

Computer Architecture
Lecture Week 7 (Part II)

Asynchronous vs. Synchronous Circuits: Latches vs. Flip-Flops Example

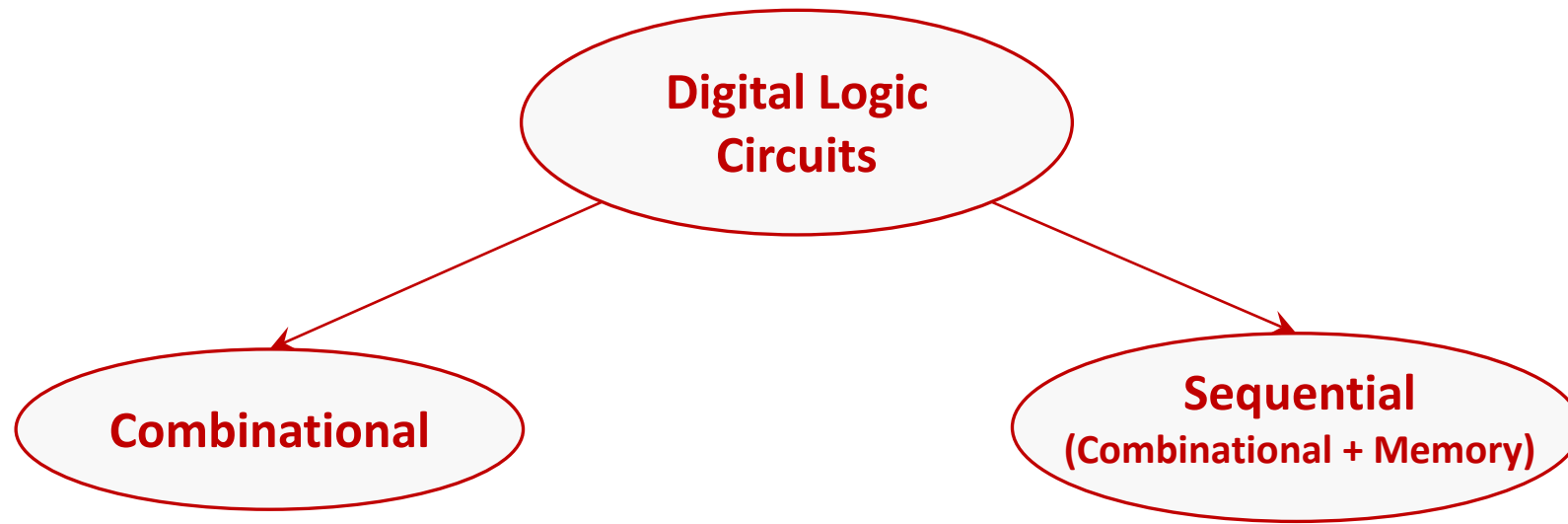
Artem Burmyakov

October 17, 2025

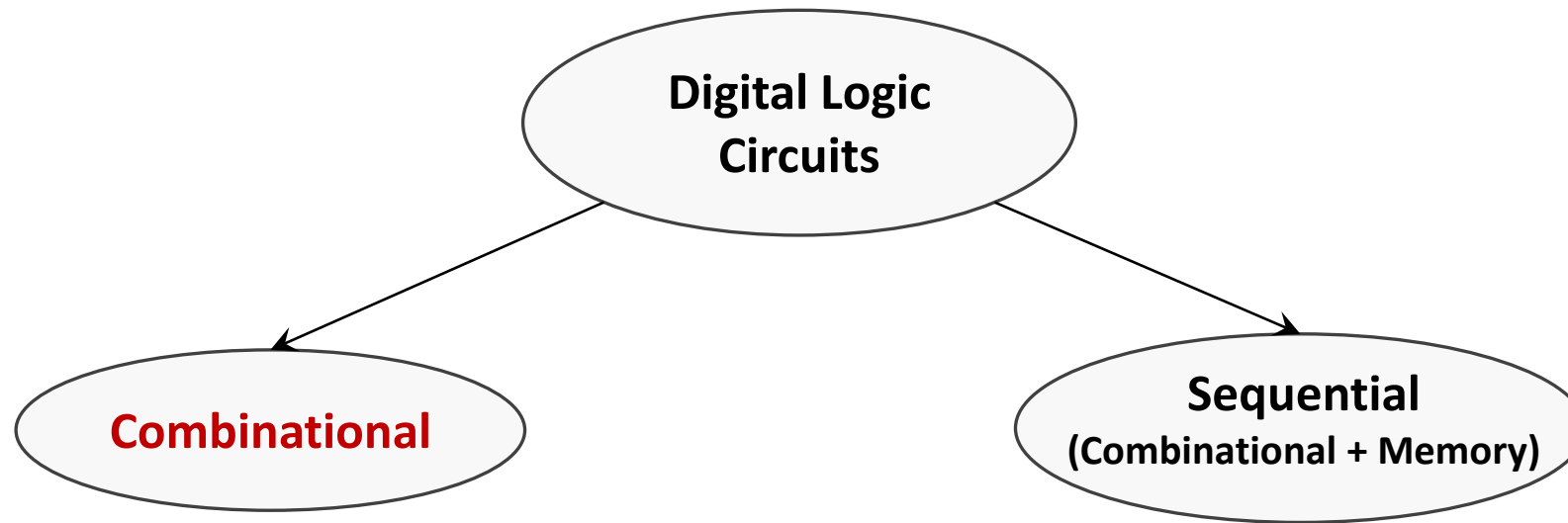


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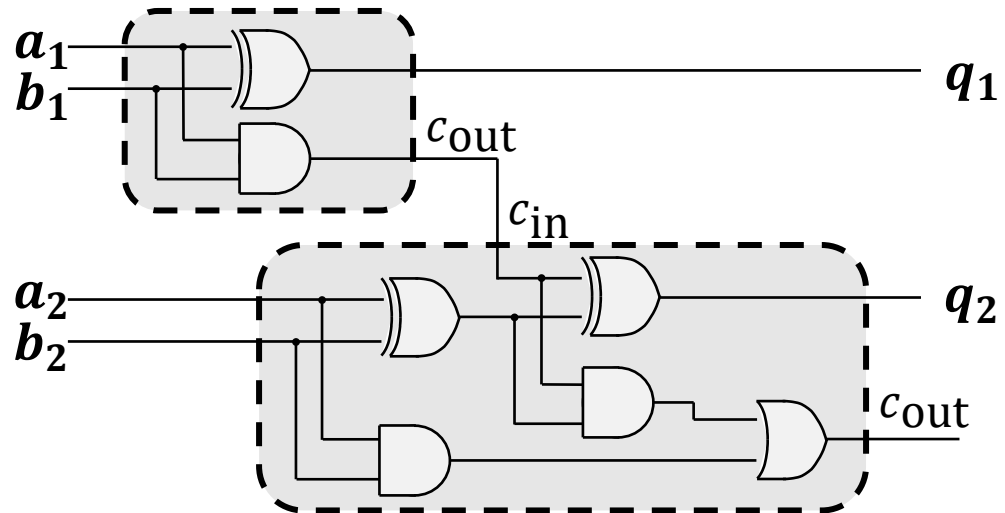
Digital Circuits Classification



