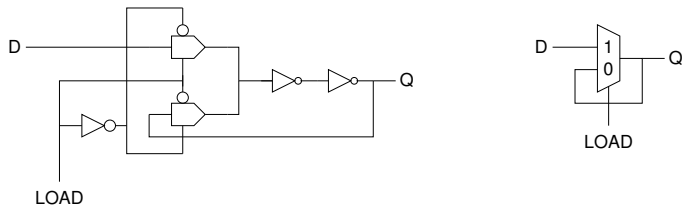## Latches and Flip-Flops

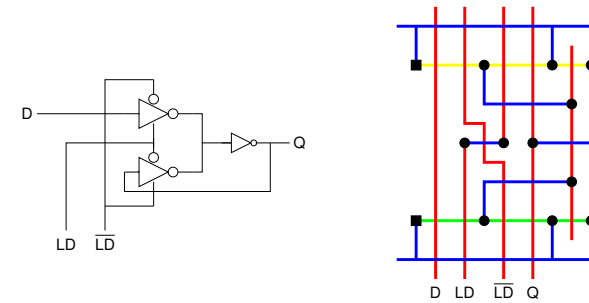- CMOS transmission gate latch

A simple transparent latch can be build around a transmission gate multiplexor

- transparent when load is high
- latched when load is low
- two inverters are required since the transmission gate cannot drive itself

Latches and Flip-Flops

- Transmission gate latch layout
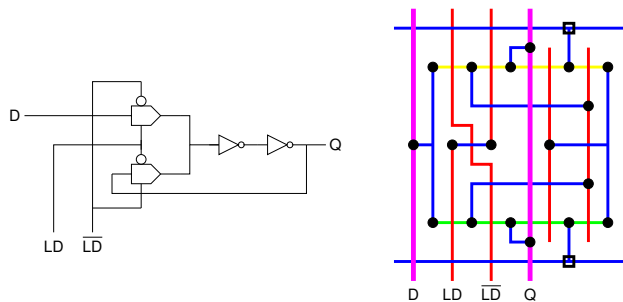
- a compact layout is possible using 2 layer metal

Latches and Flip-Flops

- A simpler layout may be achieved using tristate inverters.

- this design requires two additional transistors but may well be more compact.
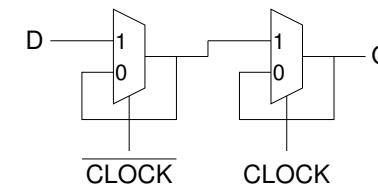
Latches and Flip-Flops

- For use in simple synchronous circuits we use a pair of latches in a master slave configuration.
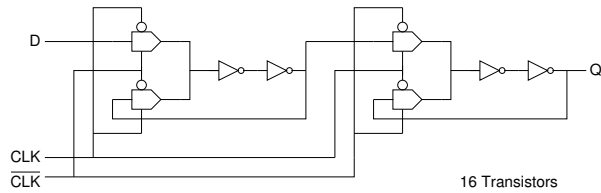

- this avoids the race condition in which a transparent latch drives a second transparent latch operating on the same clock phase.
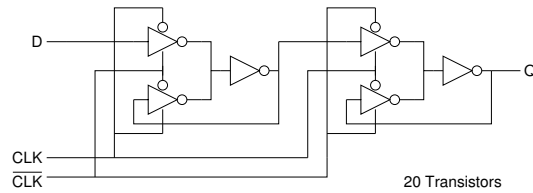- the circuit behaves as a rising edge triggered D type flip-flop.

