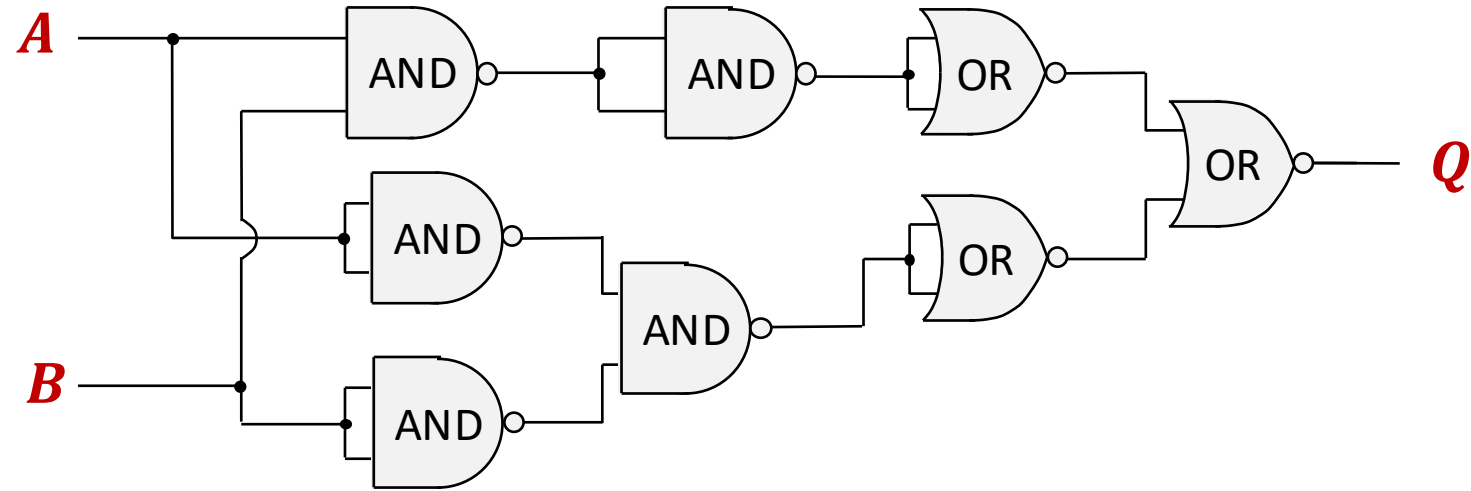
INNOPOLIS
UNIVERSITY

Combinational Logic Circuit Properties

Sample combinational
logic circuit:

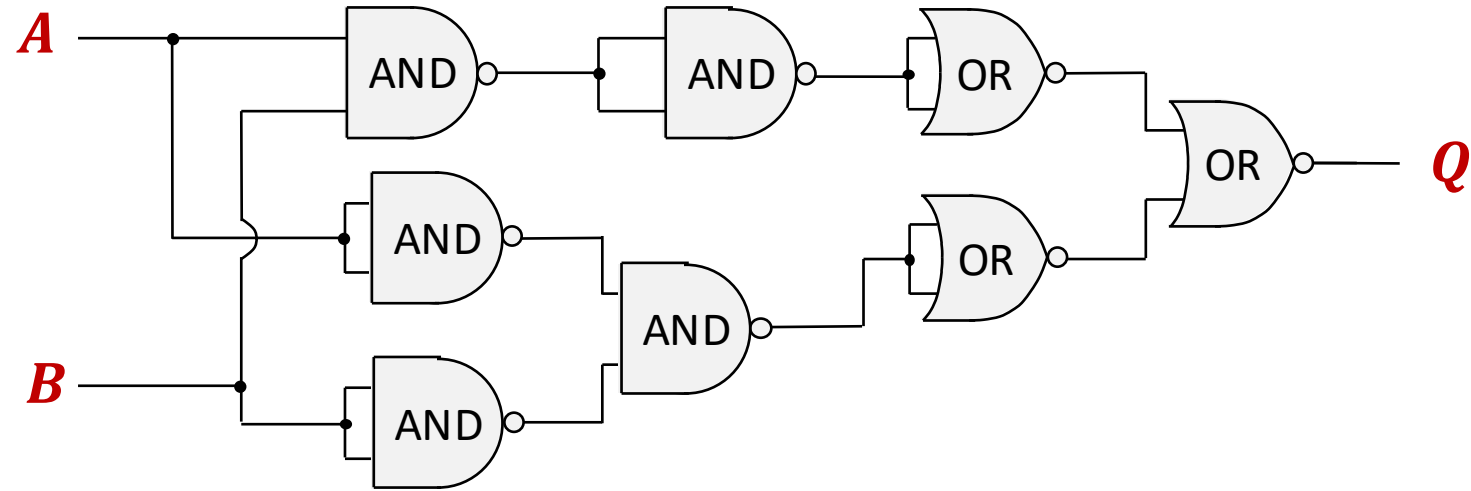


Combinational Logic Circuit Properties



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

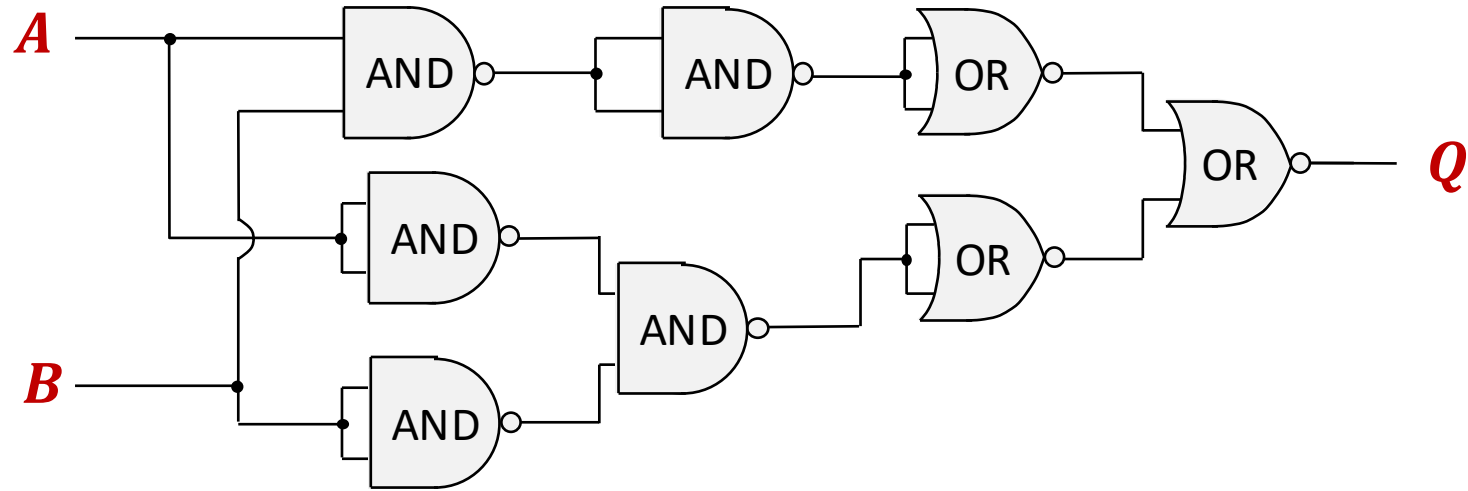
Combinational Logic Circuit Properties



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

“Combinational circuit” = to combine inputs and get the output

Combinational Logic Circuit Properties

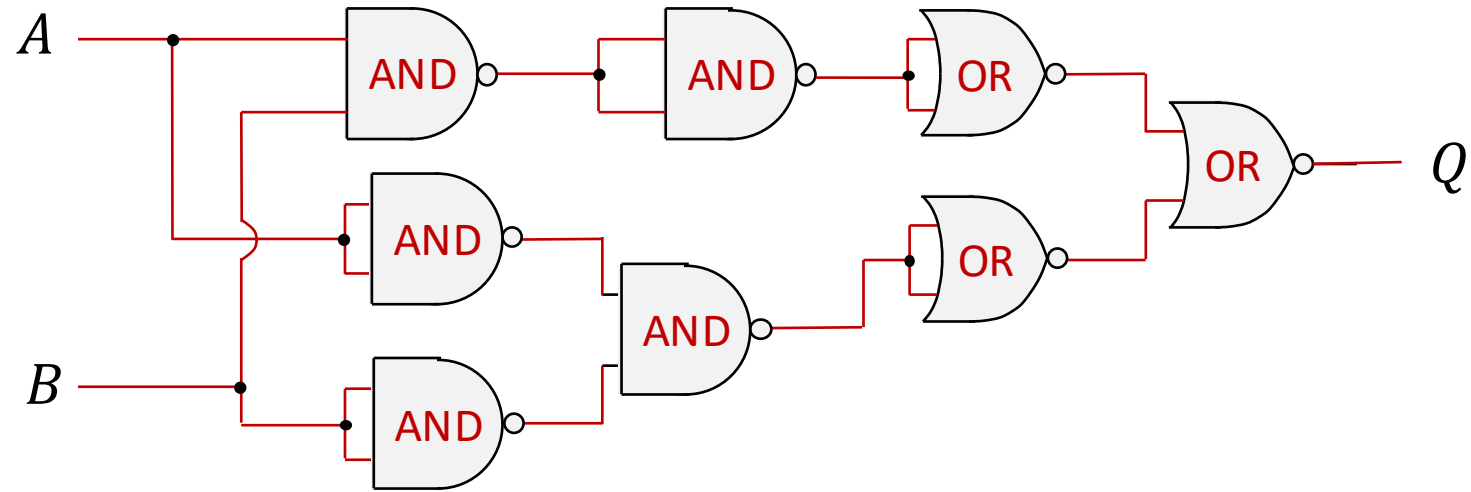


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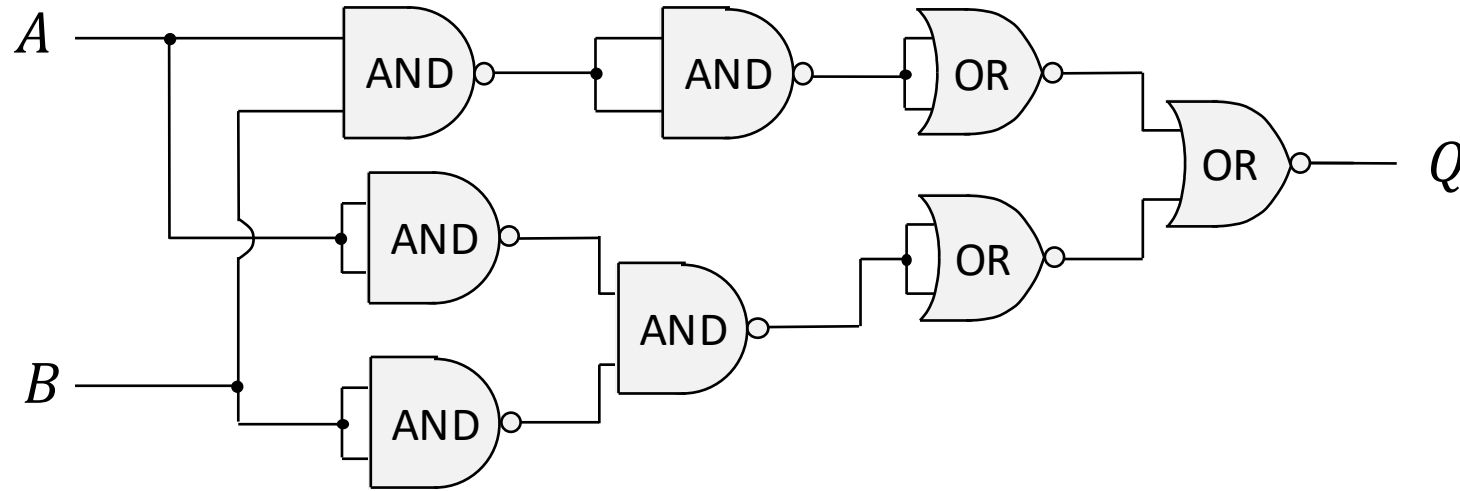
There is no dependency on previous signals or computation results