Digital Circuits Classification

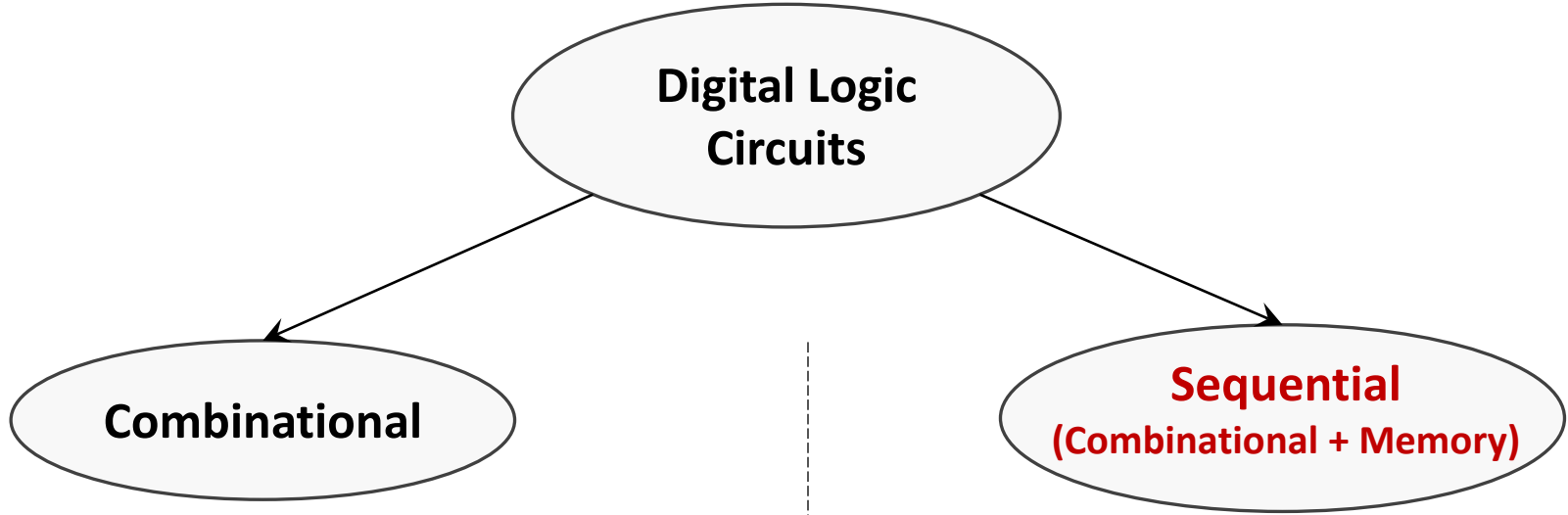


Example: Adder Circuit

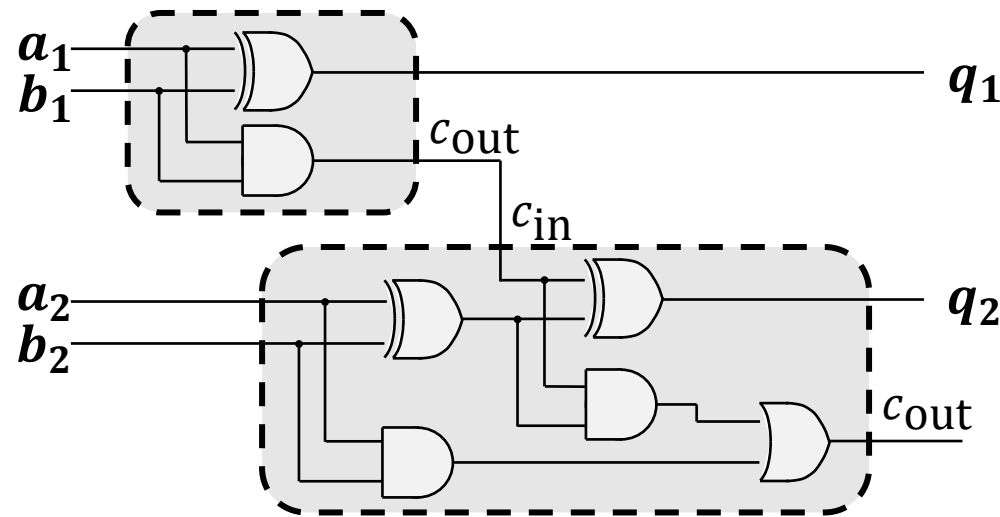


Uses **NO** memory or clock elements

Digital Circuits Classification

