FACULTY OF ENGINEERING & TECHNOLOGY

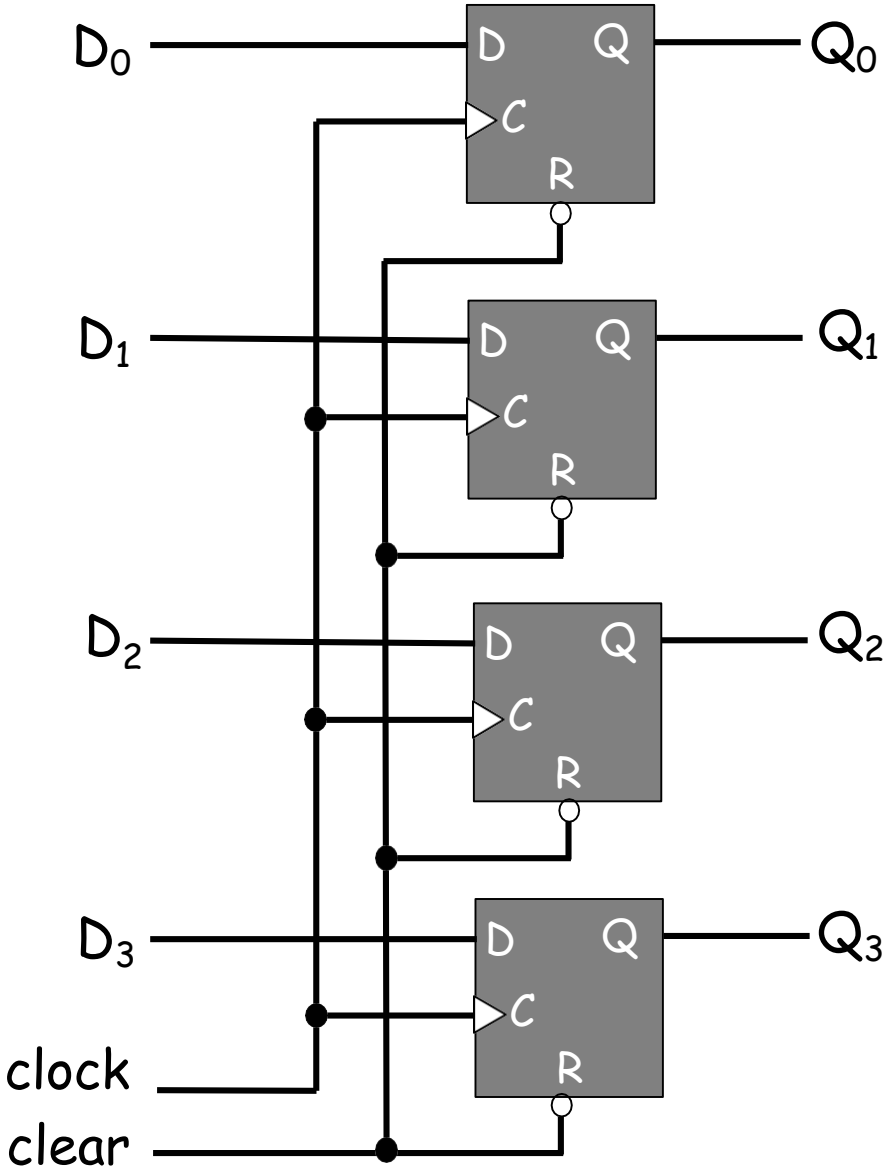
Registers

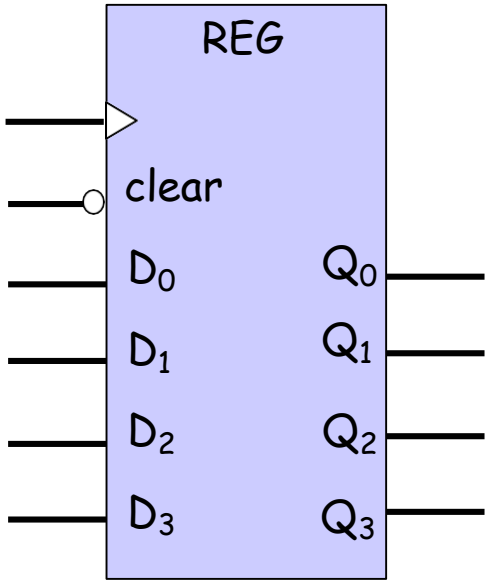
- Registers like counters are clocked sequential circuits
- A register is a group of flip-flops
  - Each flip-flop capable of storing one bit of information
  - An n-bit register
    - consists of n flip-flops
    - capable of storing n bits of information
  - besides flip-flops, a register usually contains combinational logic to perform some simple tasks
  - In summary
    - flip-flops to hold information
    - combinational logic to control the state transition