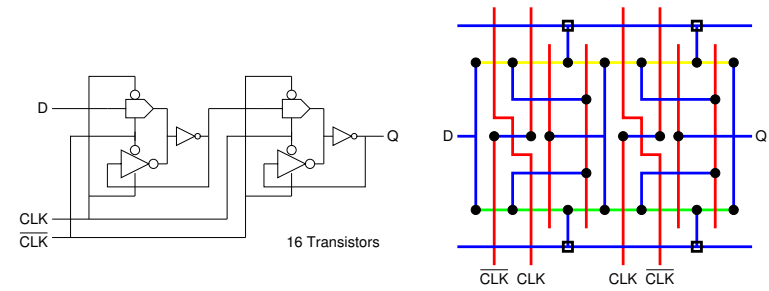# Latches and Flip-Flops

- Transmission gate implementation

D

CLK
$\overline{\text{CLK}}$

16 Transistors

- Tristate inverter implementation

D

Q

CLK
$\overline{\text{CLK}}$

20 Transistors

Latches and Flip-Flops

- Layout of master slave D type.

D

Q

CLK
$\overline{\text{CLK}}$

16 Transistors

D

Q

$\overline{\text{CLK}}$ CLK   CLK $\overline{\text{CLK}}$

– very compact using alternative configuration.

Latches and Flip-Flops

- Alternative configuration

D

1
0

1
0

Q

$\overline{\text{CLOCK}}$ CLOCK

– Implementation

D

CLK
$\overline{\text{CLK}}$

Q
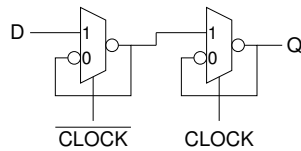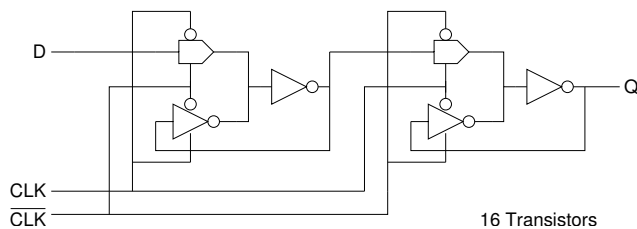
16 Transistors

Latches and Flip-Flops

- For the same functionality we could use an edge triggered D type:
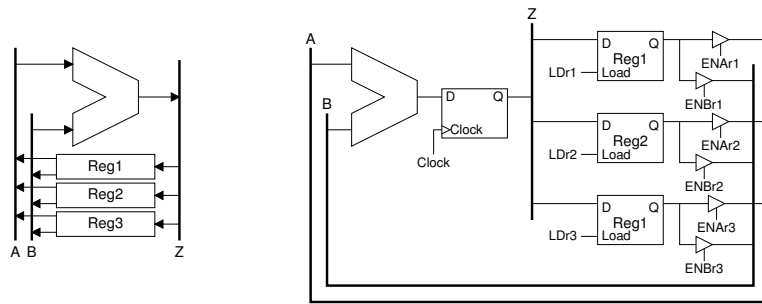
CLK   D   Q

D

Q

CLK
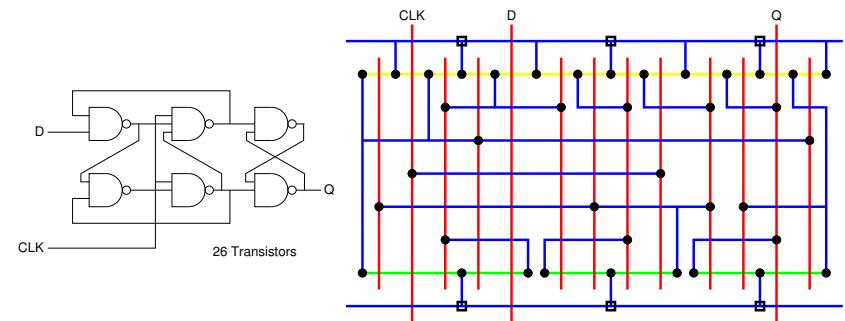
26 Transistors

– a few more transistors
– more complex wiring
– simpler clock distribution

Register File

Where we have large amounts of storage the use of individual latches can lead to space saving.

- Load signals must be glitch free with tightly controlled timing.

- Edge Triggered D-type prevents a race condition ($Reg1 \leftarrow Reg1 + Reg2$).

8009