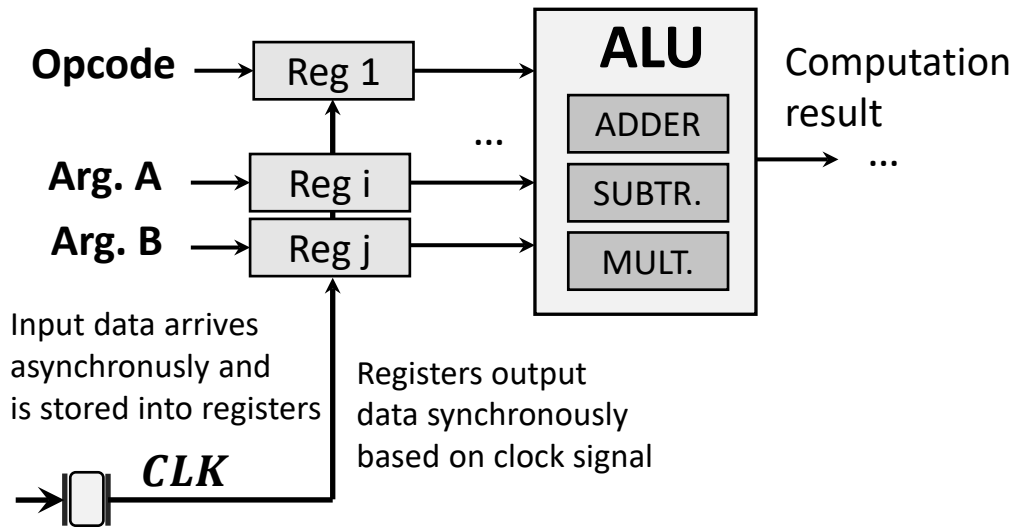


Example: Adder Circuit



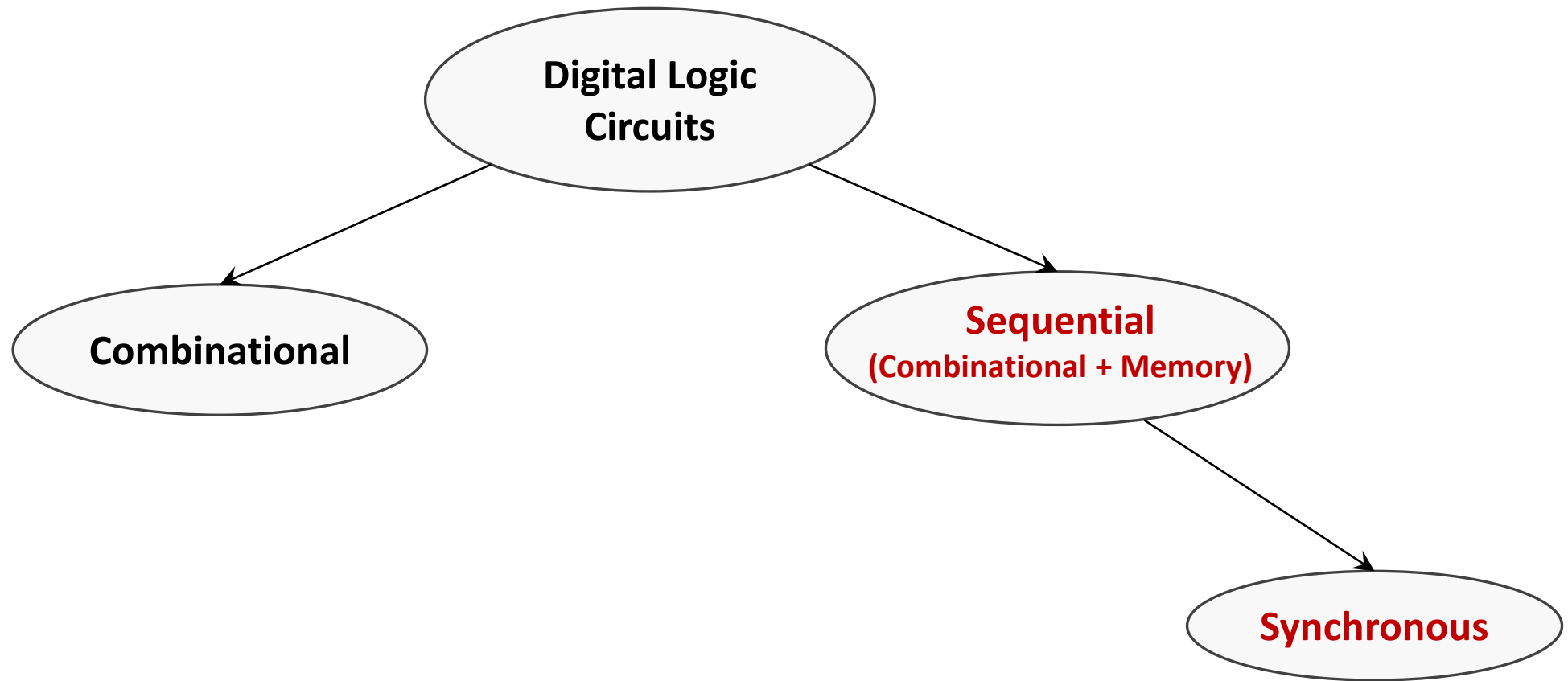
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Example: ALU + CPU Registers