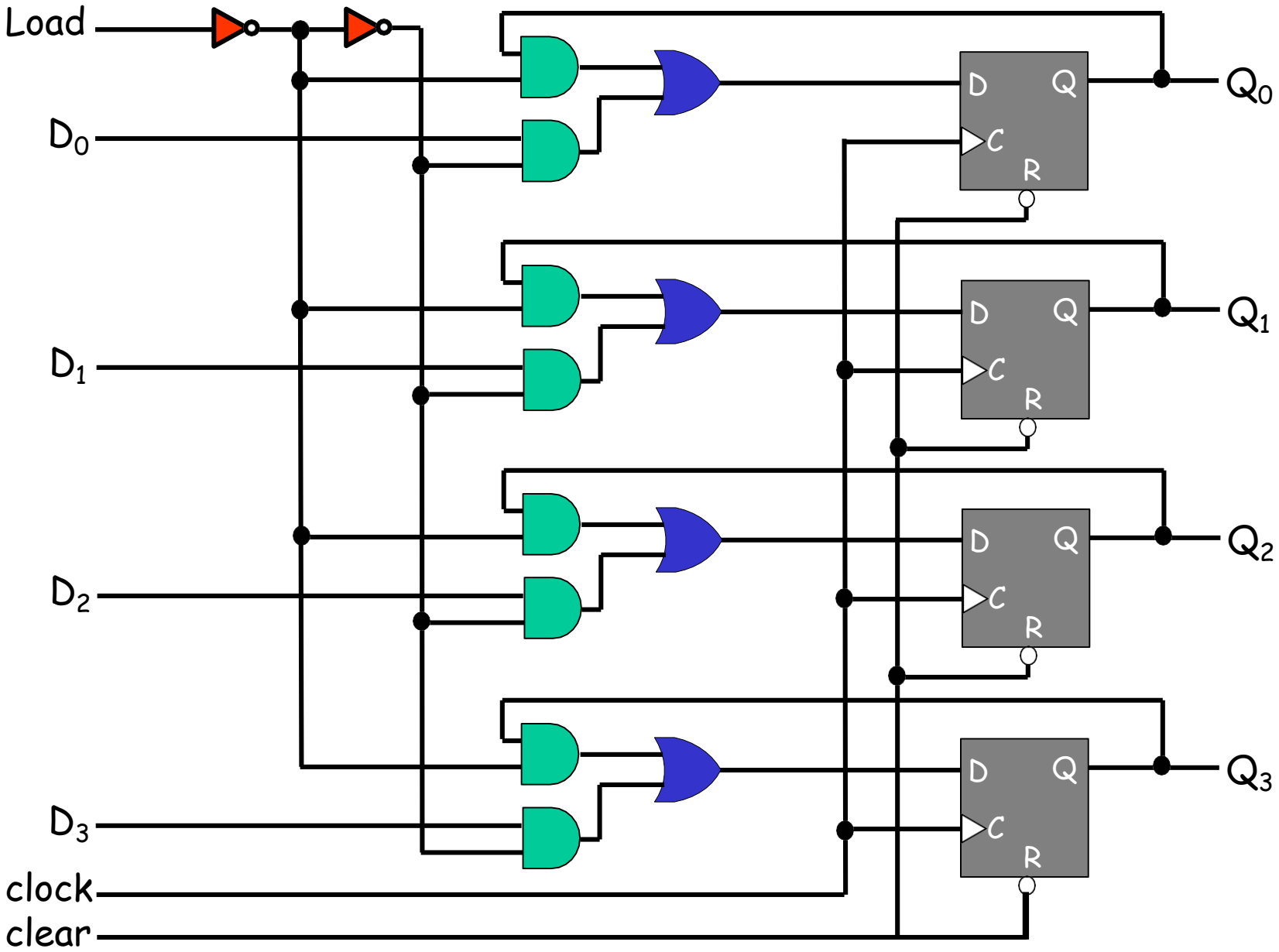
Uses of Registers

- Registers are useful for storing and manipulating information
  - internal registers in microprocessors to manipulate data