Combinational Logic Circuit Properties



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

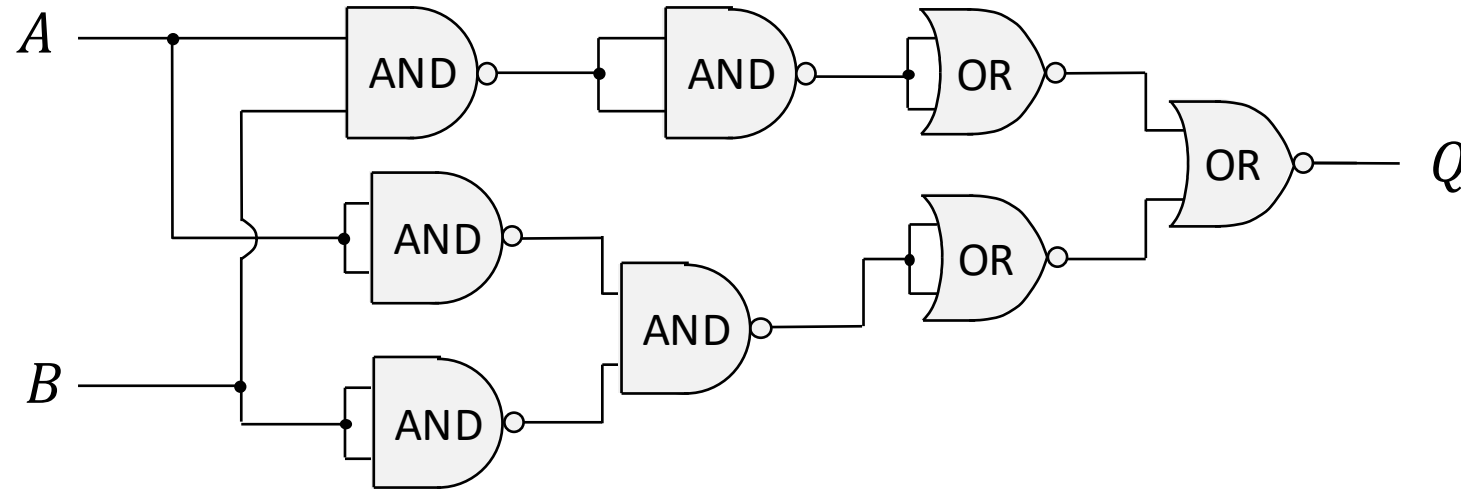
Combinational Logic Circuit Properties



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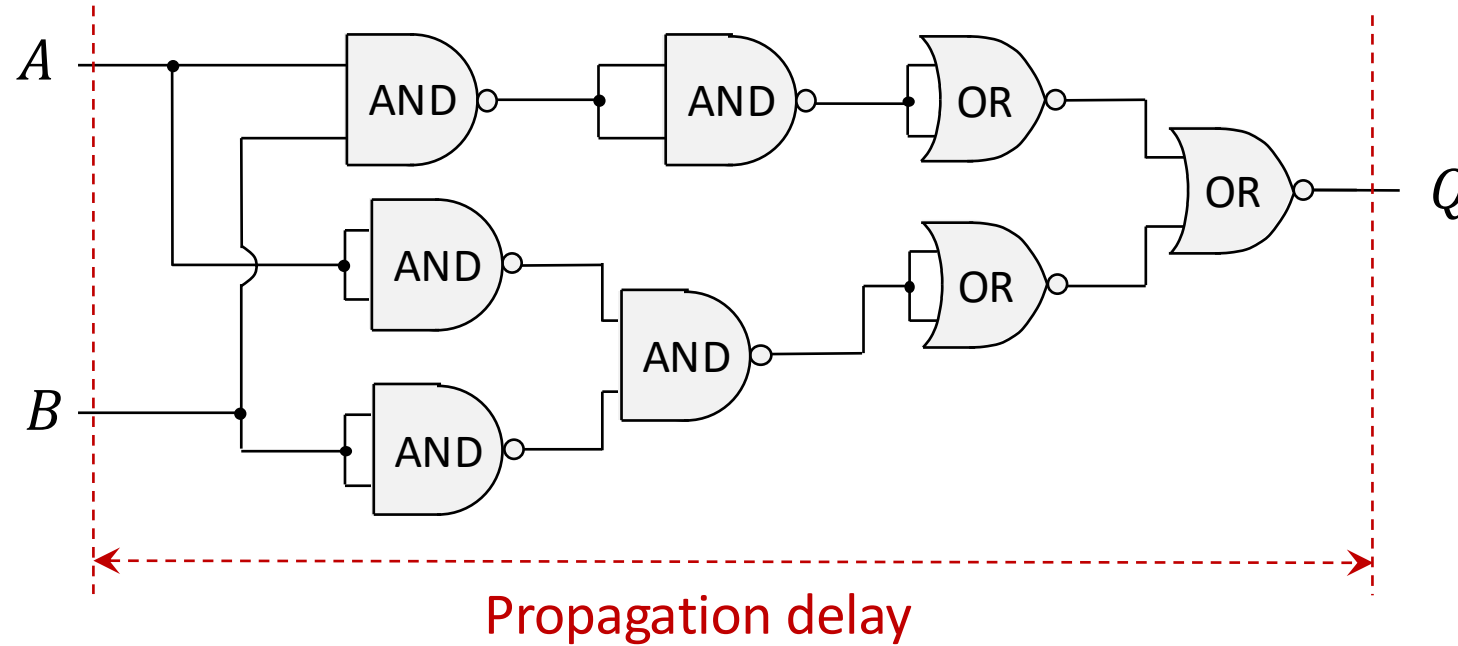
Observation: “shorter” wires are better, e.g. due to lower propagation delays
(there is some connection to Moore’s law)

Combinational Logic Circuit Properties



- 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

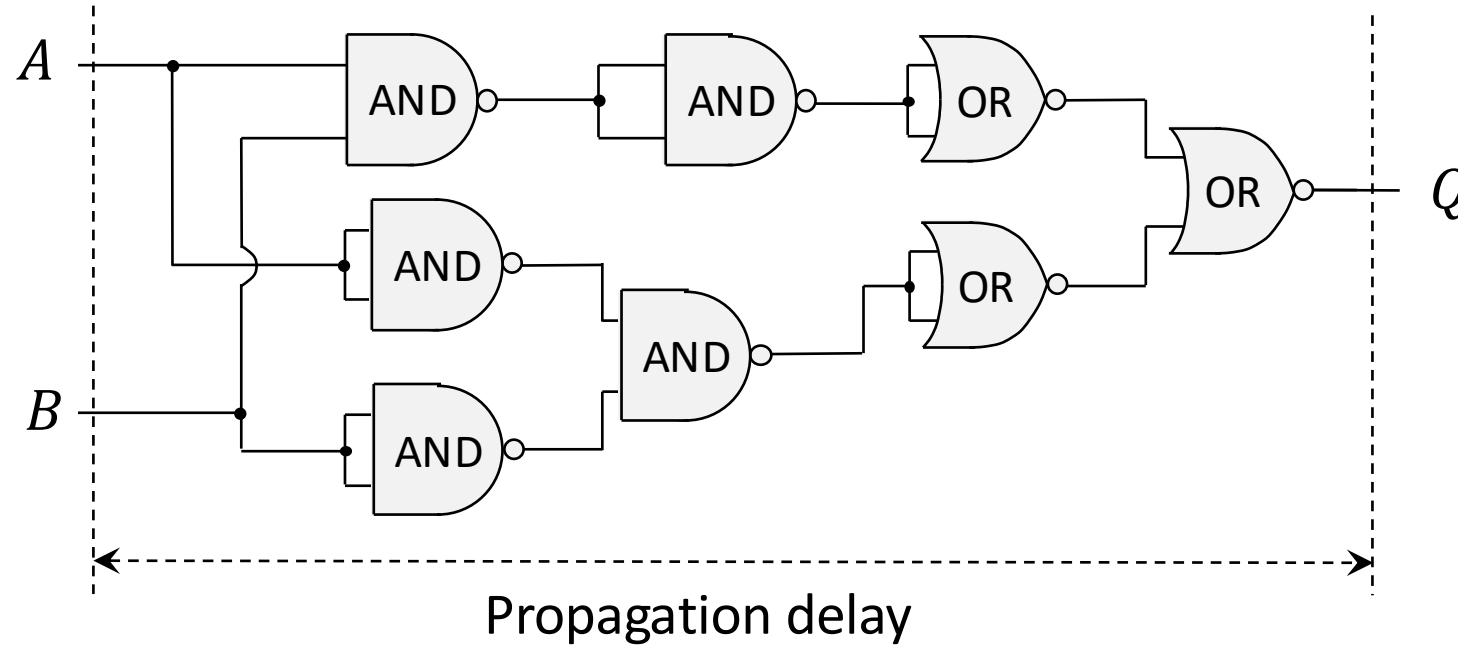
Combinational Logic Circuit Properties



- 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

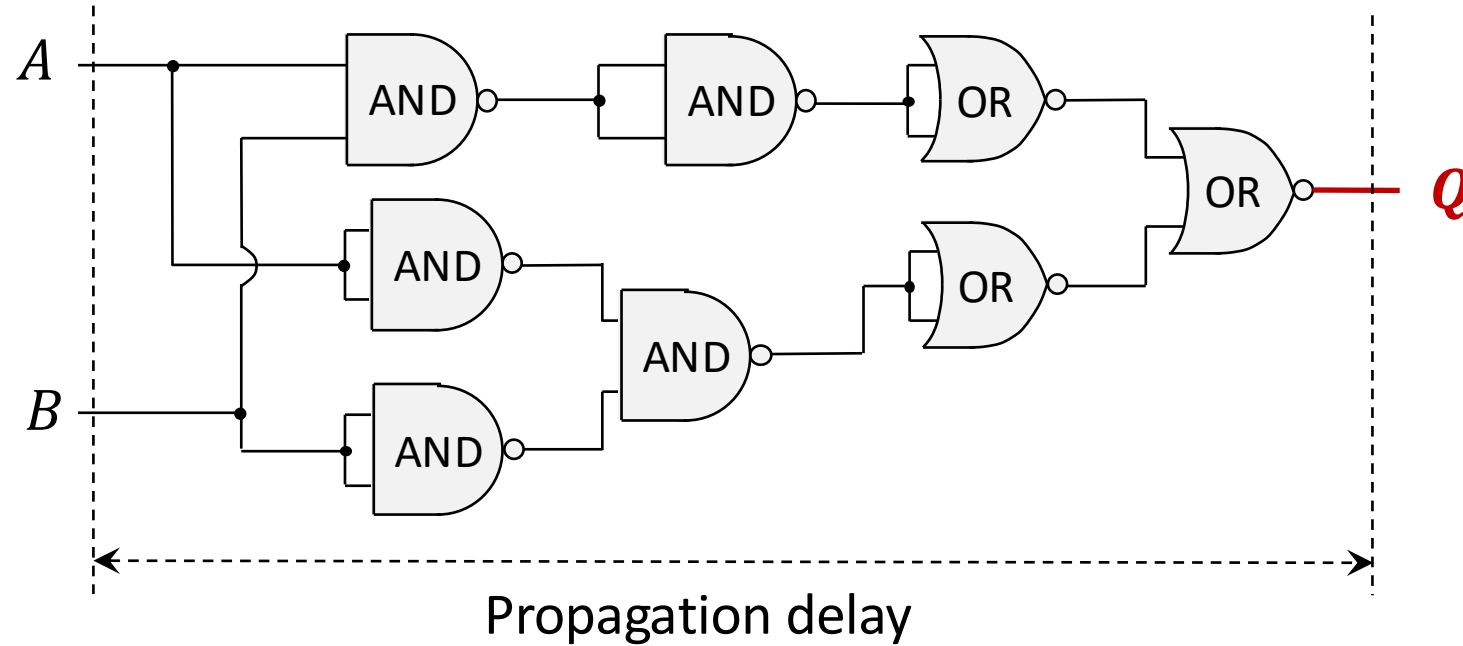
Combinational Logic Circuit Properties



- 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

Critical Path of the Integrated Circuit – the one taking the longest time
(results in the “worst case” propagation delay)