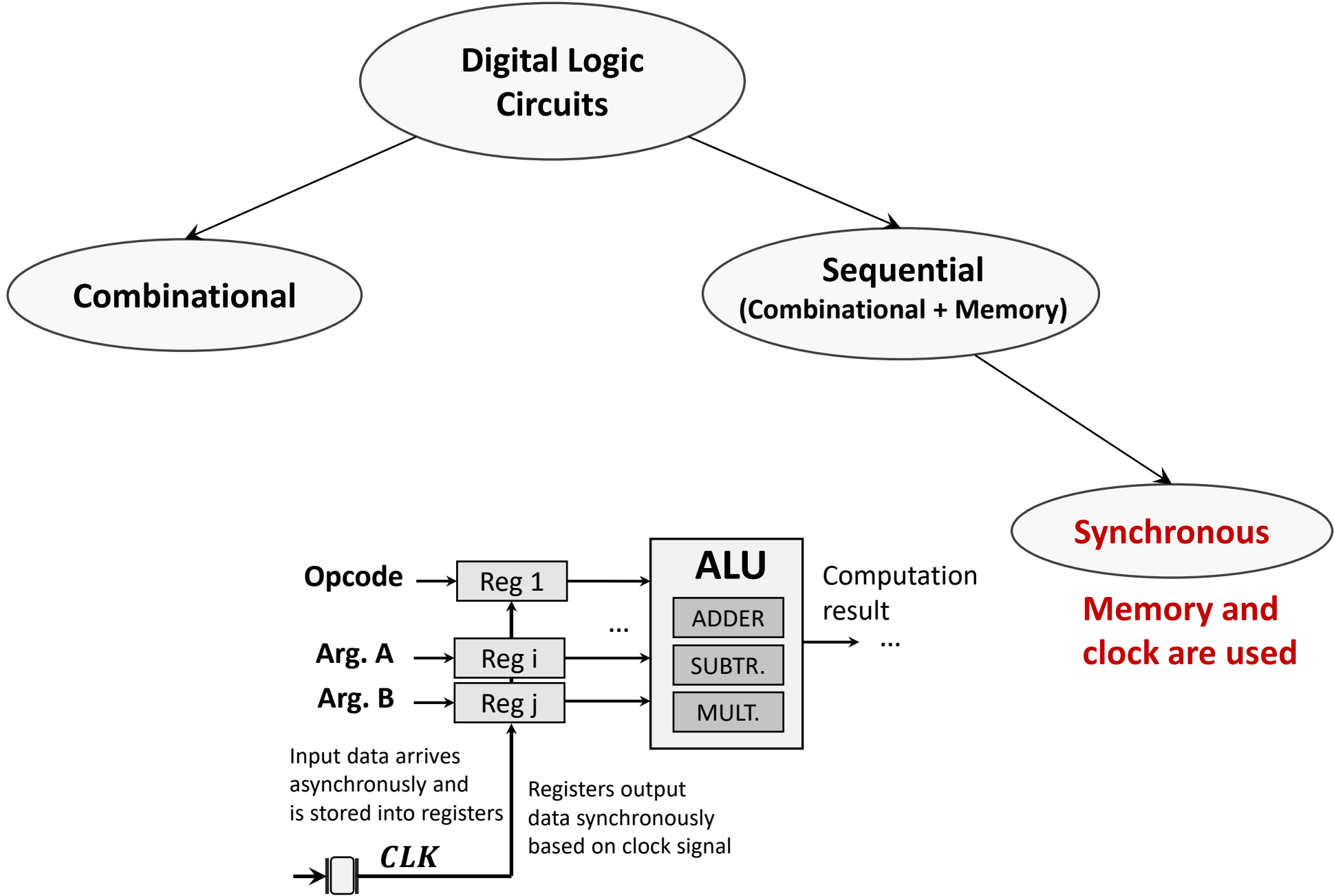


Uses memory or clock elements

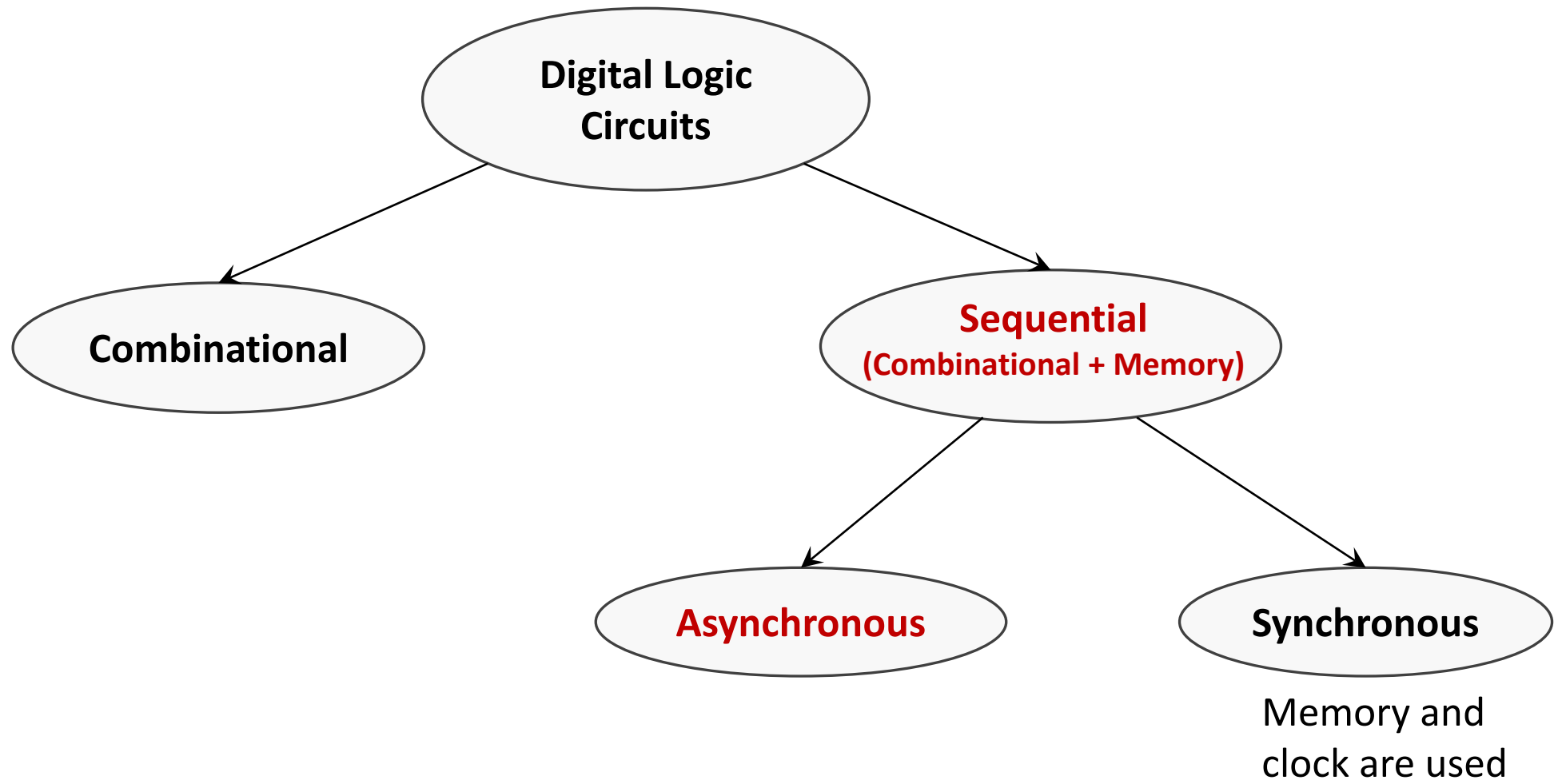
Digital Circuits Classification



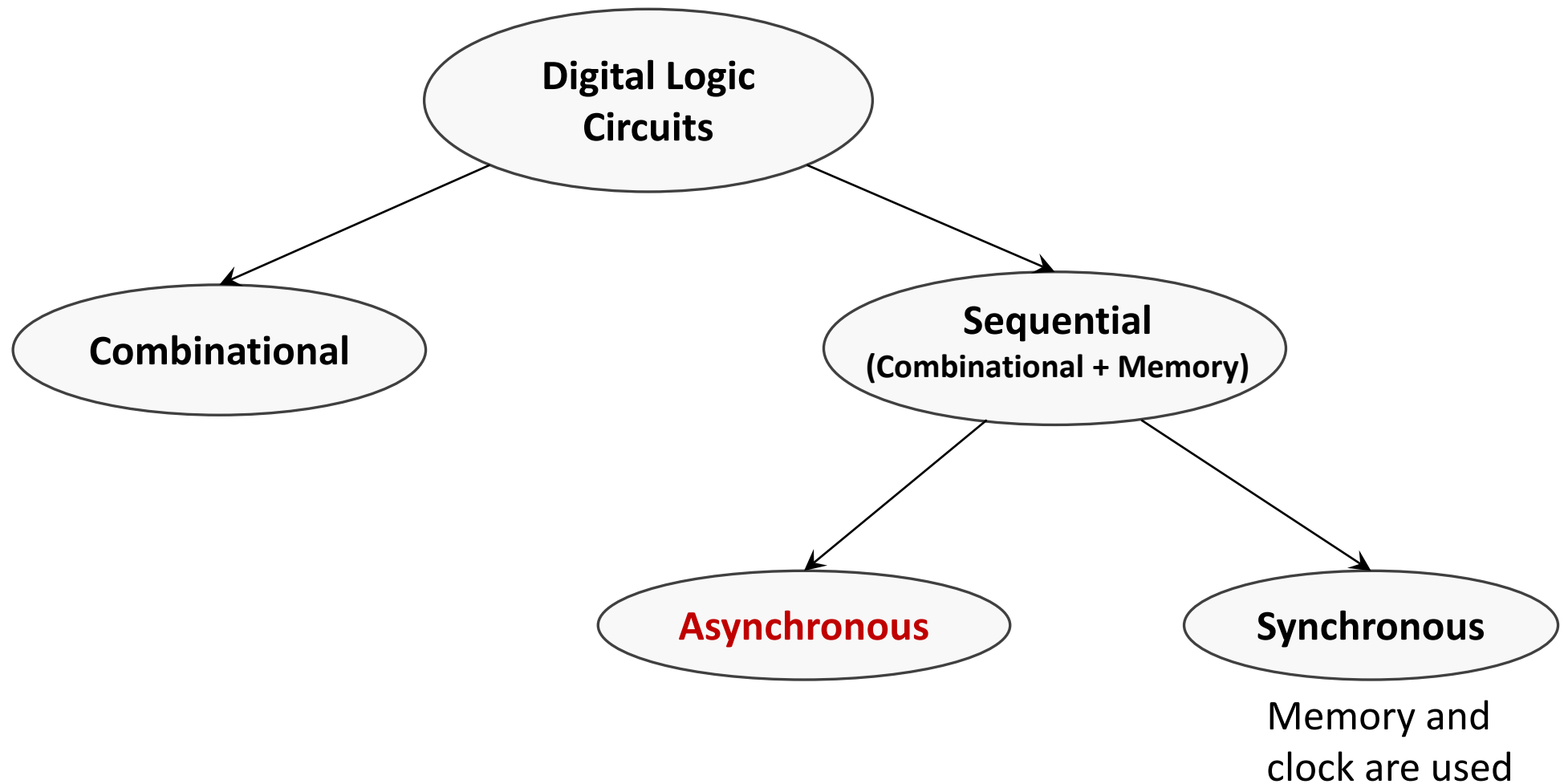
Digital Circuits Classification



Digital Circuits Classification