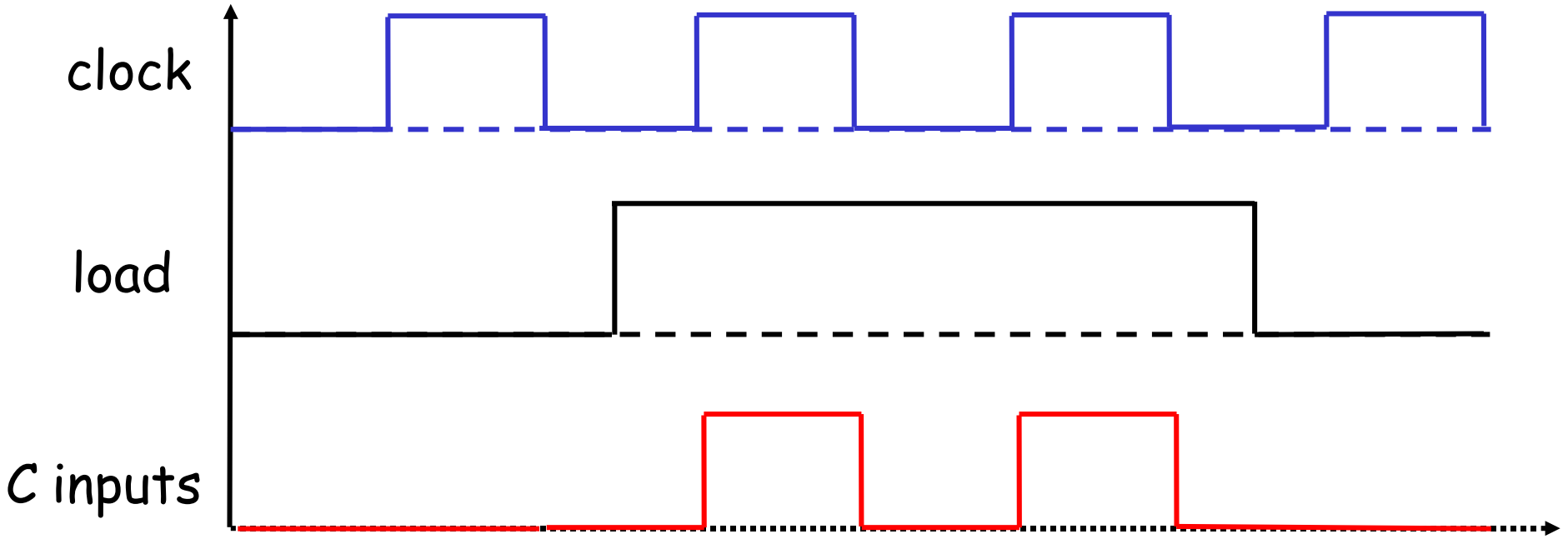
4-bit Register



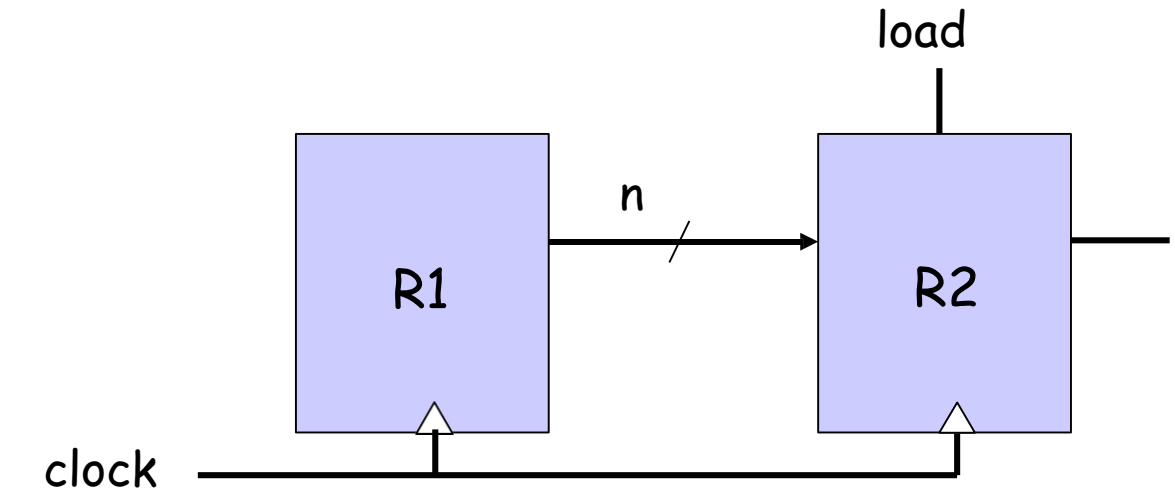



Load
D0
D1
D2
D3
clock
clear
D
Q
C
R
Q0
Q1
Q2
Q3

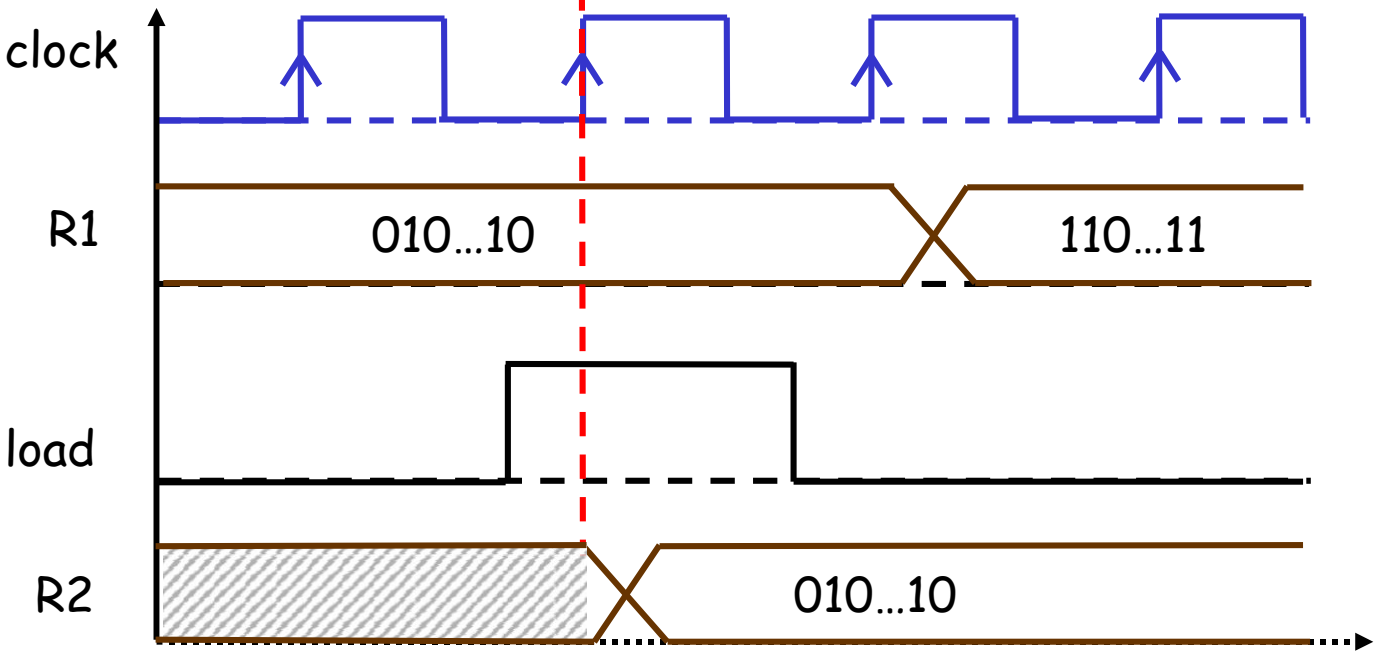
Loading Register



