

CSE460: Switching Theory

Lecture 10 : Design Flow for Reconfigurable Hardware

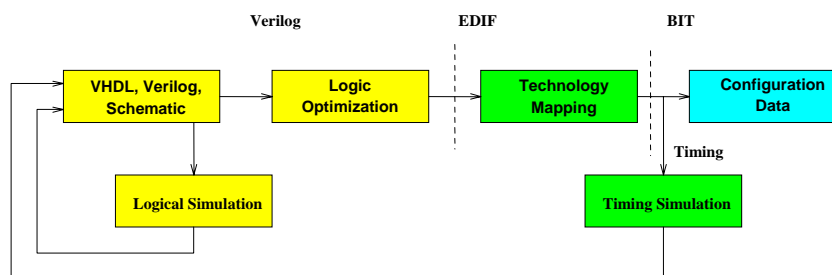
Washington University

Spring 2006

<http://www.arl.wustl.edu/~lockwood/class/cse460/>

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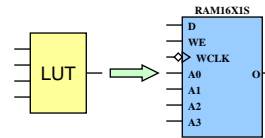
FPGA: Design Flow



- **Technology Independent Design**
 - Compilation of Verilog/VHDL Architecture
 - Minimization into minimal SOP
- **Technology Dependent**
 - Logic mapped to Silicon transistors or FPGA LUTs
 - Routing and placement

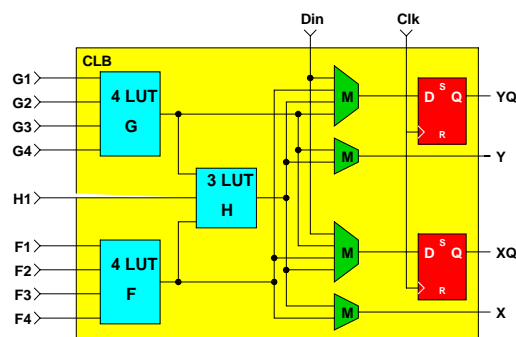
Technology-Dependent Logic: FPGA

- Circuits mapped into physical circuits
 - Field Programmable Gate Arrays (FPGAs)
 - LookUp Table (LUT)
 - Memory Element, Addressed by inputs

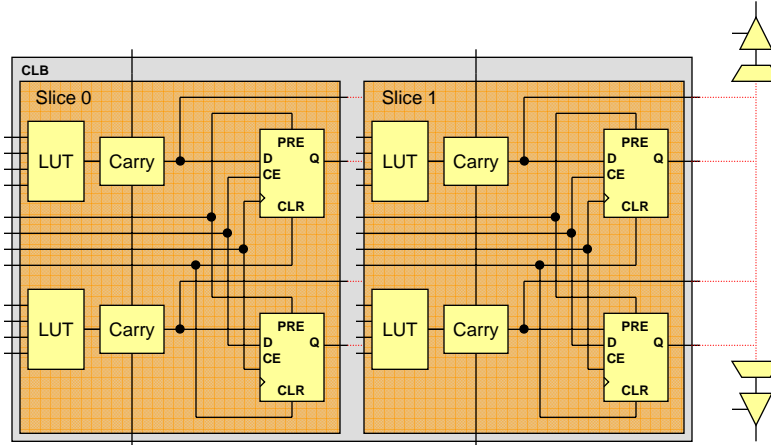


Field Programmable Gate Arrays: CLB

- Look Up Table (LUT) Function Generator
 - Calculates arbitrary $F(f_1, f_2, f_3, f_4)$
- Soft Interconnect
 - Propagates signals
- State Storage
 - Bistable latch
 - Edge-triggered F/F
- Efficiency
 - ~10x performance hit over full-custom logic
 - Latest Silicon technology (.25um)



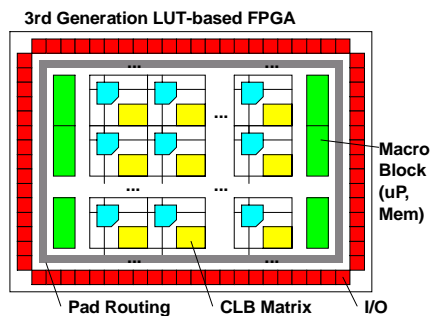
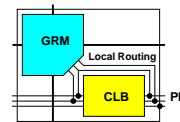
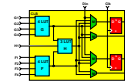
Field Programmable Gate Arrays: Virtex