Combinational Logic Circuit Properties



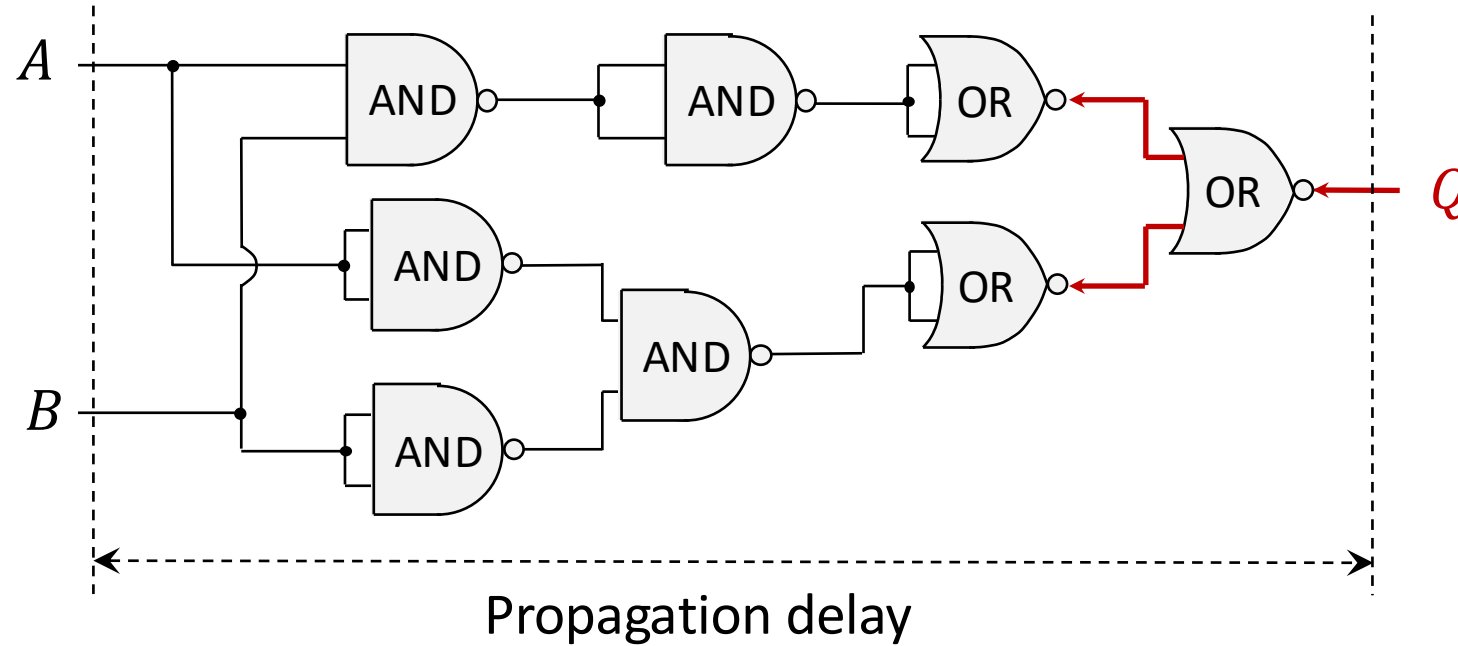
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Computed in the direction starting from the output pin(s)

Combinational Logic Circuit Properties

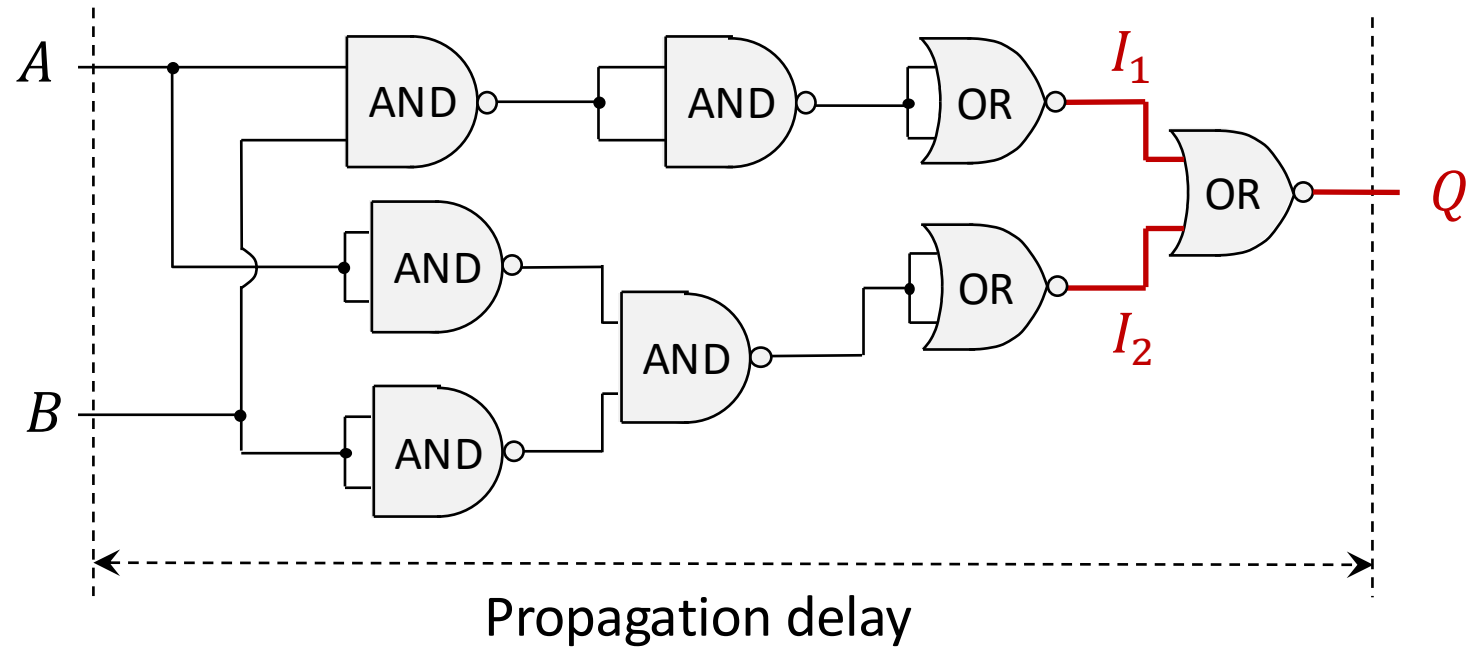


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Critical Path of the Integrated Circuit – the one taking the longest time
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Computed from the output pin(s)

Combinational Logic Circuit Properties



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;

Repeat backtracking, to compute the worst case delay

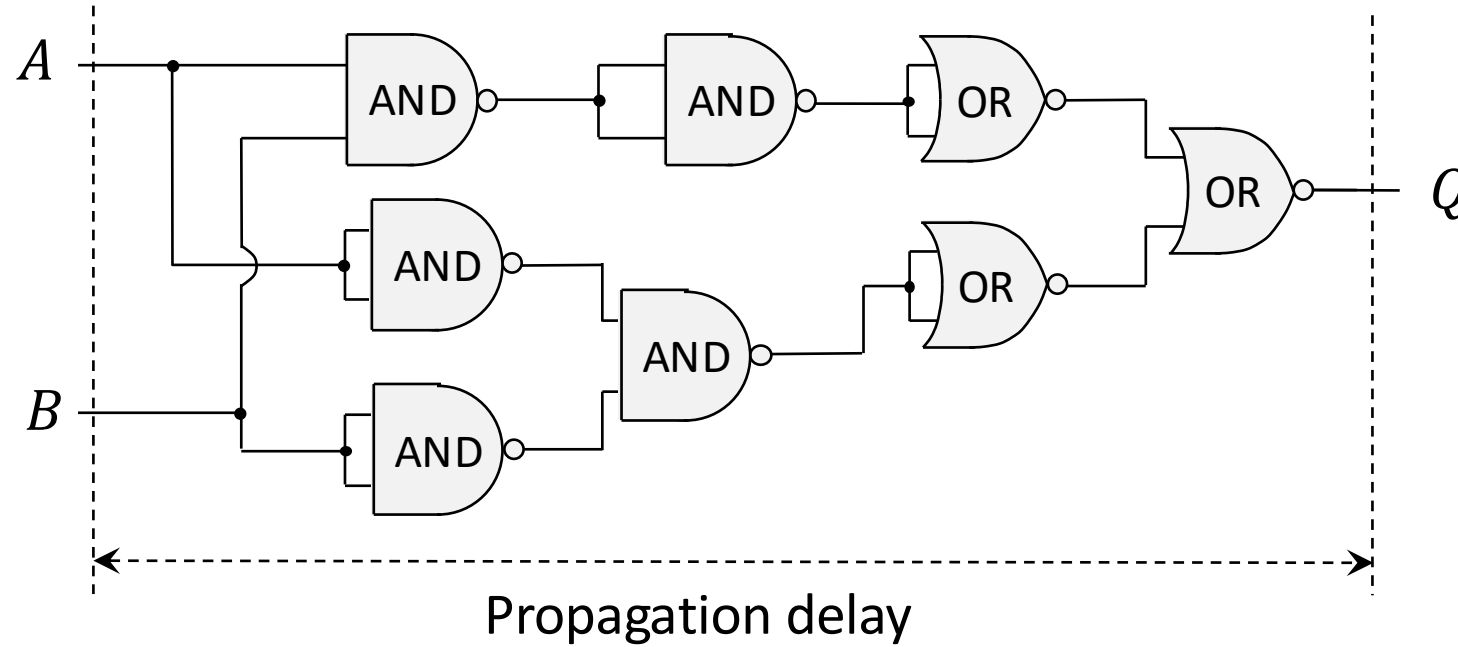
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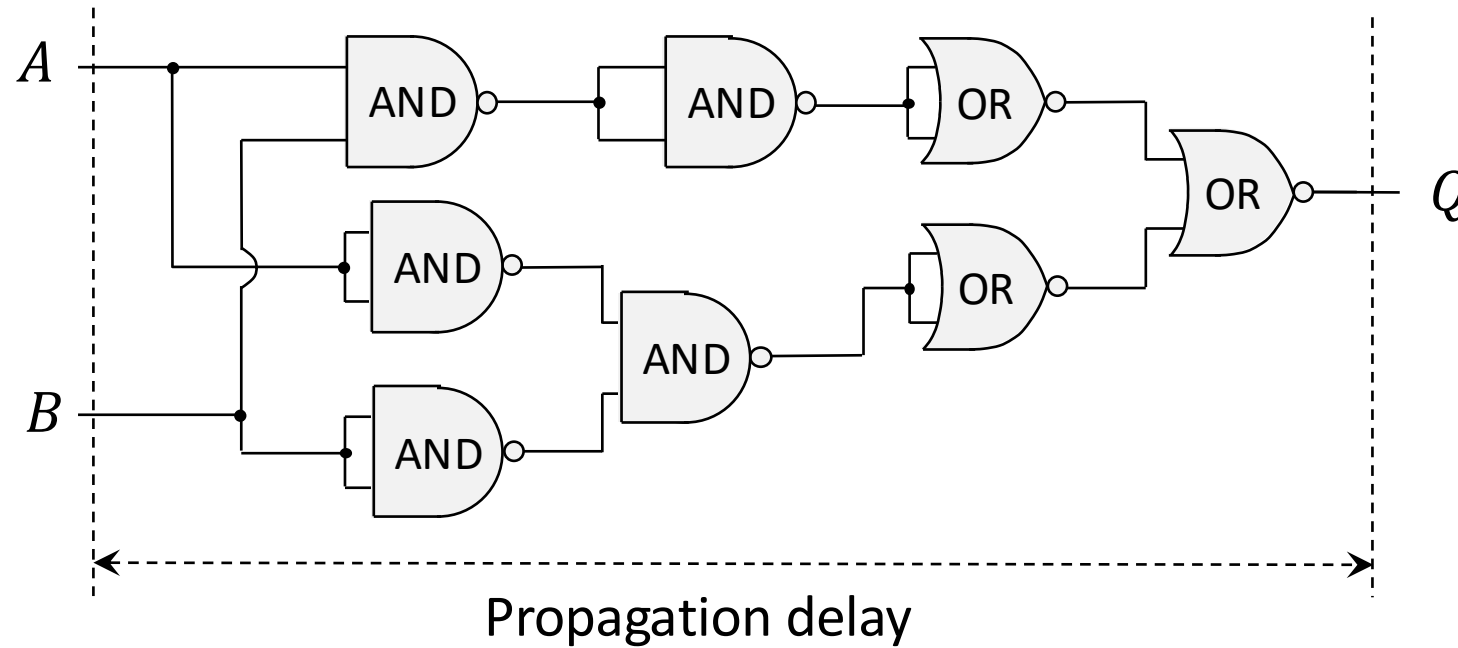
Combinational Logic Circuit Properties



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Combinational Logic Circuit Properties



