VLSI DESIGN FLOW: RTL TO GDS

Lecture 28
Timing-driven Optimizations

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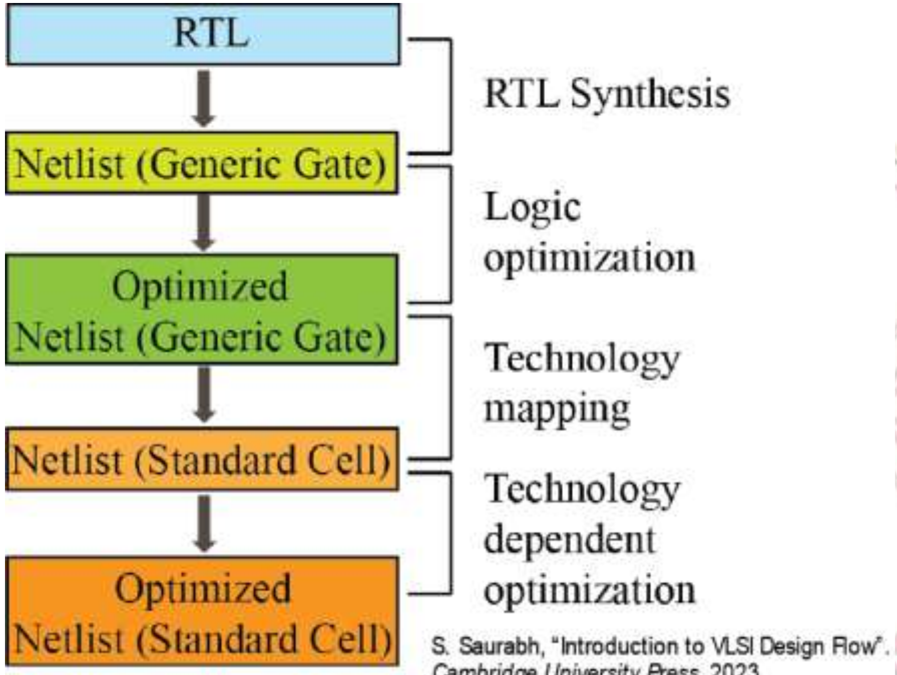
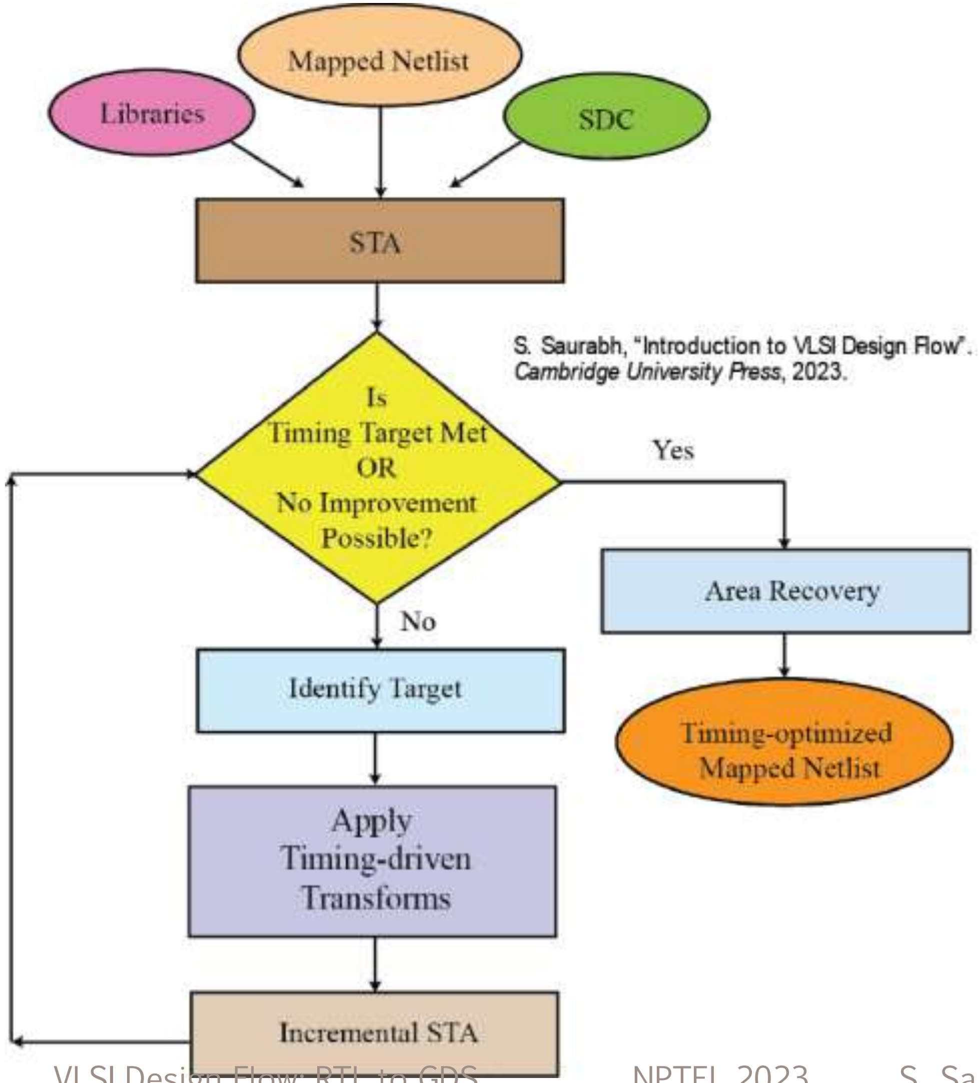
Lecture Plan