Digital Circuits Classification

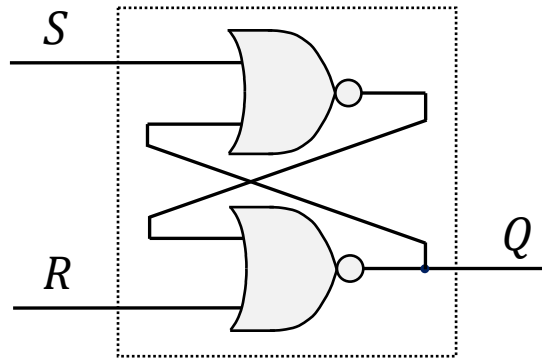


From <https://www.geeksforgeeks.org/>:

Asynchronous sequential circuits, also known as self-timed or ripple-clock circuits, are digital circuits that do not use a clock signal to determine the timing of their operations. Instead, the state of the circuit changes in response to changes in the inputs.

Asynchronous and Synchronous Circuits

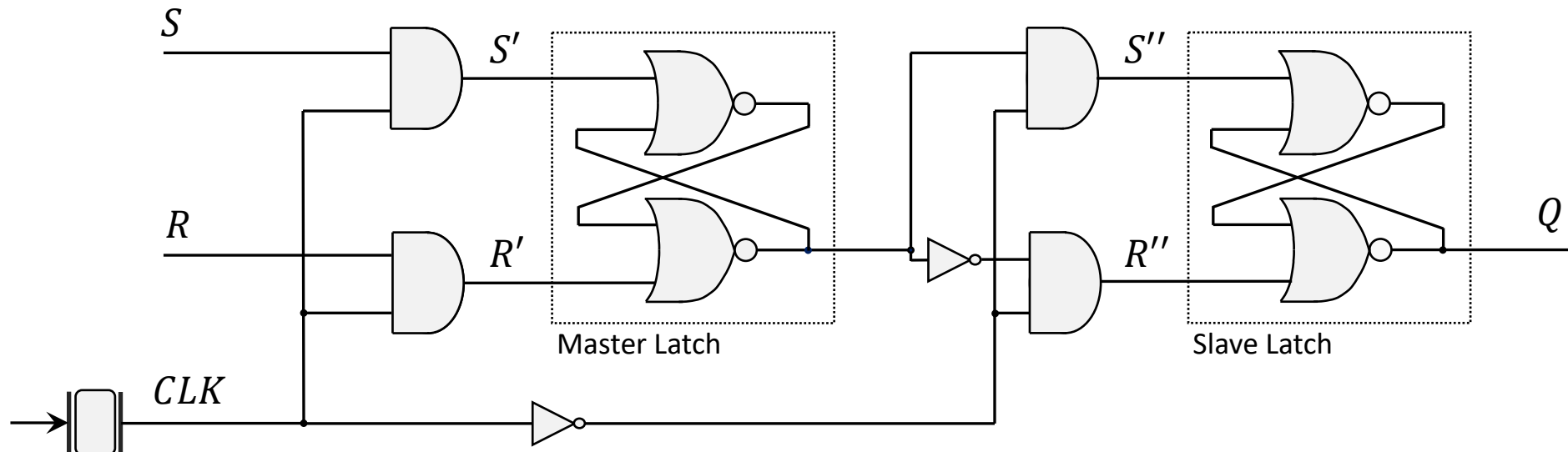
S/R latch – asynchronous circuit: updates of output signal Q are not synchronised with a clock signal