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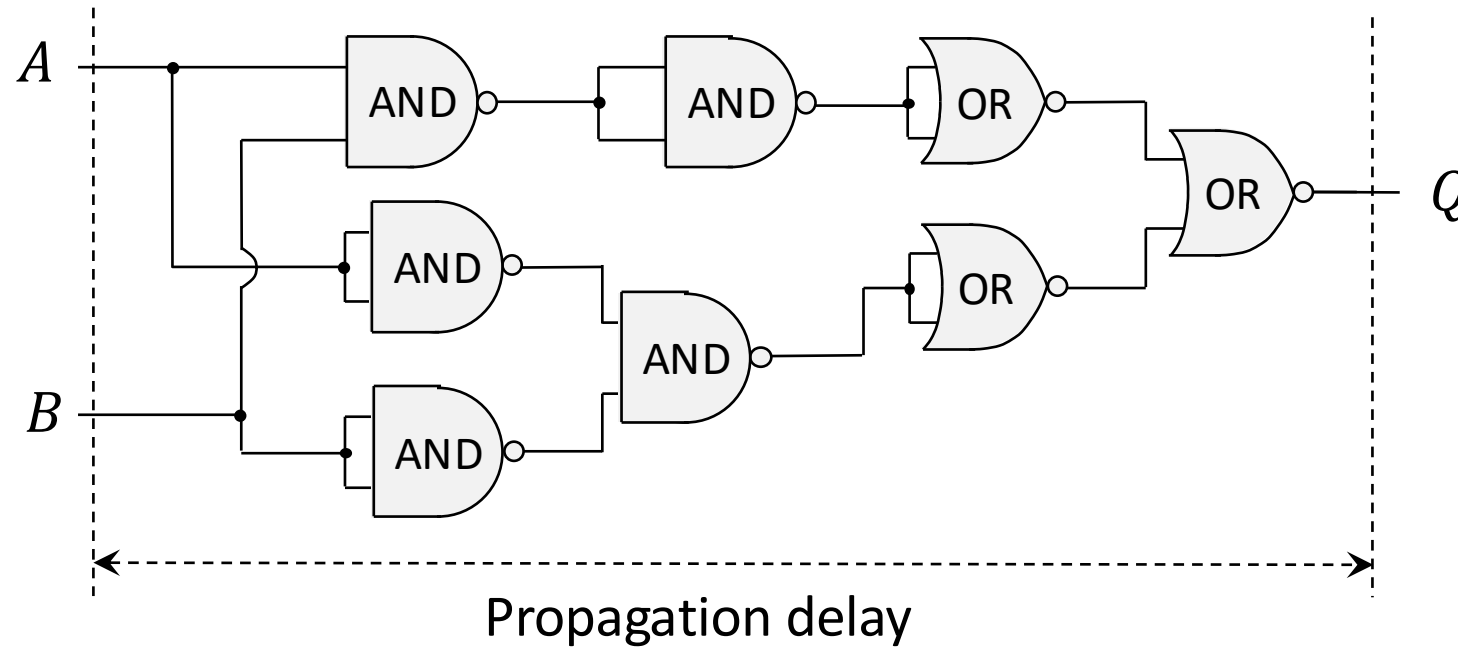
Sample timing diagram:

“0” – deasserted state;

“1” - asserted



Combinational Logic Circuit Properties



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

Sample timing diagram:

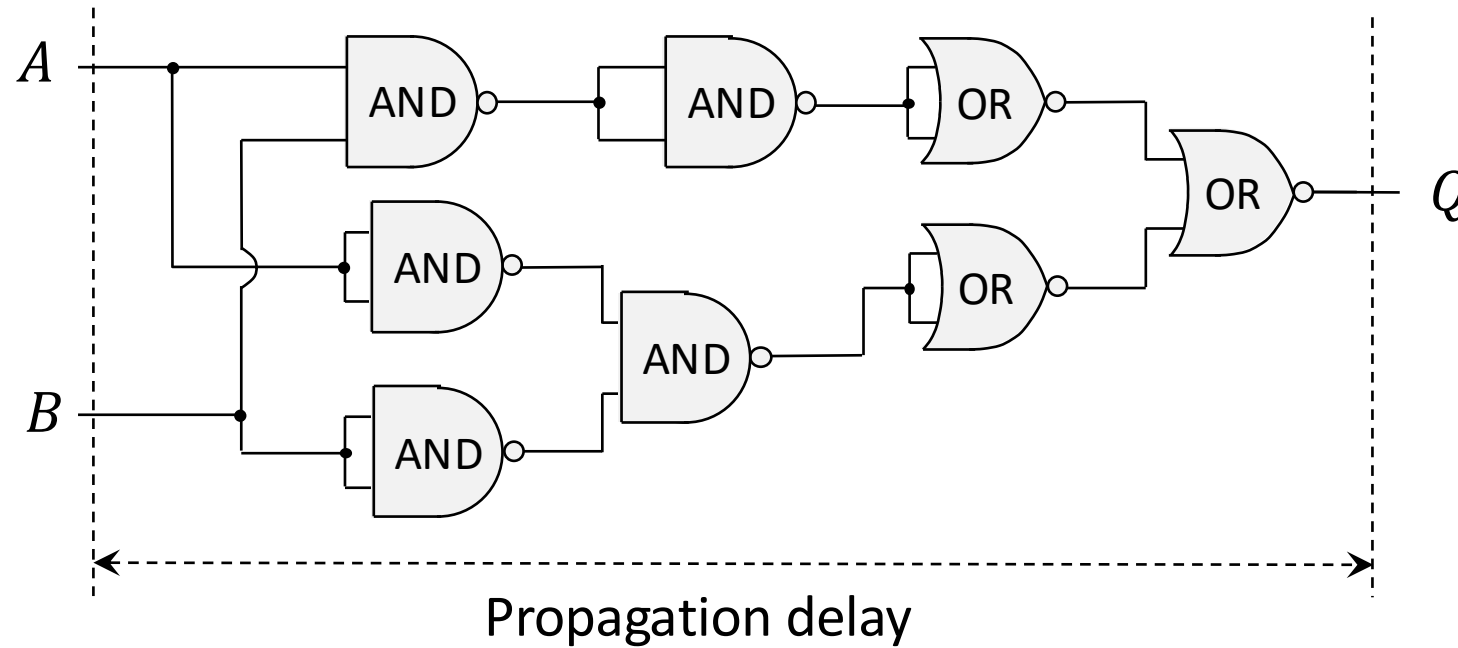
“0” – deasserted state;

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Might not correspond
to the circuit above



Recap: Characteristics of Combinational Logic Circuits



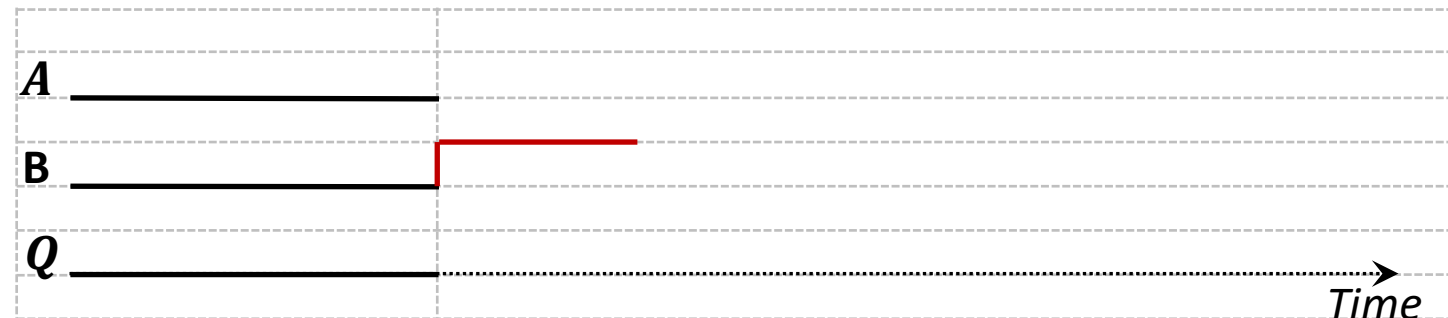
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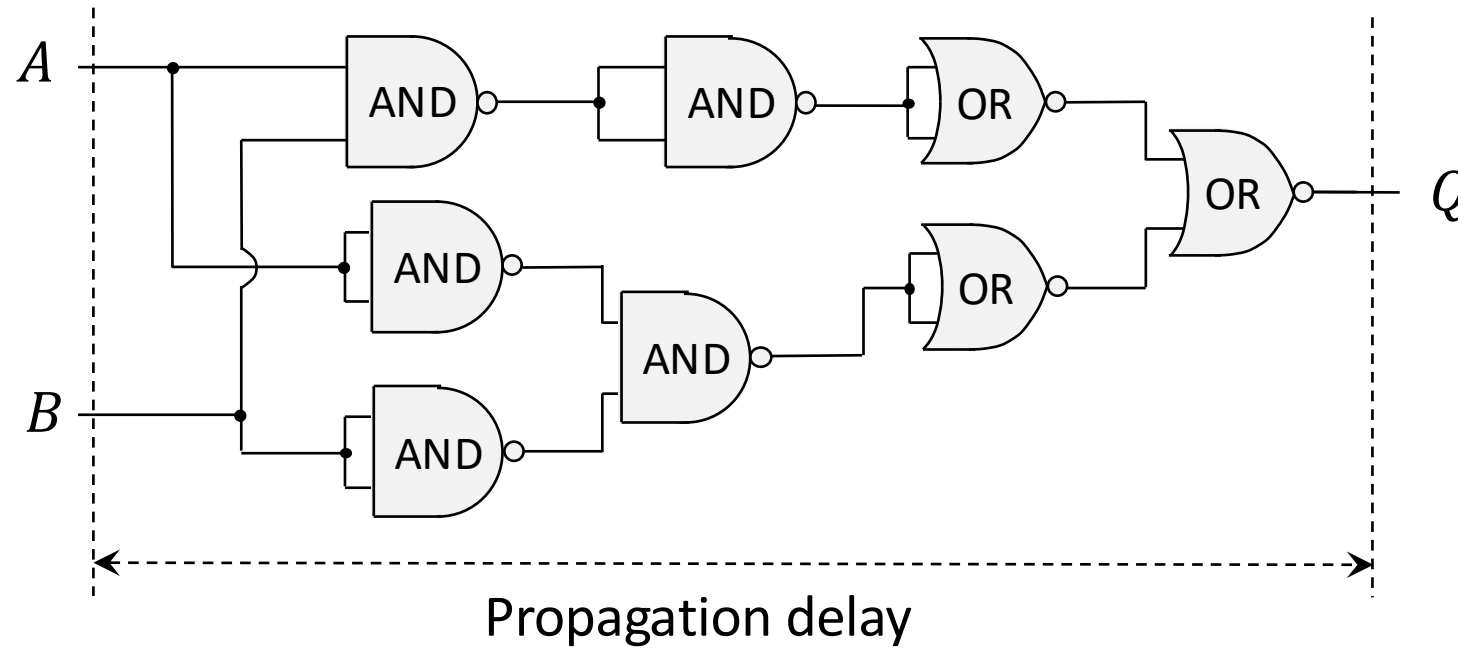
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Combinational Logic Circuit Properties