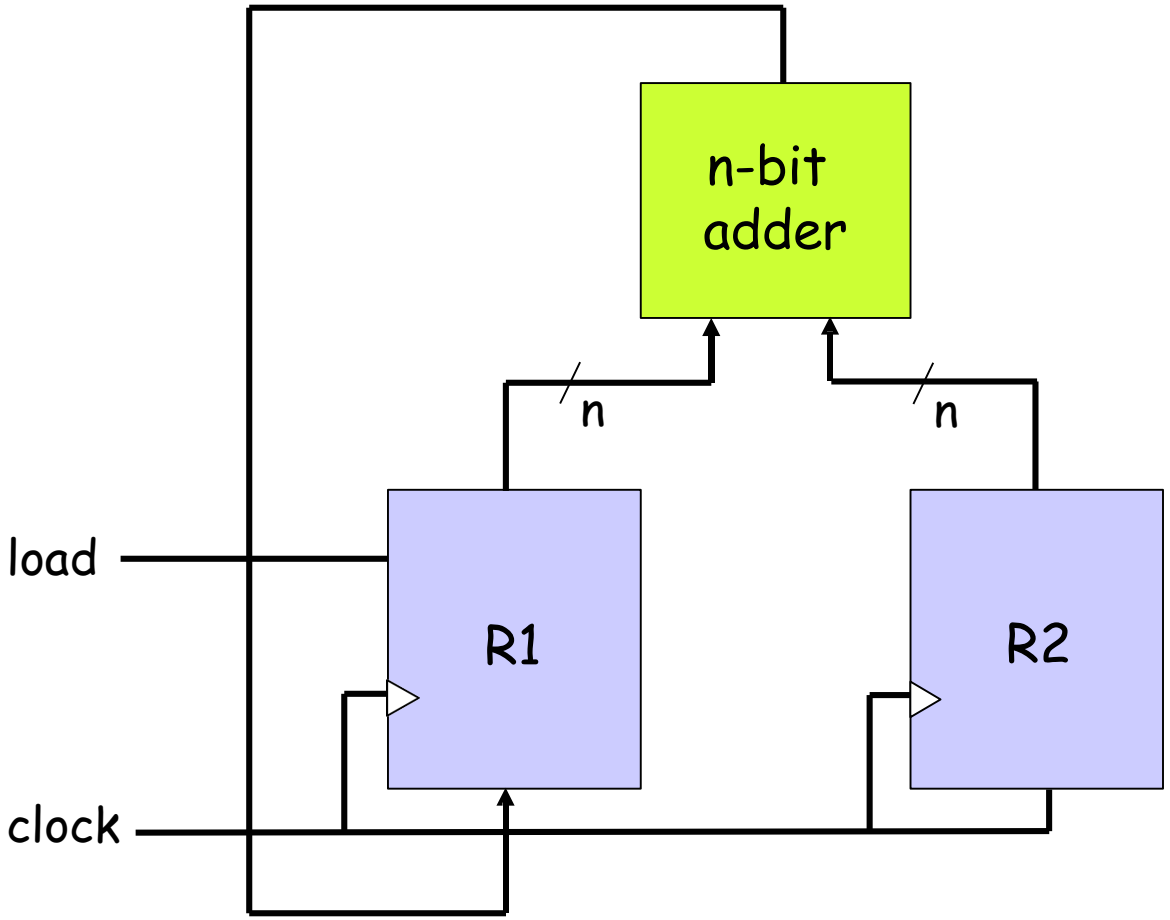
Register Transfer - 1



R2 ⓪ R1

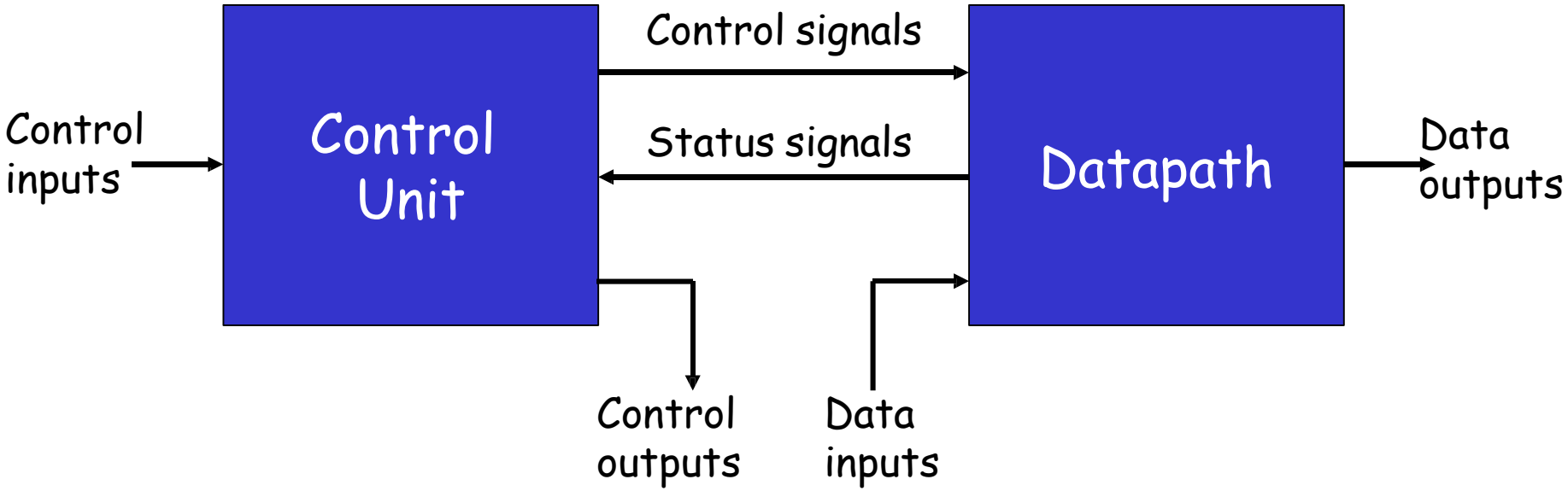


Register Transfer - 2



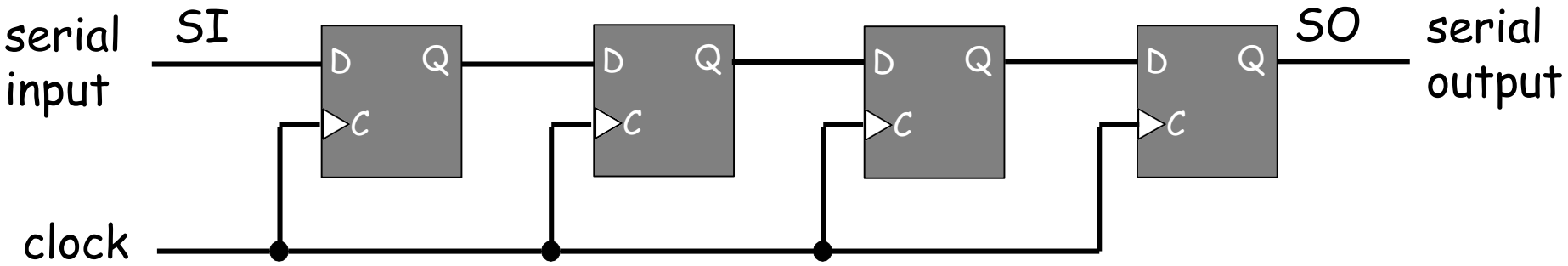
R1 ⓪ R1 + R2

Datapath & Control Unit



Shift Registers