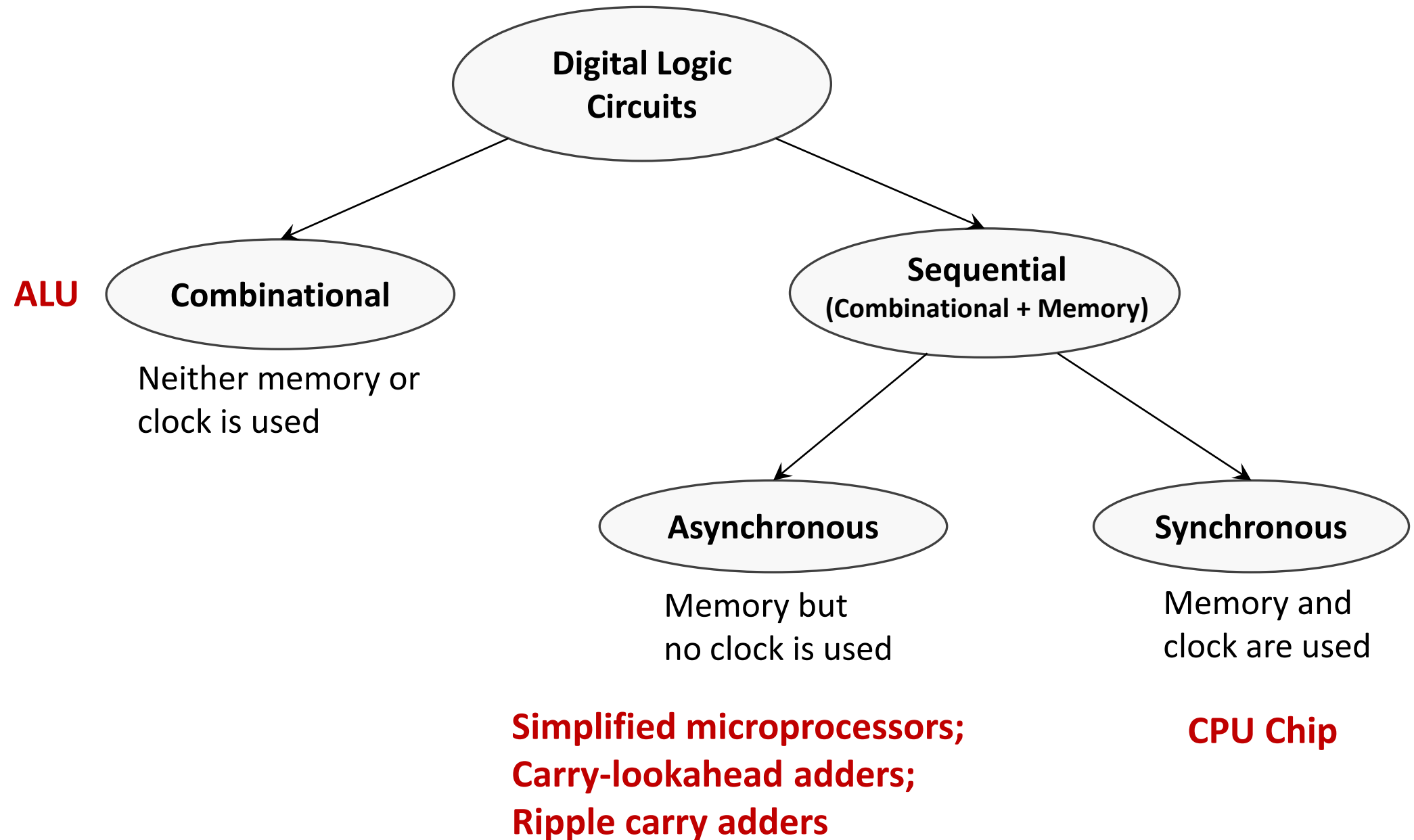
From <https://www.geeksforgeeks.org/>:

Asynchronous sequential circuits, also known as self-timed or ripple-clock circuits, are digital circuits that do not use a clock signal to determine the timing of their operations. Instead, the state of the circuit changes in response to changes in the inputs.

Flip-Flop – synchronous circuit: updates of output signal Q are synchronised with a clock signal edge



Digital Circuits Classification: Use Cases



Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
Output Update Trigger		
Clock Presence		
Reliability (for result correctness)		
Memory Element Presence		
Operation Speed		
Power Consumption		
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
Output Update Trigger		
Clock Presence		
Reliability (for result correctness)		
Memory Element Presence		
Operation Speed		
Power Consumption		
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
Output Update Trigger	Any change of one of the inputs	
Clock Presence		
Reliability (for result correctness)		
Memory Element Presence		
Operation Speed		
Power Consumption		
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
Output Update Trigger	Any change of one of the inputs	A clock signal, together with other input signals
Clock Presence		
Reliability (for result correctness)		
Memory Element Presence		
Operation Speed		
Power Consumption		
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
Output Update Trigger	Any change of one of the inputs	A clock signal, together with other input signals
Clock Presence		Clock governs the entire circuit activity
Reliability (for result correctness)		
Memory Element Presence		
Operation Speed		
Power Consumption		
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