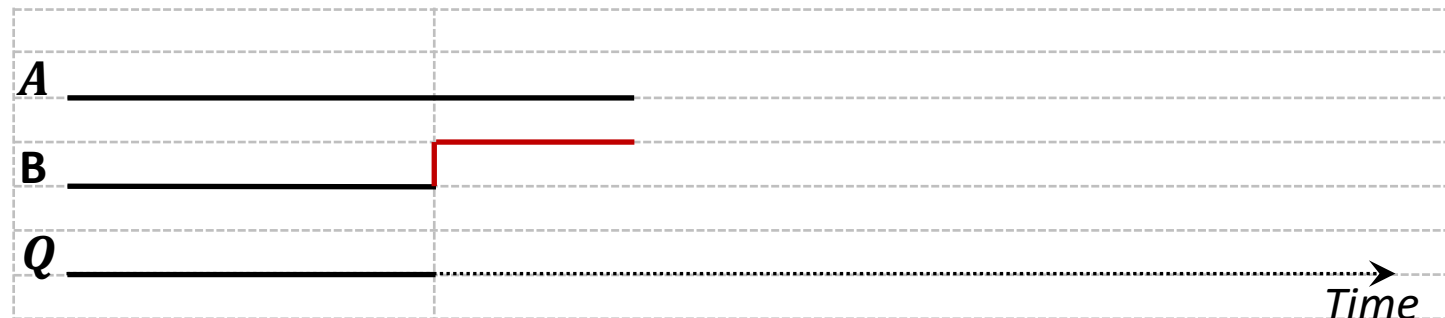
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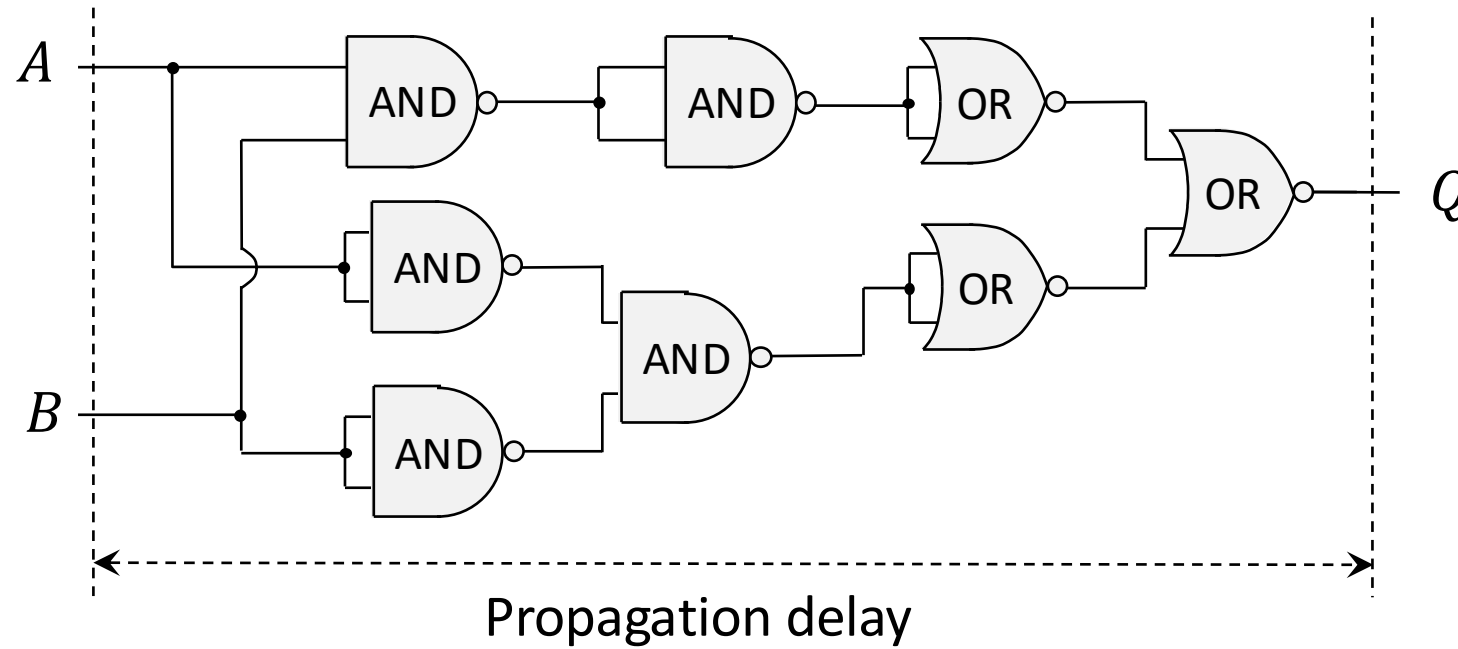
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Combinational Logic Circuit Properties



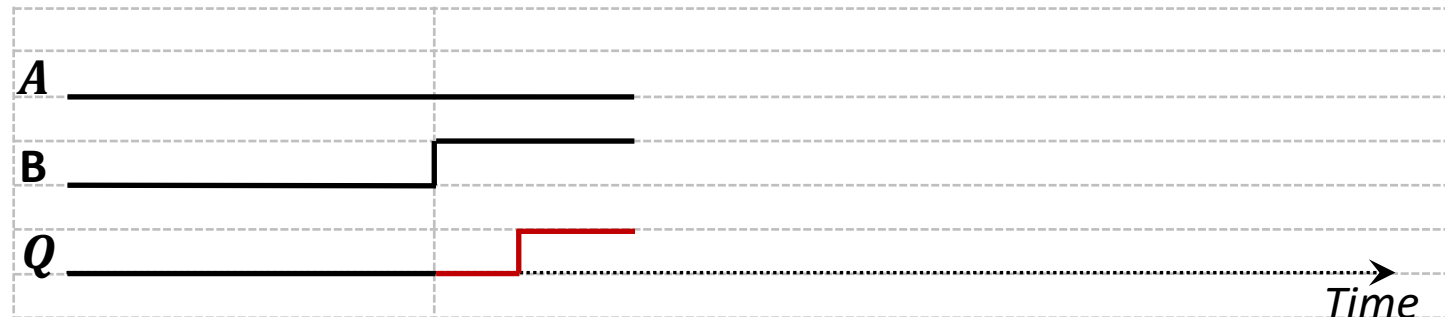
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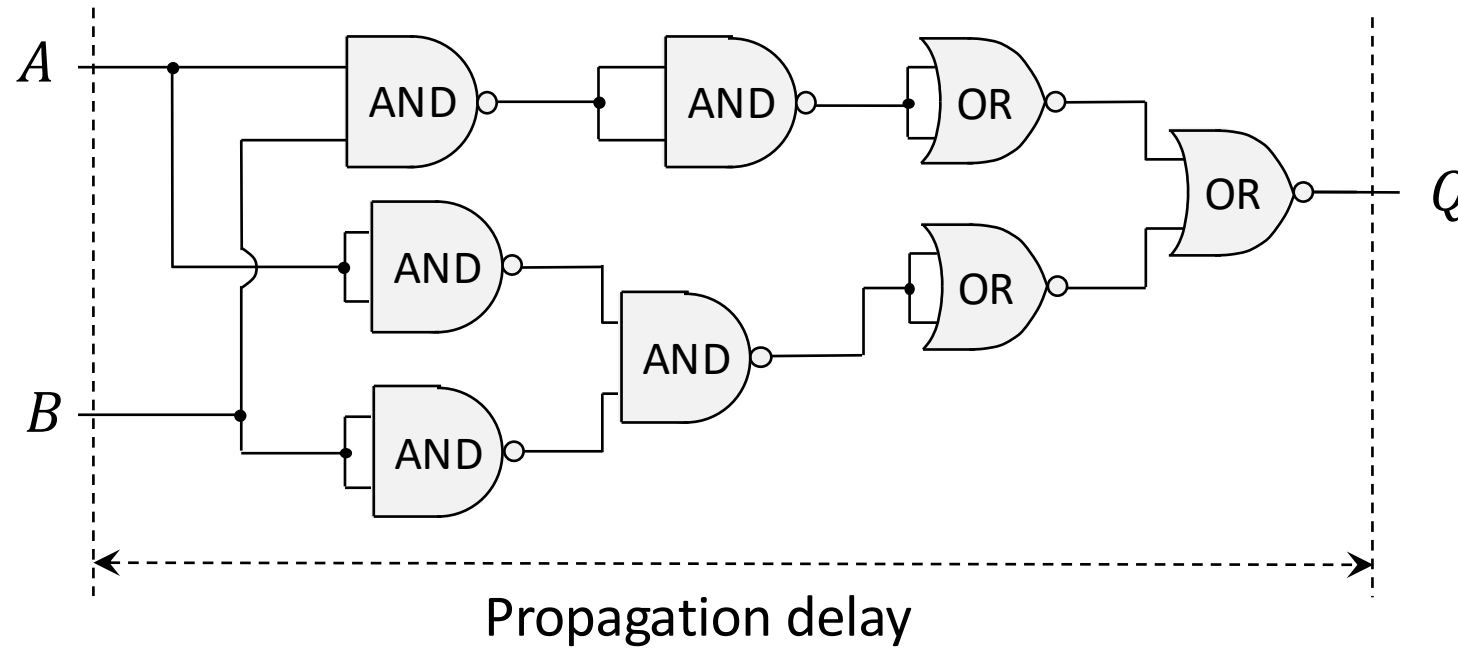
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Combinational Logic Circuit Properties



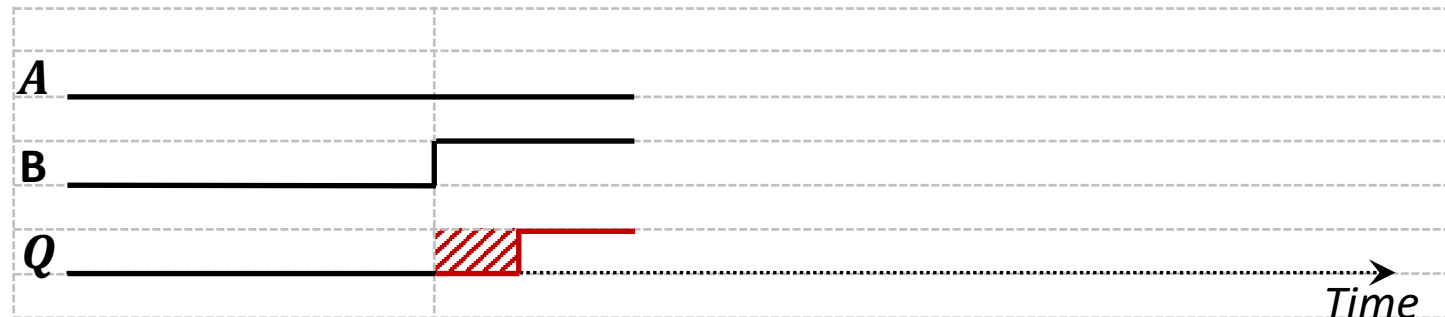
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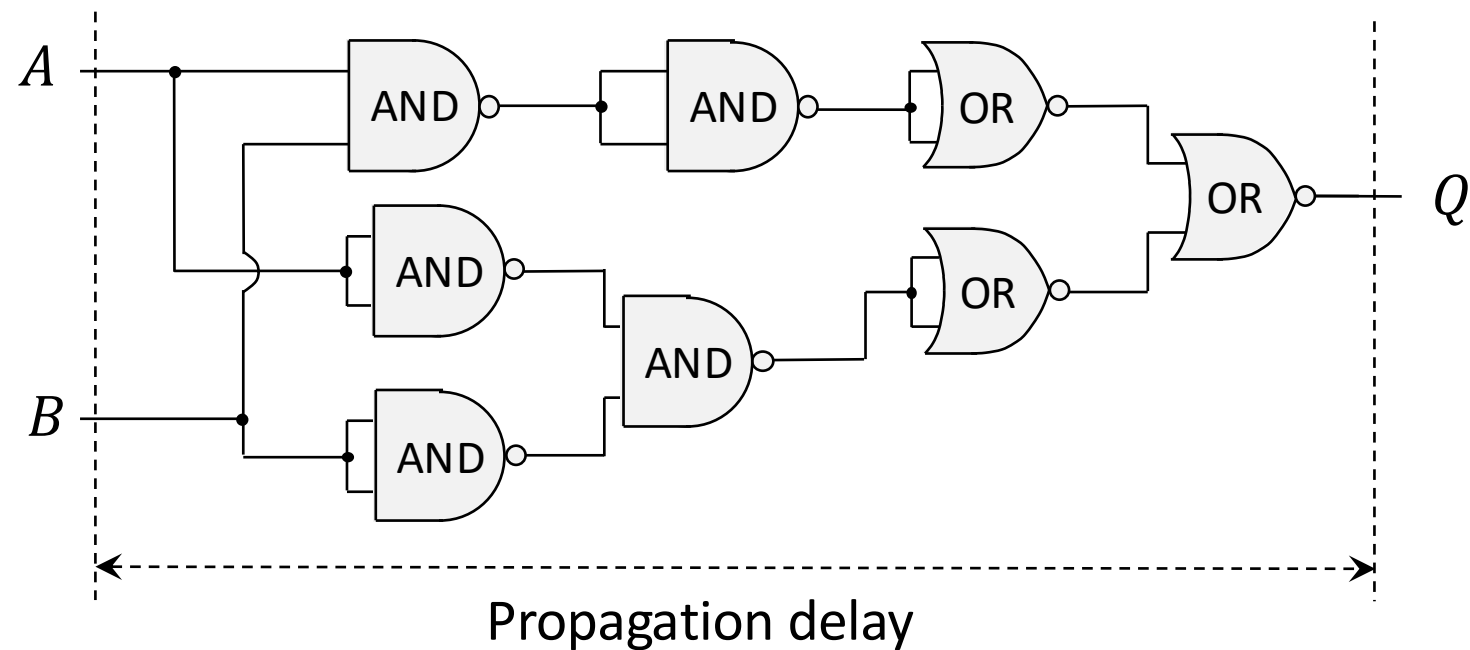
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Combinational Logic Circuit Properties