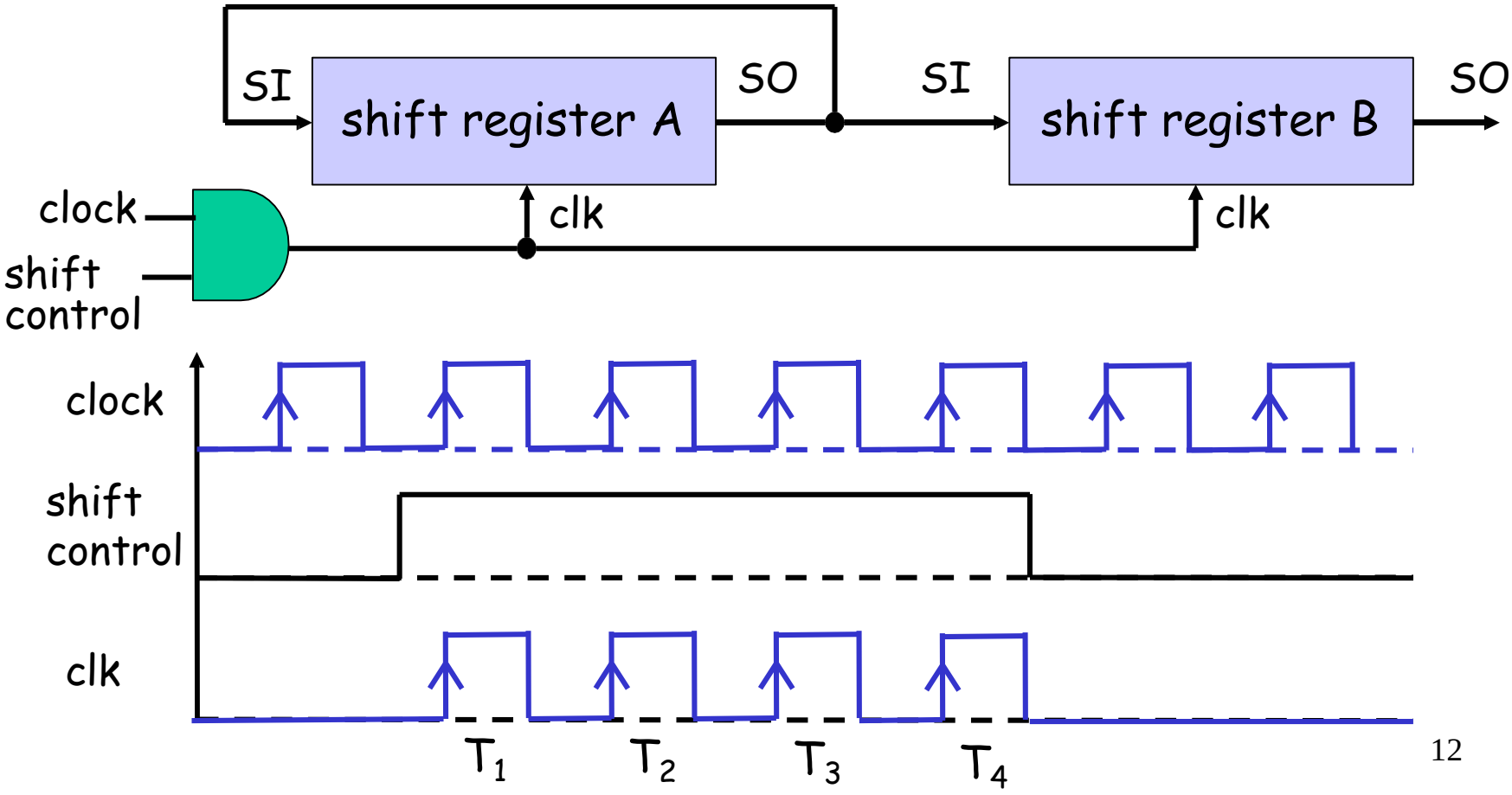
- A register capable of shifting its information in one or both directions
  - Flip-flops in cascade



- The current state can be output in n clock cycles

Serial Mode