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Sample Use Cases		

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Reliability (for result correctness)		Reliable (guarantees a correct result, independently of propagation delays)
Memory Element Presence		
Operation Speed		
Power Consumption		
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

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Memory Element Presence		
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Logical Complexity, Size (the number of elements)		
Sample Use Cases		

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Reliability (for result correctness)	Less reliable (prone to incorrect result, subject to propagation delays)	Reliable (guarantees a correct result, independently of propagation delays)
Memory Element Presence		Used
Operation Speed		
Power Consumption		
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
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Memory Element Presence	Not used	Used
Operation Speed		
Power Consumption		
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

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Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
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Reliability (for result correctness)	Less reliable (prone to incorrect result, subject to propagation delays)	Reliable (guarantees a correct result, independently of propagation delays)
Memory Element Presence	Not used	Used
Operation Speed	Faster (no clock signal for synchronisation delay is used)	
Power Consumption		
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
Output Update Trigger	Any change of one of the inputs	A clock signal, together with other input signals
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Reliability (for result correctness)	Less reliable (prone to incorrect result, subject to propagation delays)	Reliable (guarantees a correct result, independently of propagation delays)
Memory Element Presence	Not used	Used
Operation Speed	Faster (no clock signal for synchronisation delay is used)	Slower (due to overpessimistic synchronisation delays)
Power Consumption		
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
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Clock Presence	No clock present	Clock governs the entire circuit activity
Reliability (for result correctness)	Less reliable (prone to incorrect result, subject to propagation delays)	Reliable (guarantees a correct result, independently of propagation delays)
Memory Element Presence	Not used	Used
Operation Speed	Faster (no clock signal for synchronisation delay is used)	Slower (due to overpessimistic synchronisation delays)
Power Consumption	Lower	
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
Output Update Trigger	Any change of one of the inputs	A clock signal, together with other input signals
Clock Presence	No clock present	Clock governs the entire circuit activity
Reliability (for result correctness)	Less reliable (prone to incorrect result, subject to propagation delays)	Reliable (guarantees a correct result, independently of propagation delays)
Memory Element Presence	Not used	Used
Operation Speed	Faster (no clock signal for synchronisation delay is used)	Slower (due to overpessimistic synchronisation delays)
Power Consumption	Lower	Higher (e.g. due to the presence of flip-flops, consuming power for data storage)
Logical Complexity, Size (the number of elements)		
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
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Power Consumption	Lower	Higher (e.g. due to the presence of flip-flops, consuming power for data storage)
Logical Complexity, Size (the number of elements)	Simpler , smaller (<i>Note: an asynchronous circuit might behave as a synchronous, but at the price of a higher hardware implementation complexity</i>)	
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

Characteristic	Asynchronous (like S/R latch)	Synchronous (like Flip-Flop)
Output Update Trigger	Any change of one of the inputs	A clock signal, together with other input signals
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Reliability (for result correctness)	Less reliable (prone to incorrect result, subject to propagation delays)	Reliable (guarantees a correct result, independently of propagation delays)
Memory Element Presence	Not used	Used
Operation Speed	Faster (no clock signal for synchronisation delay is used)	Slower (due to overpessimistic synchronisation delays)
Power Consumption	Lower	Higher (e.g. due to the presence of flip-flops, consuming power for data storage)
Logical Complexity, Size (the number of elements)	Simpler , smaller (Note: an asynchronous circuit might behave as a synchronous, but at the price of a higher hardware implementation complexity)	More complex , larger
Sample Use Cases		

Synchronous vs. Asynchronous Circuits

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Clock Presence	No clock present	Clock governs the entire circuit activity
Reliability (for result correctness)	Less reliable (prone to incorrect result, subject to propagation delays)	Reliable (guarantees a correct result, independently of propagation delays)
Memory Element Presence	Not used	Used
Operation Speed	Faster (no clock signal for synchronisation delay is used)	Slower (due to overpessimistic synchronisation delays)
Power Consumption	Lower	Higher (e.g. due to the presence of flip-flops, consuming power for data storage)
Logical Complexity, Size (the number of elements)	Simpler , smaller (<i>Note: an asynchronous circuit might behave as a synchronous, but at the price of a higher hardware implementation complexity</i>)	More complex , larger
Sample Use Cases		Register files; Most of the circuits containing memory elements

Synchronous vs. Asynchronous Circuits

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Output Update Trigger	Any change of one of the inputs	A clock signal, together with other input signals
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Memory Element Presence	Not used	Used
Operation Speed	Faster (no clock signal for synchronisation delay is used)	Slower (due to overpessimistic synchronisation delays)
Power Consumption	Lower	Higher (e.g. due to the presence of flip-flops, consuming power for data storage)
Logical Complexity, Size (the number of elements)	Simpler , smaller (<i>Note: an asynchronous circuit might behave as a synchronous, but at the price of a higher hardware implementation complexity</i>)	More complex , larger
Sample Use Cases	Arithmetic-Logic Unit (ALU); Small fast peripheral circuits supporting CPU operation	Register files; Most of the circuits containing memory elements

Digital Circuits Classification