RTL
Netlist (Generic Gate)
Optimized Netlist (Generic Gate)
Netlist (Standard Cell)
Optimized Netlist (Standard Cell)
RTL Synthesis
Logic optimization
Technology mapping
Technology dependent optimization

S. Saurabh, "Introduction to VLSI Design Flow". *Cambridge University Press*, 2023.

- Timing-driven Optimizations

Timing-driven Optimization: Flow



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Timing Driven Optimization: Resizing

- Libraries contain cells of same functionality and different sizes
  - Size of the cell increases, delay decreases

Resizing:

- Replace a cell *C1* with another cell *C2* that produces the same Boolean function but has a different size

Example: cell *C1* replaced with a functionally equivalent cell *C2* of a **larger size**

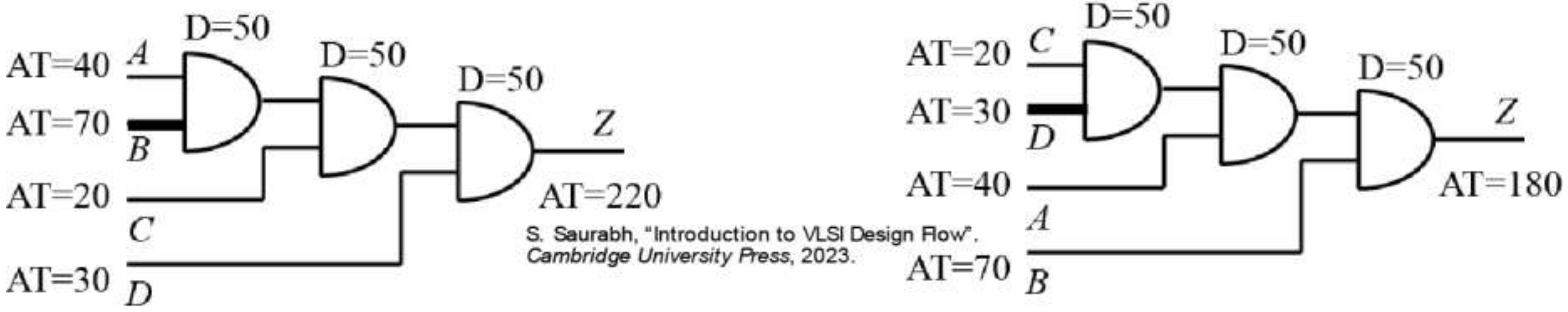
Effects:

1. Delay and output slew of *C2* can reduce
   - Delay of cells in the fanout of *C2* can also reduce
2. Delay and output slew of the driver of *C2* can increase
   - Delay of the cells in its fanout, including that of C2, can increase

Timing Driven Optimization: Restructure (1)