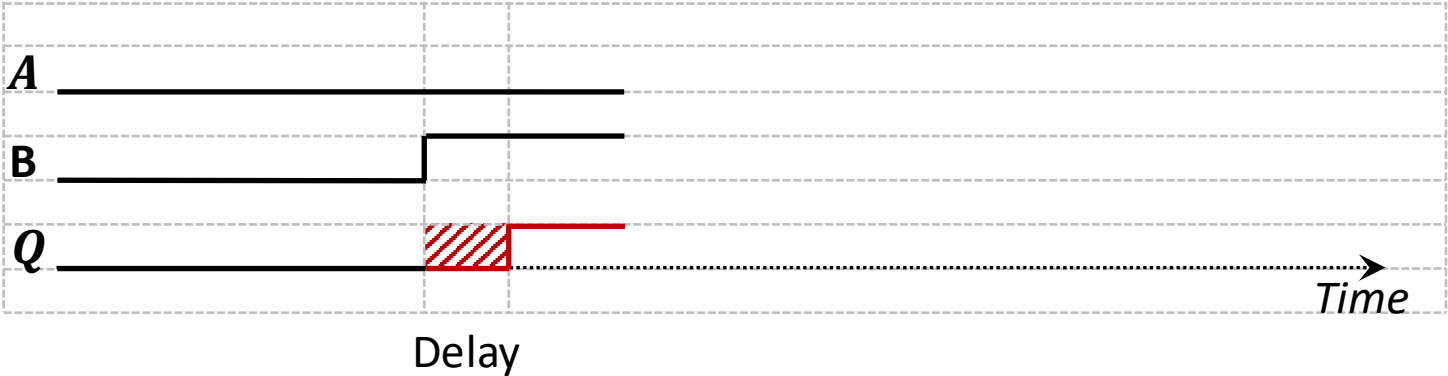


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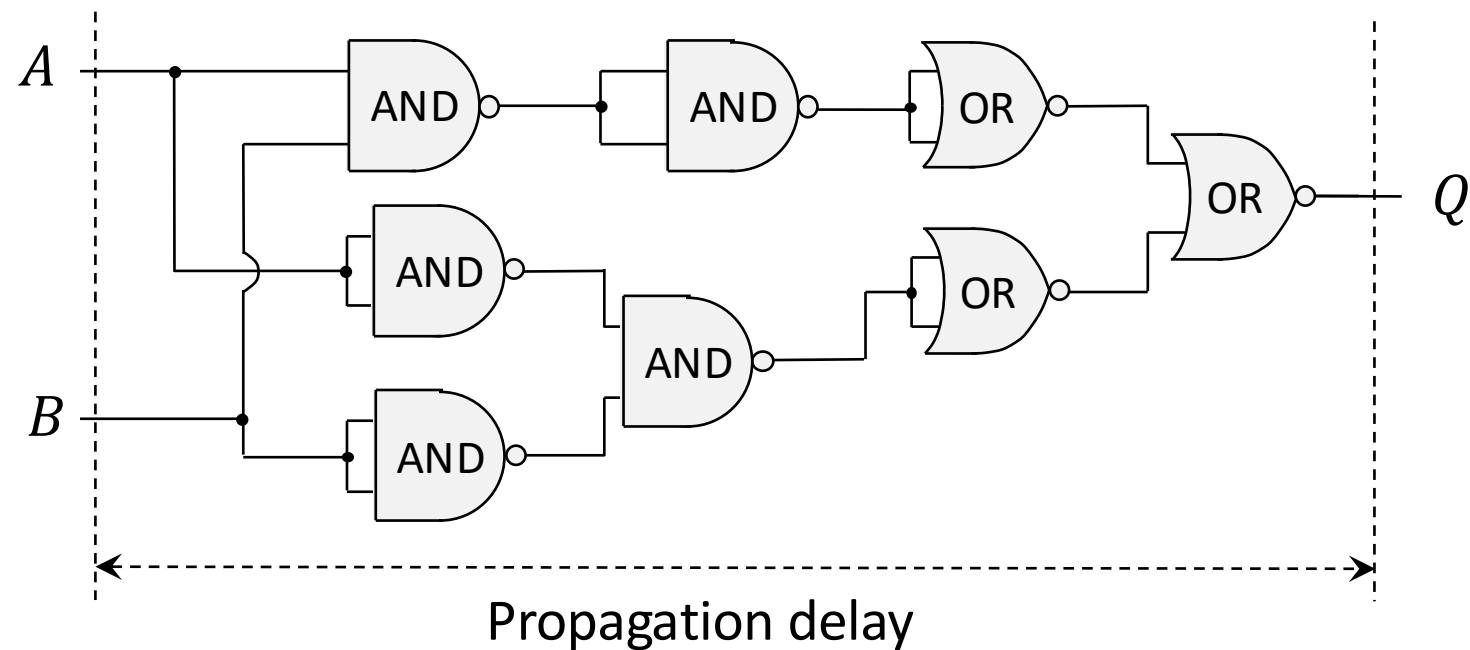
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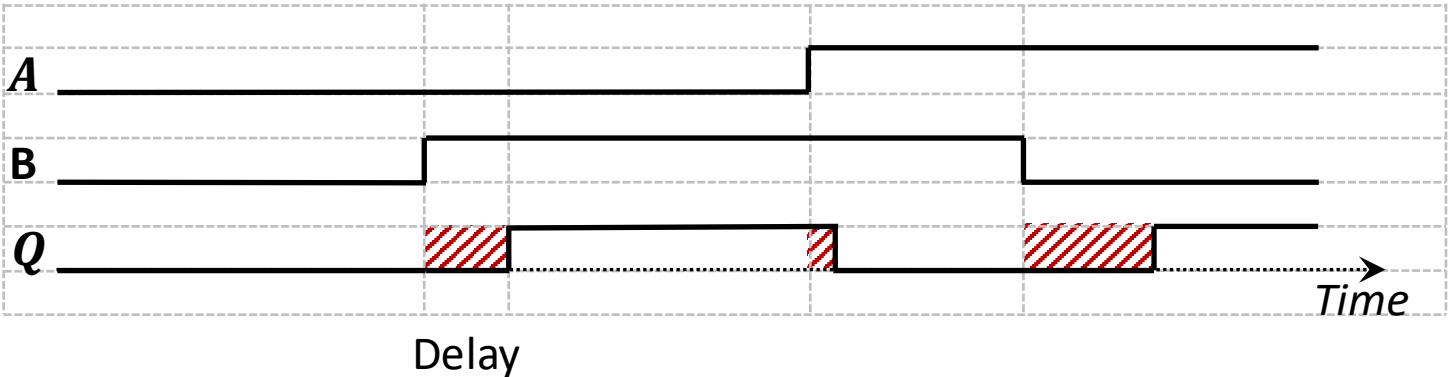


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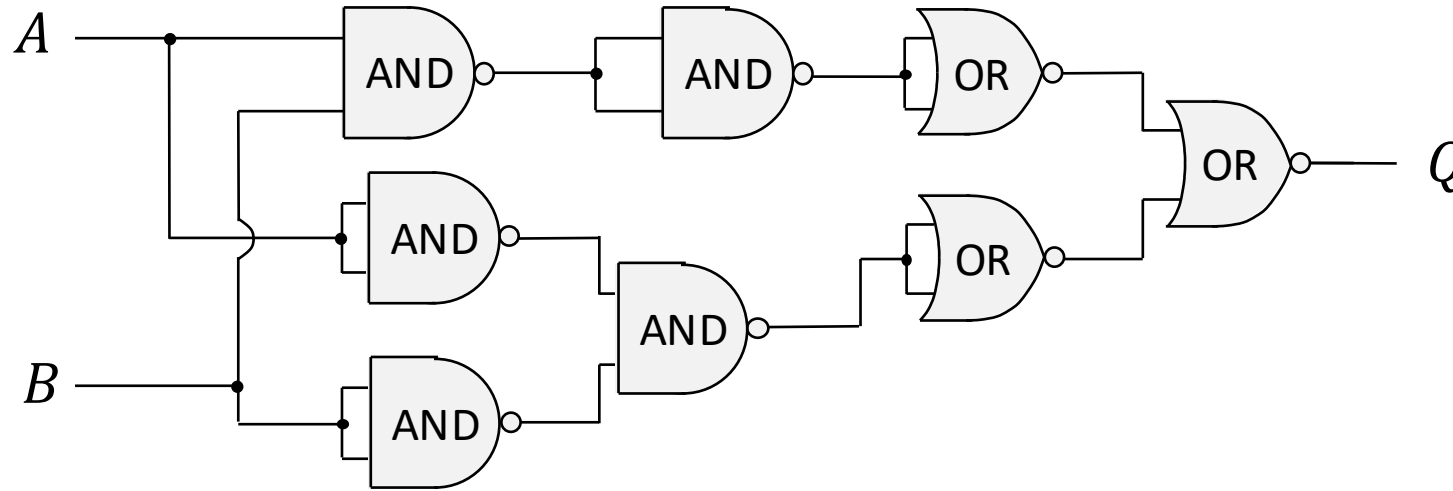
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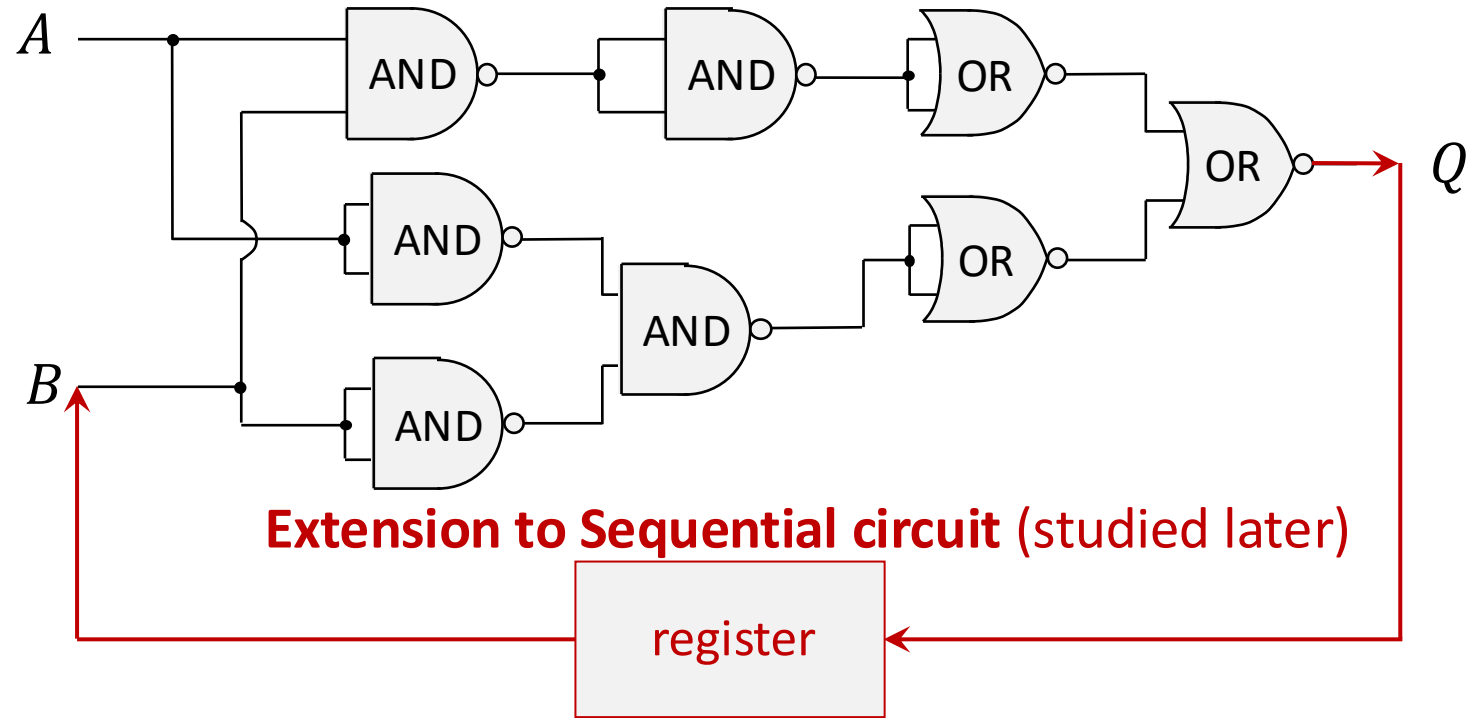