- A digital system is said to operate in <u>serial mode</u> when information is transferred and manipulated one bit a time.



Serial Transfer

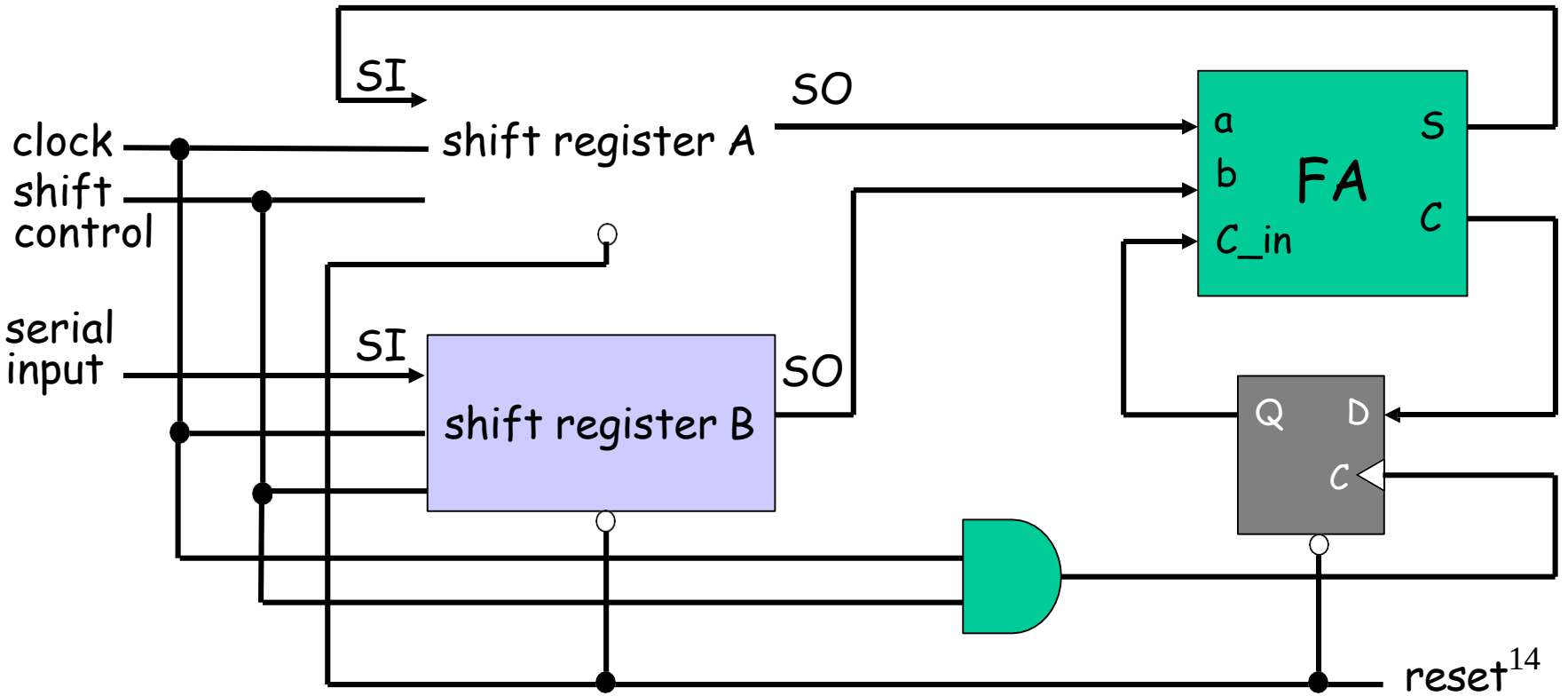
- Suppose we have two 4-bit shift registers

