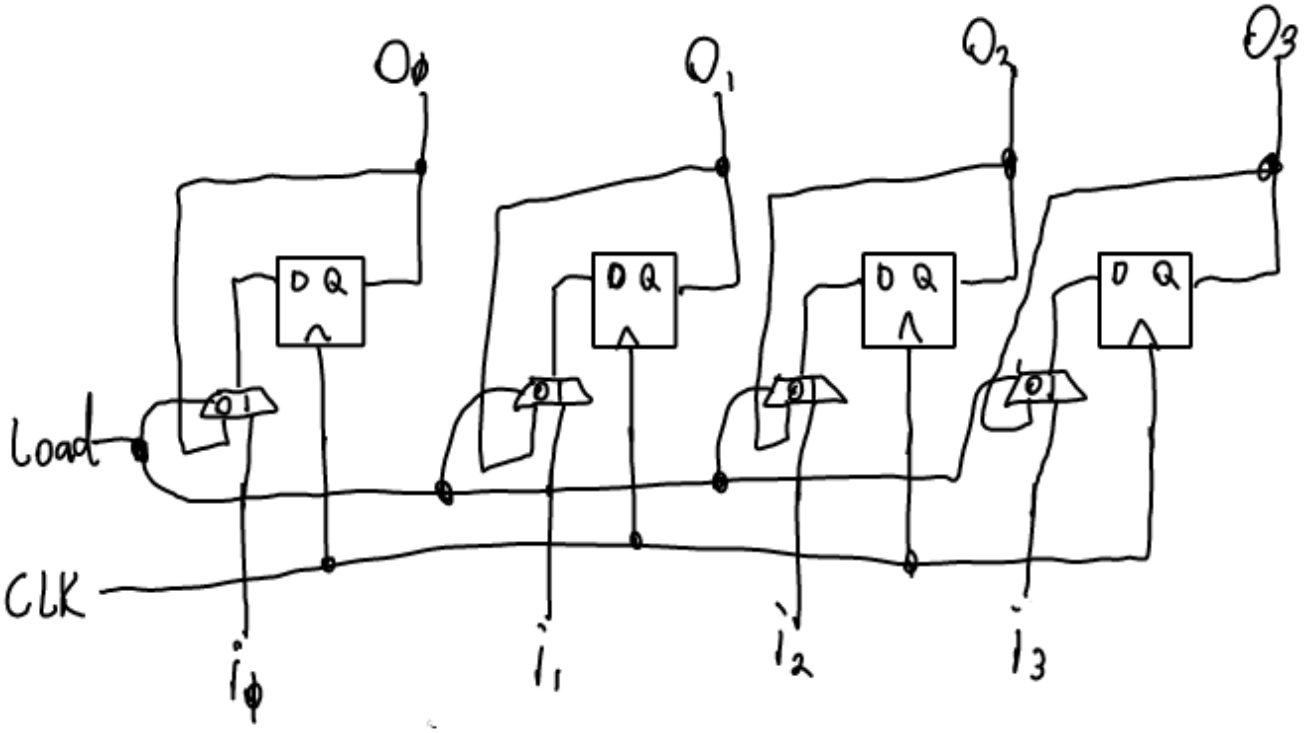
Registers

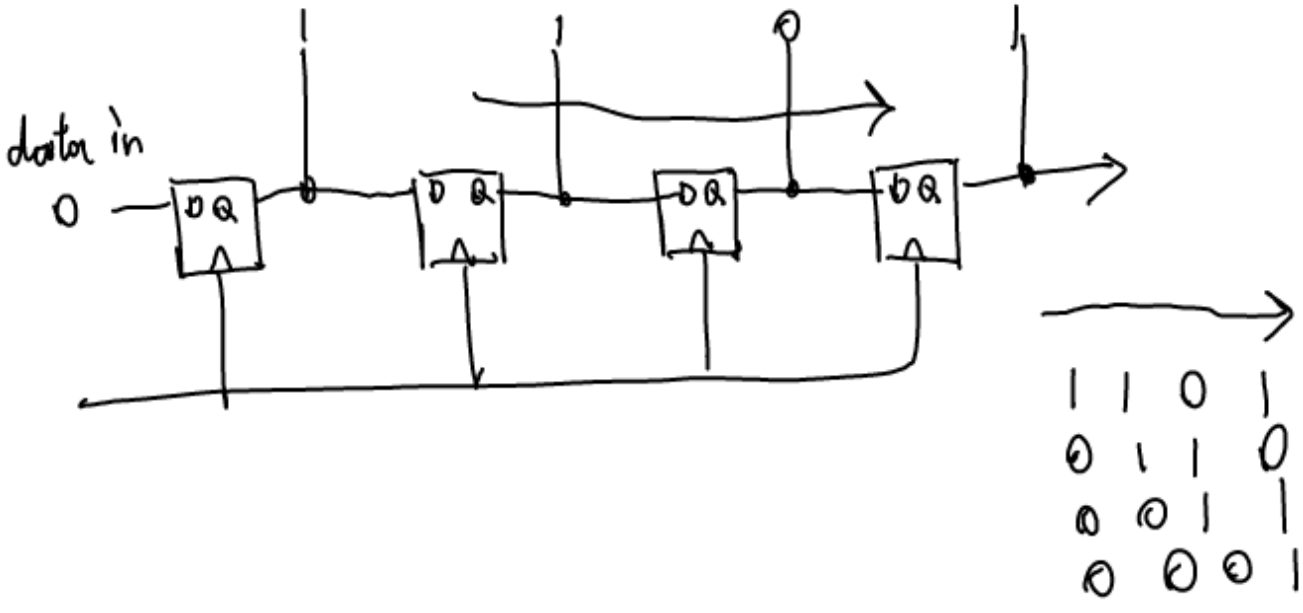
- Simply a bunch of flipflops "grouped together" to perform some function in which the bits are related. FFs typically clocked by the same clock.

e.g., design a 4-bit register that can either hold its current outputs or load some new data.