Combinational Logic Circuit Properties



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

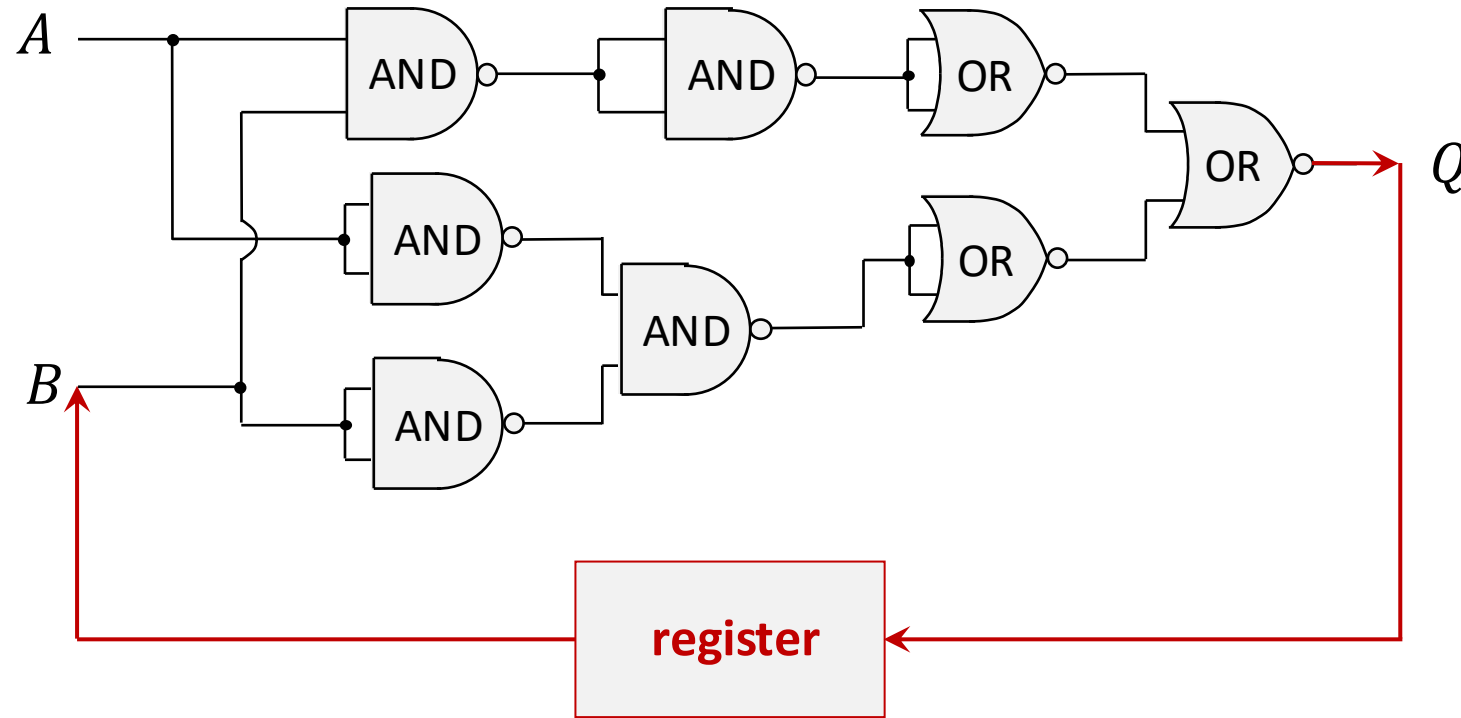
Combinational Logic Circuit Properties



- 4) Use no memory units, such as registers (as opposed to “sequential” circuits – to be discussed)

Sequential circuits – the addition to combinational

Combinational Logic Circuit Properties

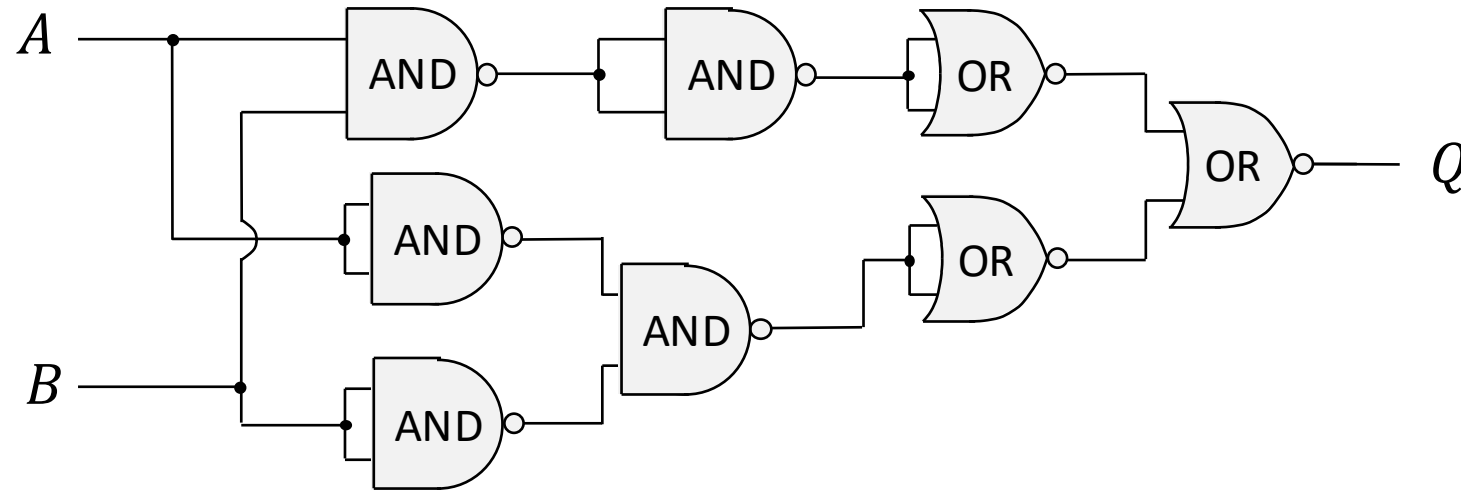


- 4) Use no memory units, such as registers (as opposed to “sequential” circuits – to be discussed)

Sequential circuits – an alternative to combinational

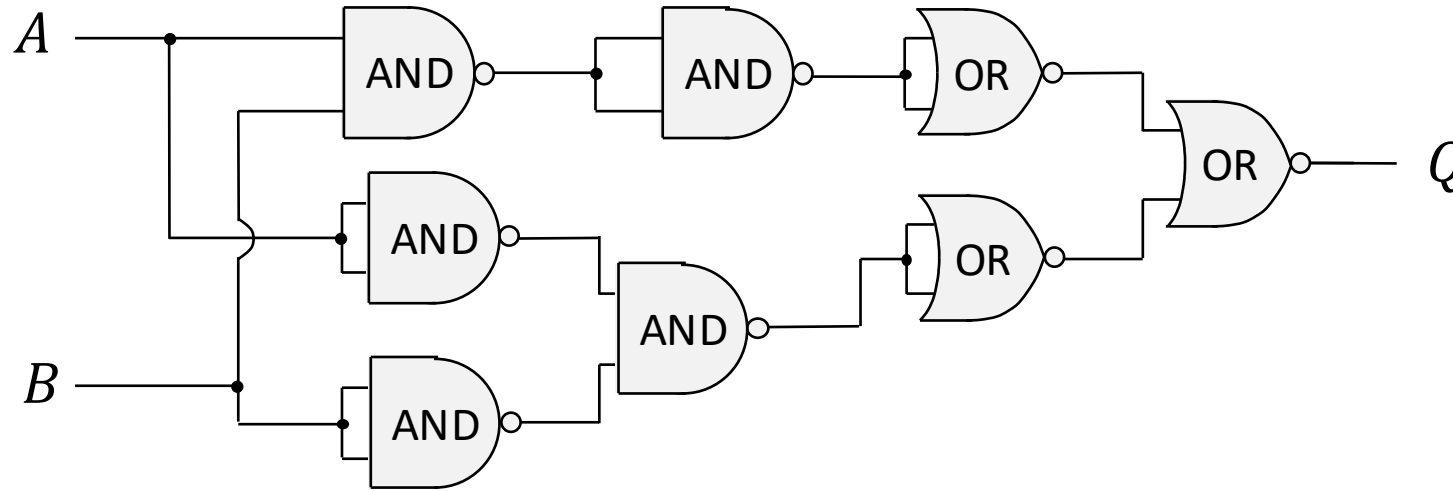
Register (from “to register” = “to remember”) – a memory element, to store an electrical charge

Recap: Characteristics of Combinational Logic Circuits



- 1) An output signal depends just on “current” input signals (“combinational” = combine inputs)
- 2) Comprised of logic gates, such as AND, OR, etc., and wires connecting them
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- 5) **Typically, no clock signal is present (exceptions might apply)**

Recap: Characteristics of Combinational Logic Circuits

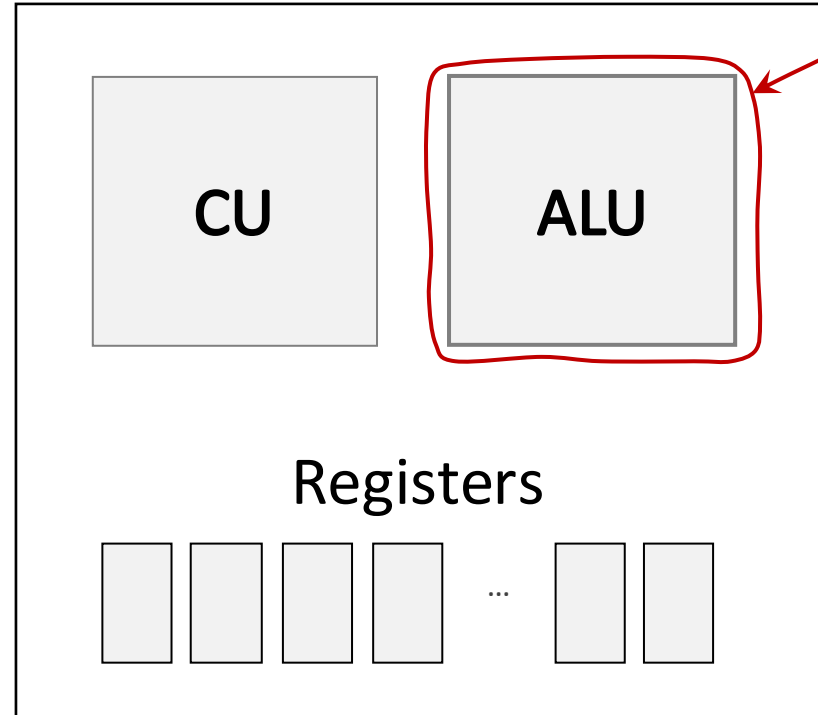


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- 5) Typically, no clock signal is present (exceptions might apply)

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

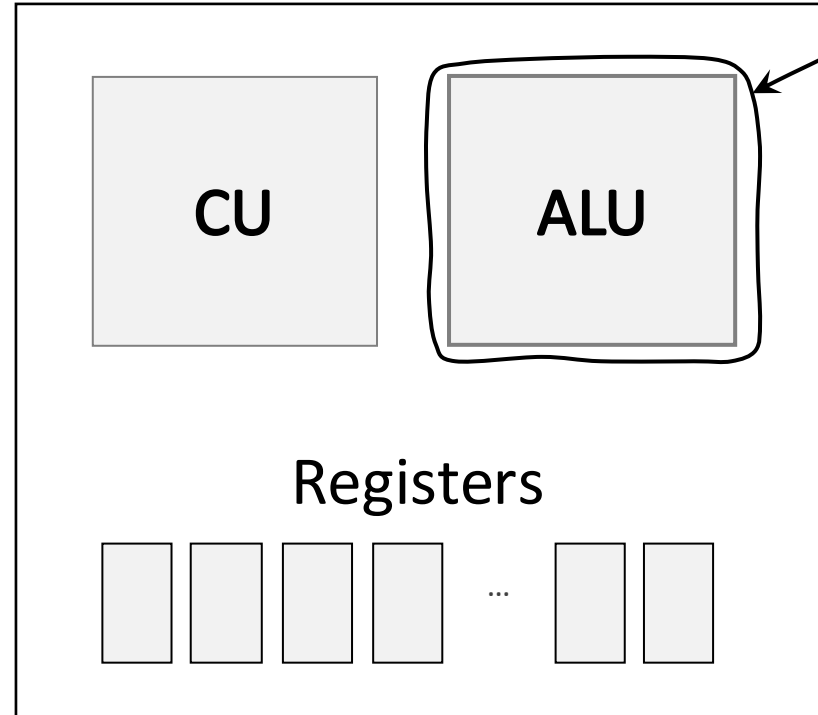
Key disadvantage: No support of inputs synchronization (will be discussed later)