Timing pulse	Shift register A				Shift register B			
initial value	1	0	1	1	0	0	1	0
After T_1	1	1	0	1	1	0	0	1
After T_2	1	1	1	0	1	1	0	0
After T_3	0	1	1	1	0	1	1	0
After T_4	1	0	1	1	1	0	1	1

B ⊚ A

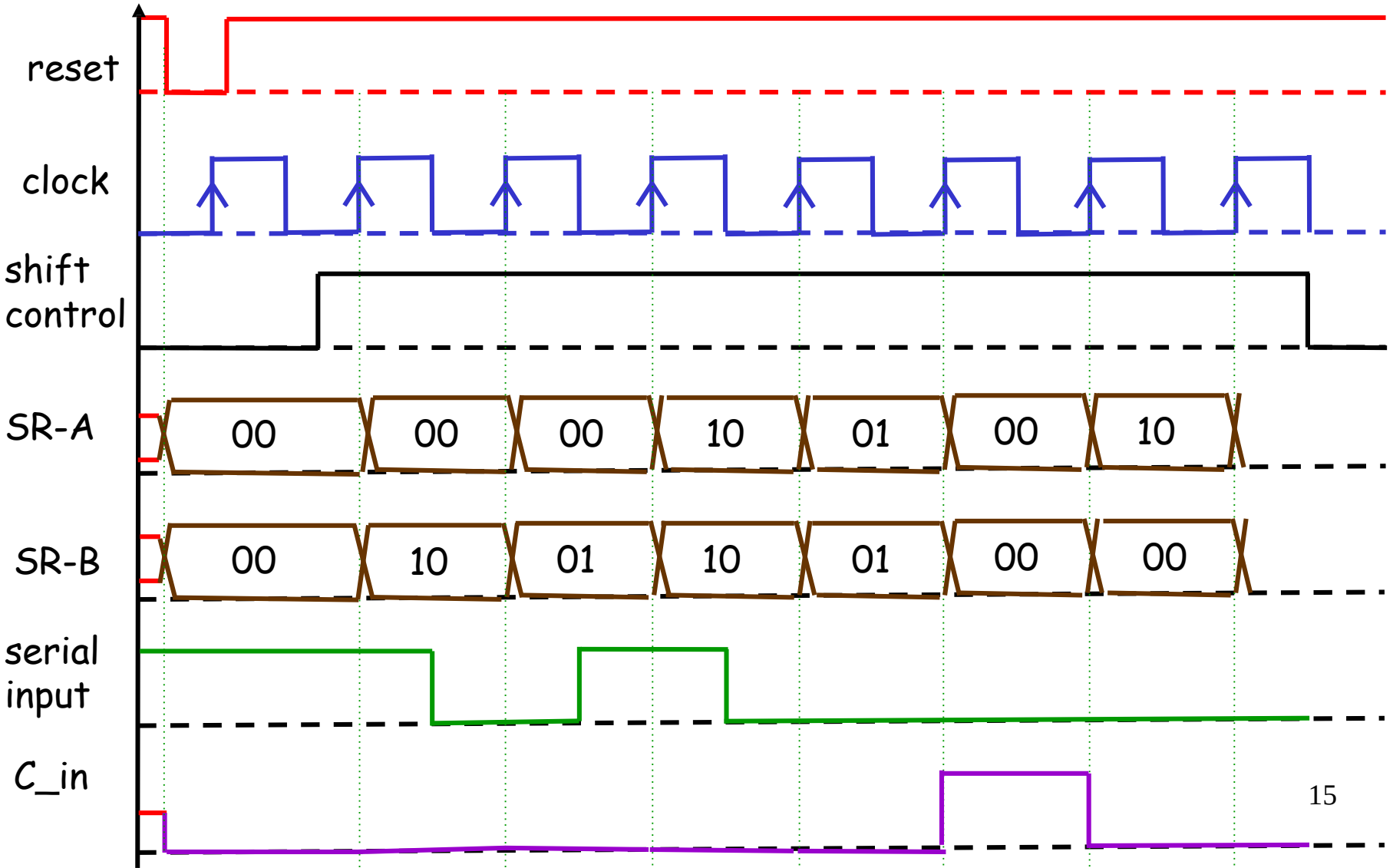
Serial Addition

- In digital computers, operations are usually executed in parallel, since it is faster
- Serial mode is sometimes preferred since it requires less equipment