- Diagram From: Xilinx, Inc (Courtesy Peter Alfke)

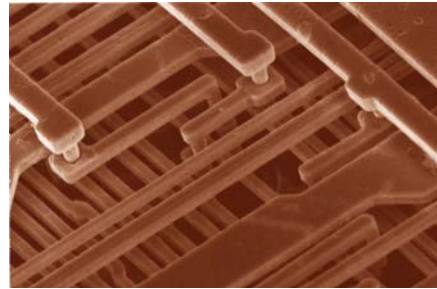
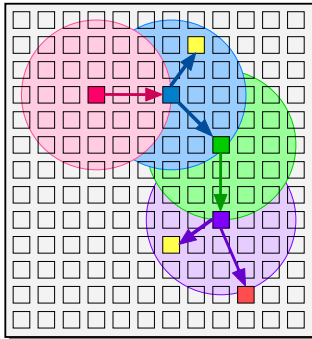
Field Programmable Gate Array: Device

- CLB
 - Primitive element of FPGA
- Routing Module
 - Global routing
 - Local interconnect
- Macro Blocks
 - Block SRAM
- I/O Block



Delay-Based Routing

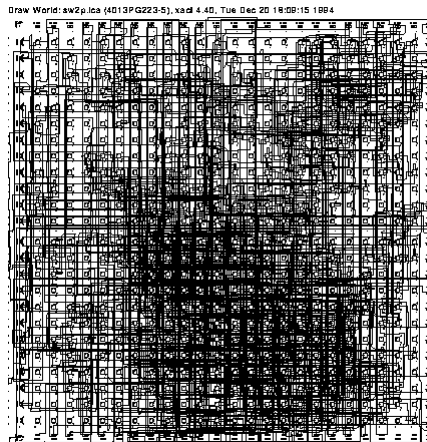
Vector-based Interconnect



The circles show 1.4-ns routing delay

- Diagram From: Xilinx, Inc (Courtesy Peter Alfke)

Automated Routing and Placement



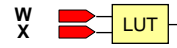
Routed FPGA
(Xilinx XC4013)

Examples: Lookup table function mapping

- $$F(w,x) = w'x + wx'$$

$$= \{01, 10\}$$

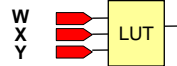
$$= \{1,2\}$$



- $$F(w,x,y) = w'x'y + w'xy' + wx'y' + wxy$$

$$= \{001, 010, 100, 111\}$$

$$= \{1,2,4,7\}$$

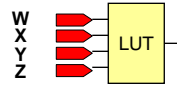


- $$F(w,x,y,z) = wxyz + wx' + w'xy'$$

$$= \{1111, 10--, 010-\}$$

$$= \{1111, 1000, 1001, 1010, 1011, 0100, 0101\}$$

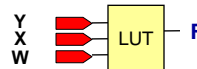
$$= \{4,5,8,9,10,11,15\}$$



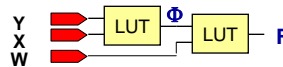
Decomposition

- $$F(w,x,y) = \{1,2,4,7\}$$

| | | | | | |
|------------|---|---|---|---|---------|
| W=0 | 0 | 1 | 2 | 3 | Φ |
| W=1 | 4 | 5 | 6 | 7 | Φ' |

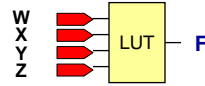


- $$F(w,x,y) = F(w, \Phi(x,y))$$

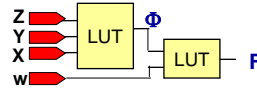


Decomposition (cont)

- $F(w,x,y,z)$



- $F(w,x,y,z) = F(w, \Phi(x,y,z))$



- $F(v,w,x,y,z) = F(v,w, \Phi(x,y,z))$