Types of Logic Circuits for CPU Components



Combinational logic circuit
for arithmetical and logic
operations

Types of Logic Circuits for CPU Components

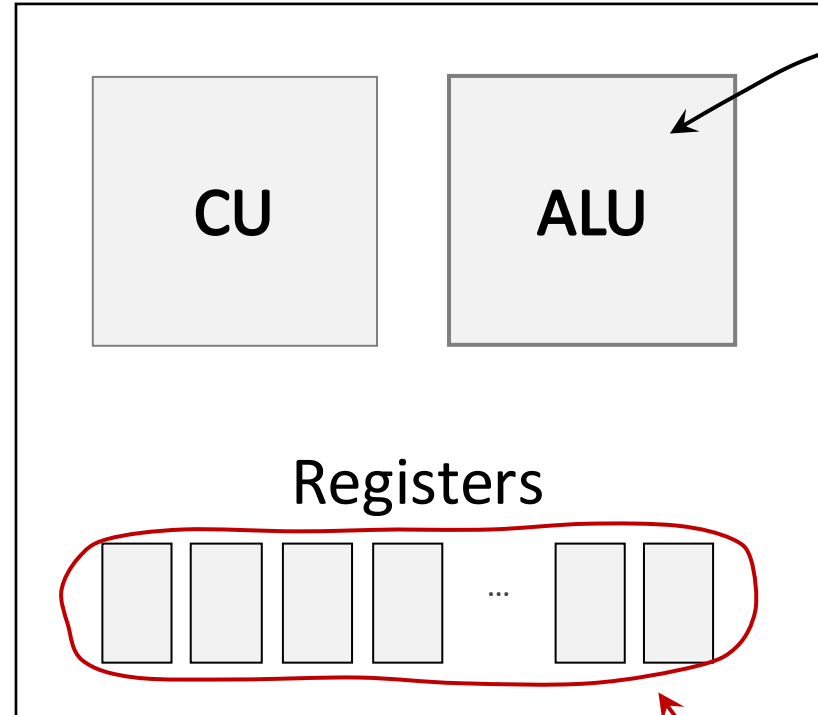


Combinational logic circuit
for arithmetical and logic
operations

Fast - advantage

No synchronization support
- disadvantage

Types of Logic Circuits for CPU Components



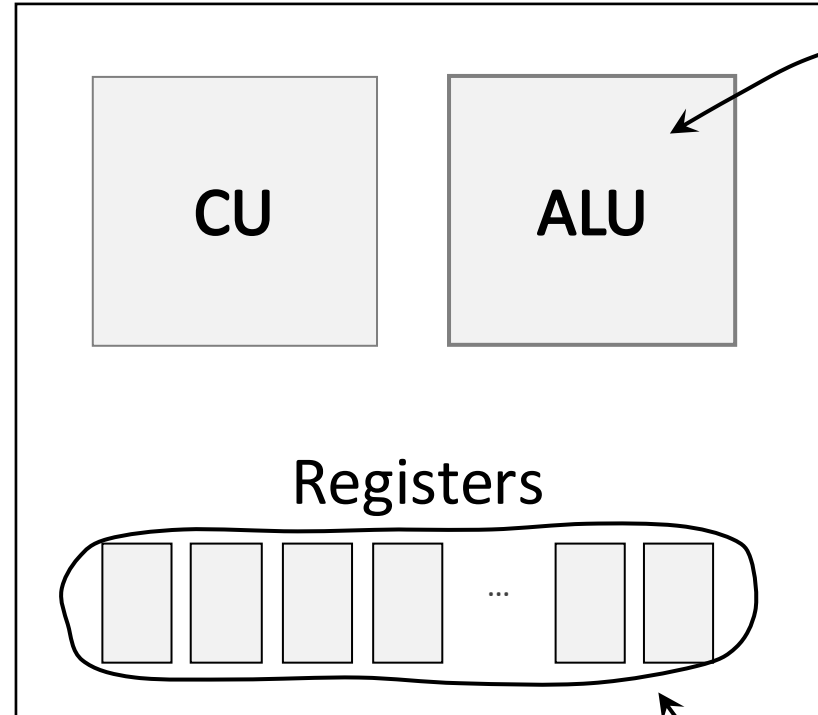
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Sequential logic circuits (clocked)

Types of Logic Circuits for CPU Components



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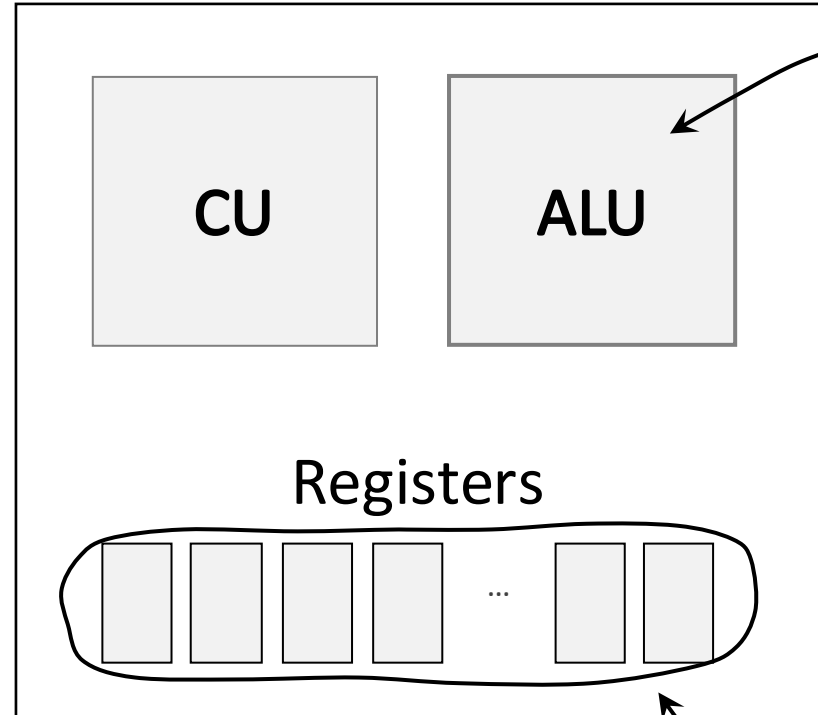
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Sequential logic circuits (clocked)

1) Capture inputs (might arrive not simultaneously);

Types of Logic Circuits for CPU Components



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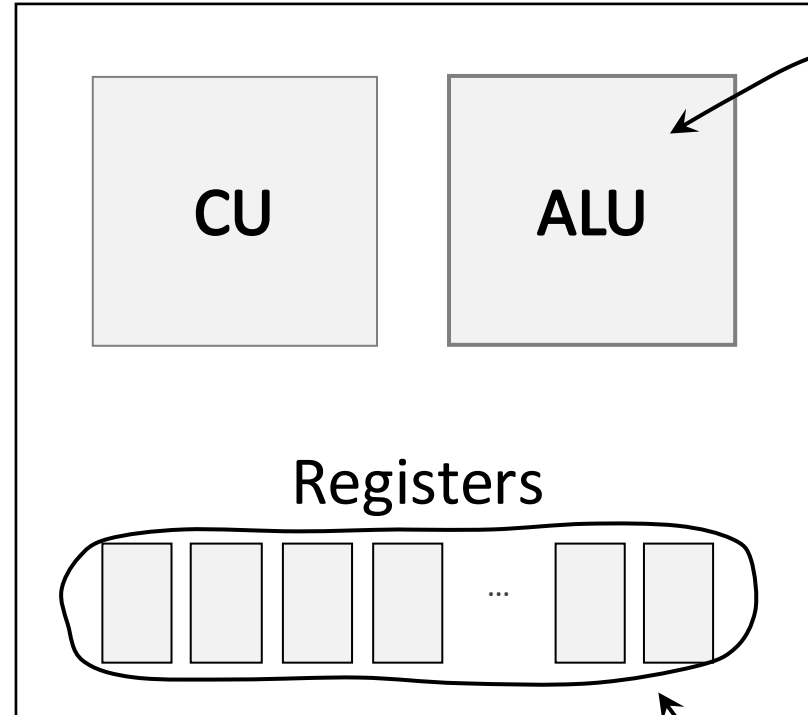
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Sequential logic circuits (clocked)

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

Types of Logic Circuits for CPU Components



Combinational logic circuit
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operations

Fast - advantage

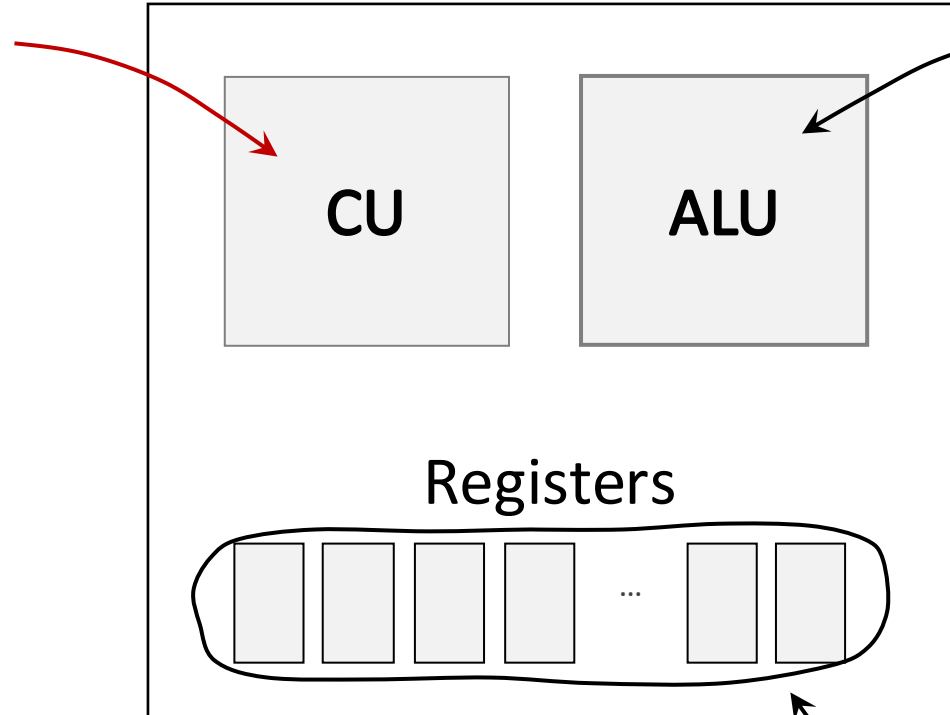
No synchronization support
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Sequential logic circuits (clocked)

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

No synchronization support
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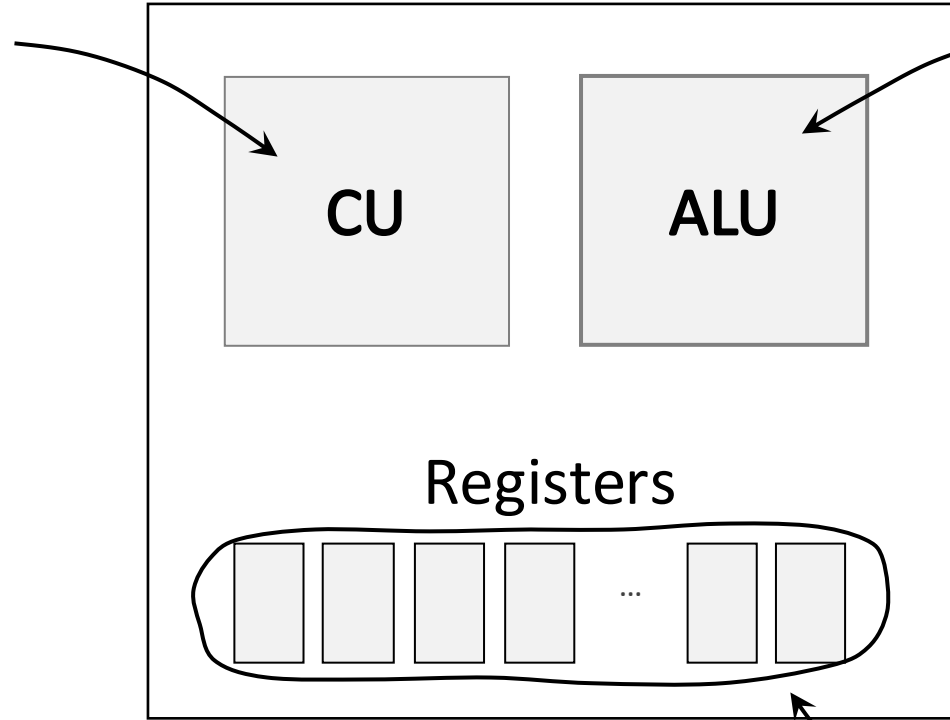
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Types of Logic Circuits for CPU Components

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
operations

Fast - advantage

No synchronization support
- disadvantage

Sequential logic circuits (clocked)

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