Rewiring:

- Timing critical signals are moved closer to the sink in a cone of logic to reduce the overall path delay



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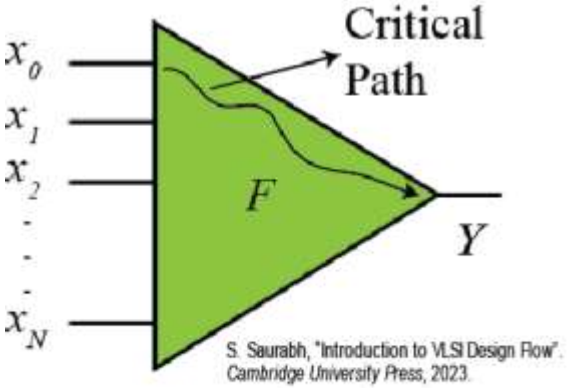
Timing Driven Optimization: Restructure (2)



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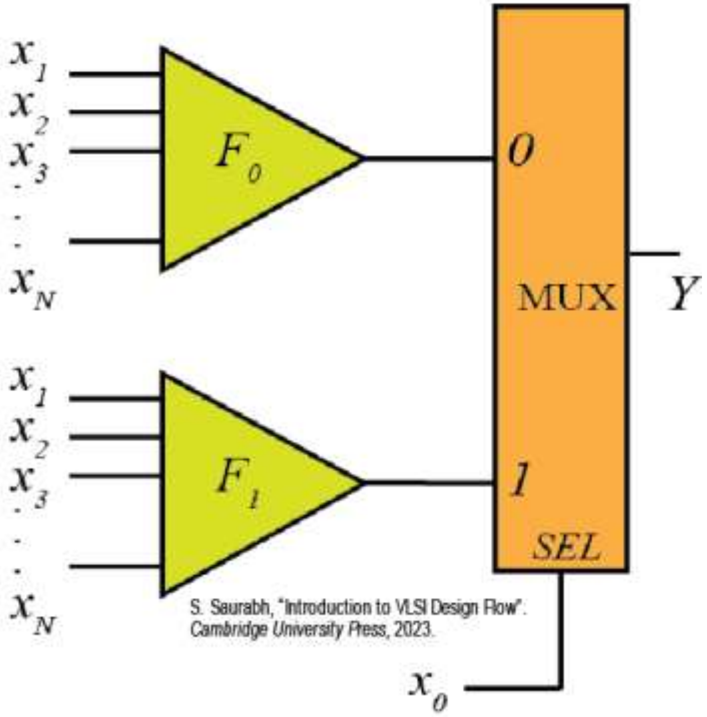
$$Y = F(x_0, x_1, x_2, \ldots, x_N)$$

- Let x_0 be the signal that arrives last (AT of x_0 is greatest) and is on the critical path
- How to restructure the circuit such that the worst delay of the circuit improves?

Shannon Expansion

- $F_0 = F(0, x_1, x_2, \ldots, x_N)$
- $F_1 = F(1, x_1, x_2, \ldots, x_N)$



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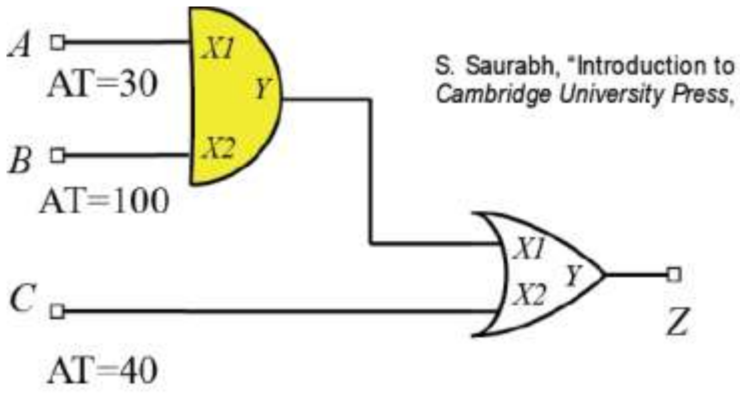
Restructure: Illustration