Shift Registers

Connect outputs of register bits to make it look like data moves left-to-right (or right-to-left) as clock arrives.

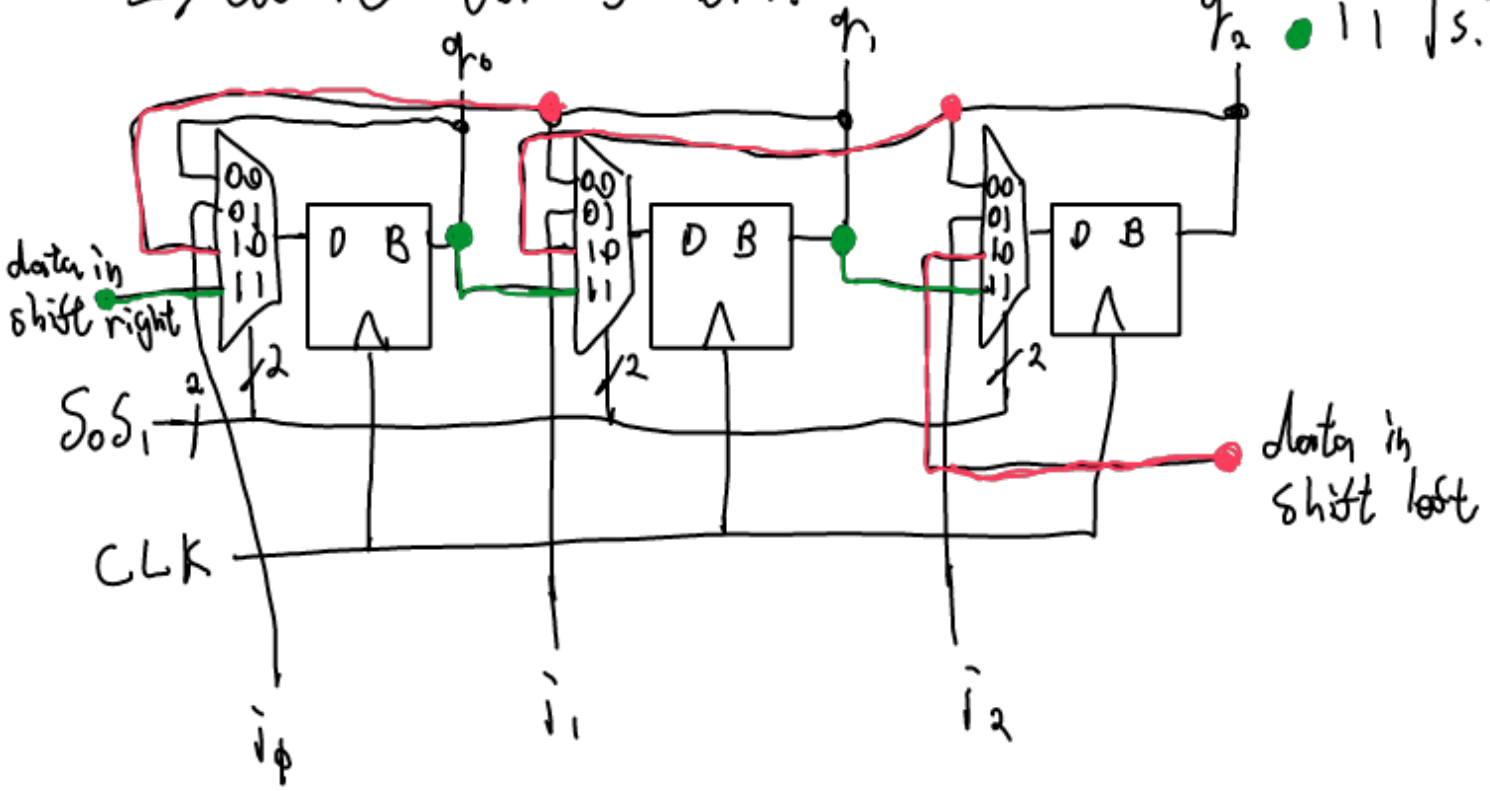


Universal Shift Registers

make a circuit that 1) can hold data;
2) can load new data in parallel,
3) can shift left
4) can shift right.

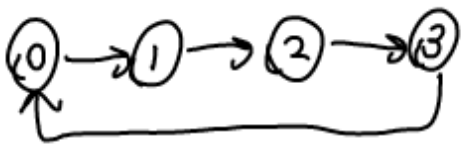
S_1 S_0	Op.
0 0	Hold
0 1	Load
1 0	S. Left
1 1	S. Right

⇒ do it for 3 bits.



Counters

* A register whose output goes thru a prescribed sequence + repeats.

e.g., 

* start with simple binary up-down counters.

n-flip-flops count $0 \to 2^{n-1}$, repeat (up)

$2^{n-1} \to 0$, repeat (down)

4-bit counter

a_3	a_2	a_1	a_0
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0
⋮			
1	1	1	1

a_0 always toggles

a_1 always toggles when a_0 changes $1 \to 0$

a_2 " " " a_1 " $1 \to 0$