Example: Serial Addition

- A and B are 2-bit shift registers



Designing Serial Adder - 1

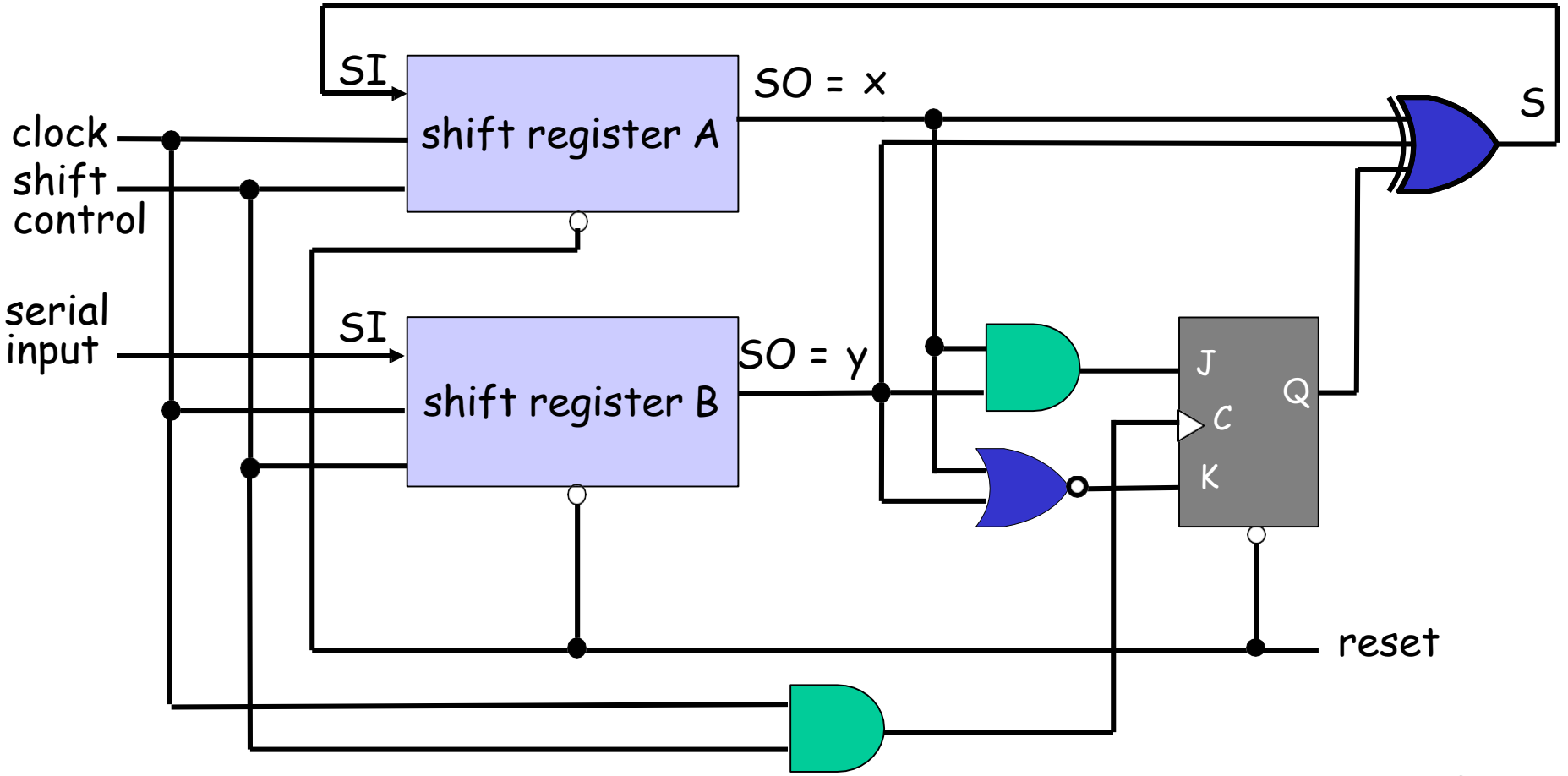
$$Q(t+1) = JQ' + K'Q$$

Present state	Inputs		Next state	Output	Flip-flop inputs	
Q	x	y	Q	S	J_Q	K_Q
0	0	0	0	0	0	X
0	0	1	0	1	0	X
0	1	0	0	1	0	X
0	1	1	1	0	1	X
1	0	0	0	1	X	1
1	0	1	1	0	X	0
1	1	0	1	0	X	0
1	1	1	1	1	X	0

$J_Q = xy$ $K_Q = x'y' = (x + y)'$ $S = x \oplus y \oplus Q$

Designing Serial Adder - 2

$J_Q = xy$ $K_Q = x'y' = (x + y)'$ $S = x \oplus y \oplus Q$



Universal Shift Register

- Capabilities:
  1. A *clear* control to set the register to 0.
  2. A *clock* input
  3. A *shift-right* control
  4. A *shift-left* control
  5. n input lines
  6. A *parallel-load* control
  7. n parallel output lines
  8. A *shift-control*

Universal Shift Register