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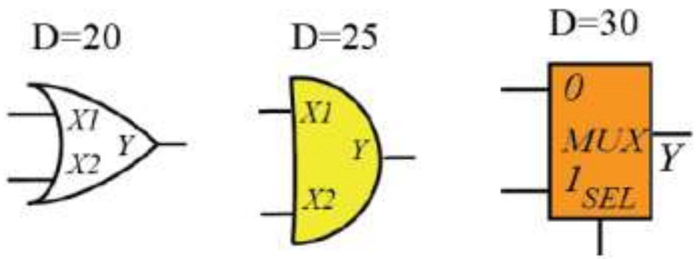
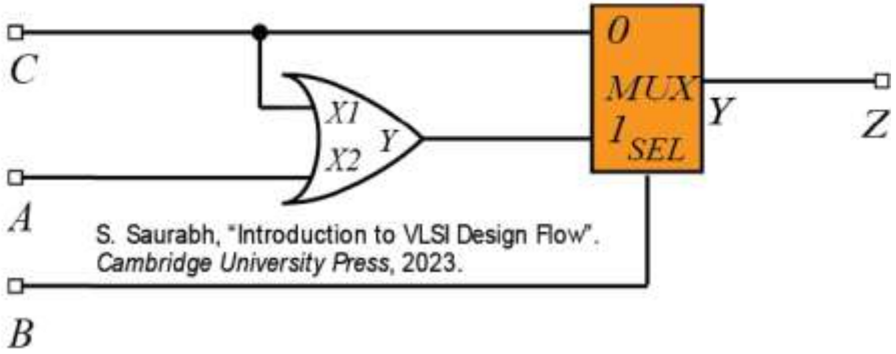


Arrival Time: 145 ps

$$Z = F(A, B, C) = AB + C$$

$$F_{B=0} = C$$

$$F_{B=1} = A + C$$



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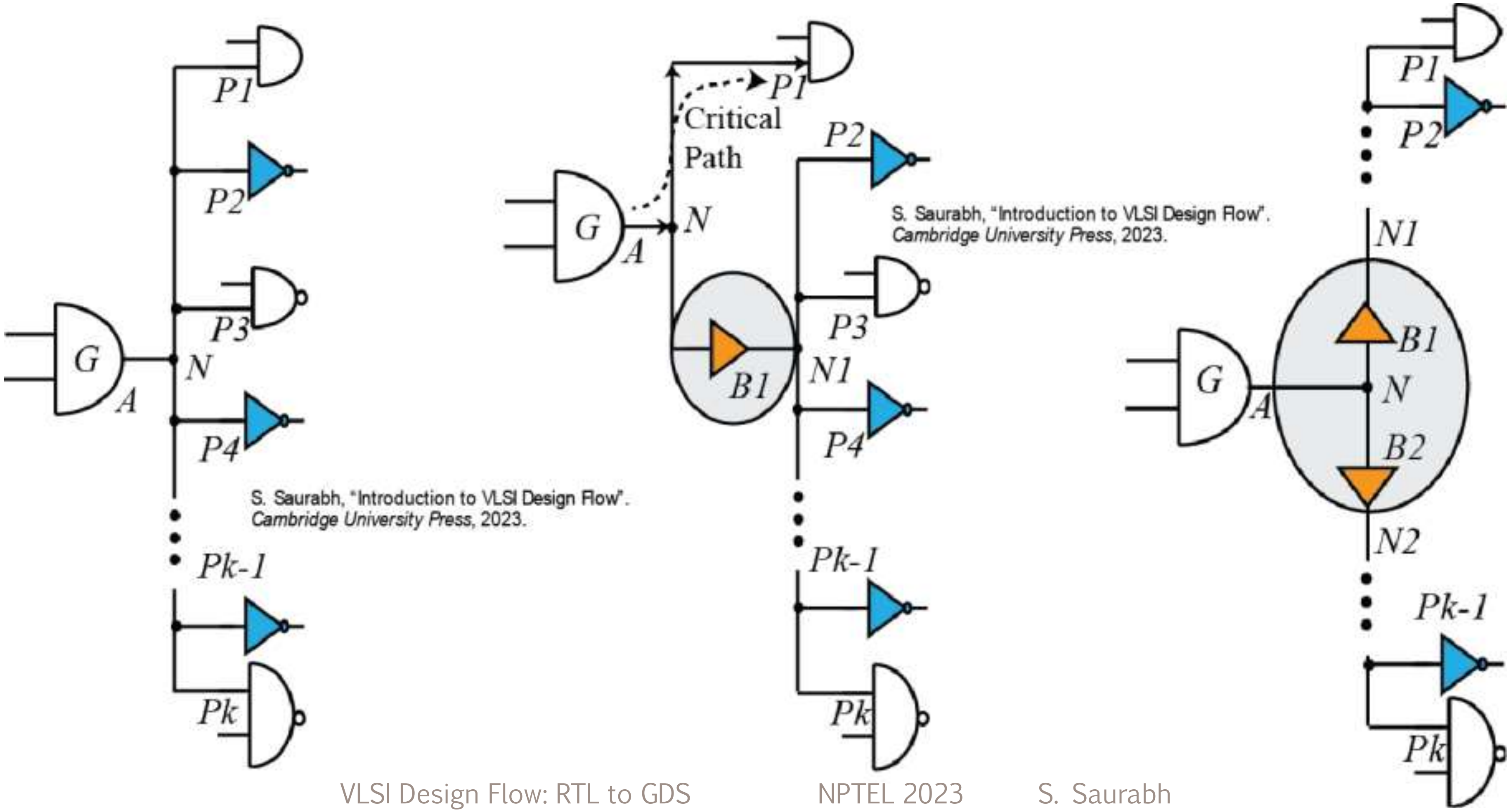
Arrival Time: 130 ps

Fanout Optimization

Fanout optimization: inserting buffers in a high-fanout



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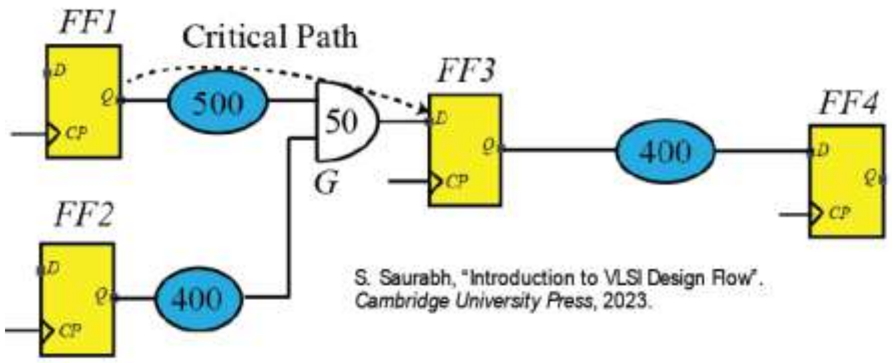
Retiming

Retiming: balance the amount of logic between registers



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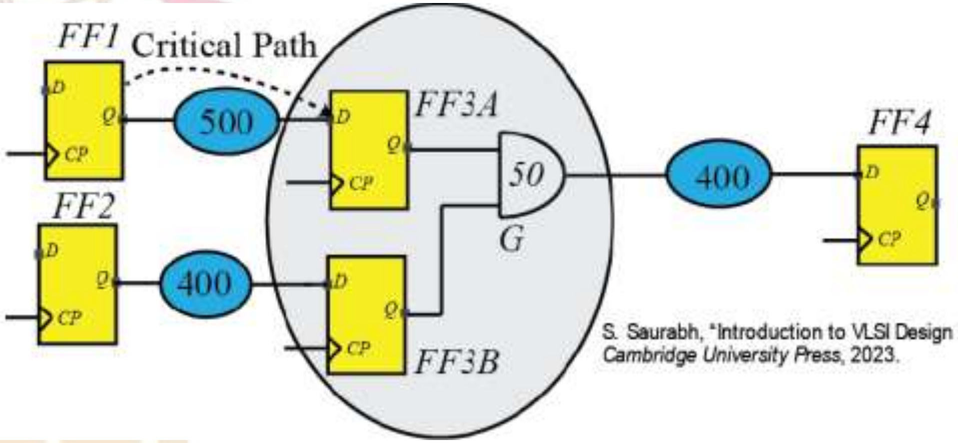

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References

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