BSC~Microsoft Research Centre

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VLSI Design

ASIC and FPGA

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Outline

ASIC

FPGA

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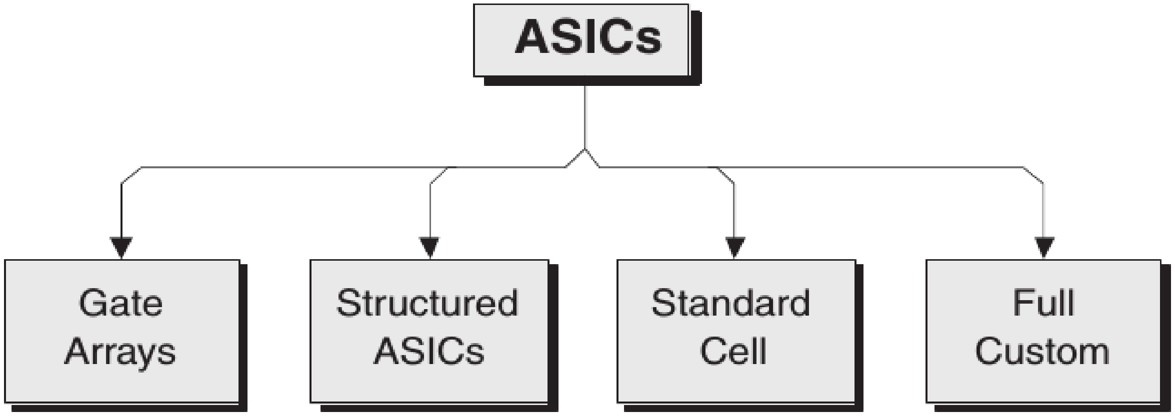
ASIC

ASIC: An application-specific integrated circuit (ASIC) is an integrated circuit designed for a particular use, rather than intended for general-purpose use. Processors, RAM, ROM, etc are examples of ASICs.

Fine-, medium-, and coarse-grained architectures



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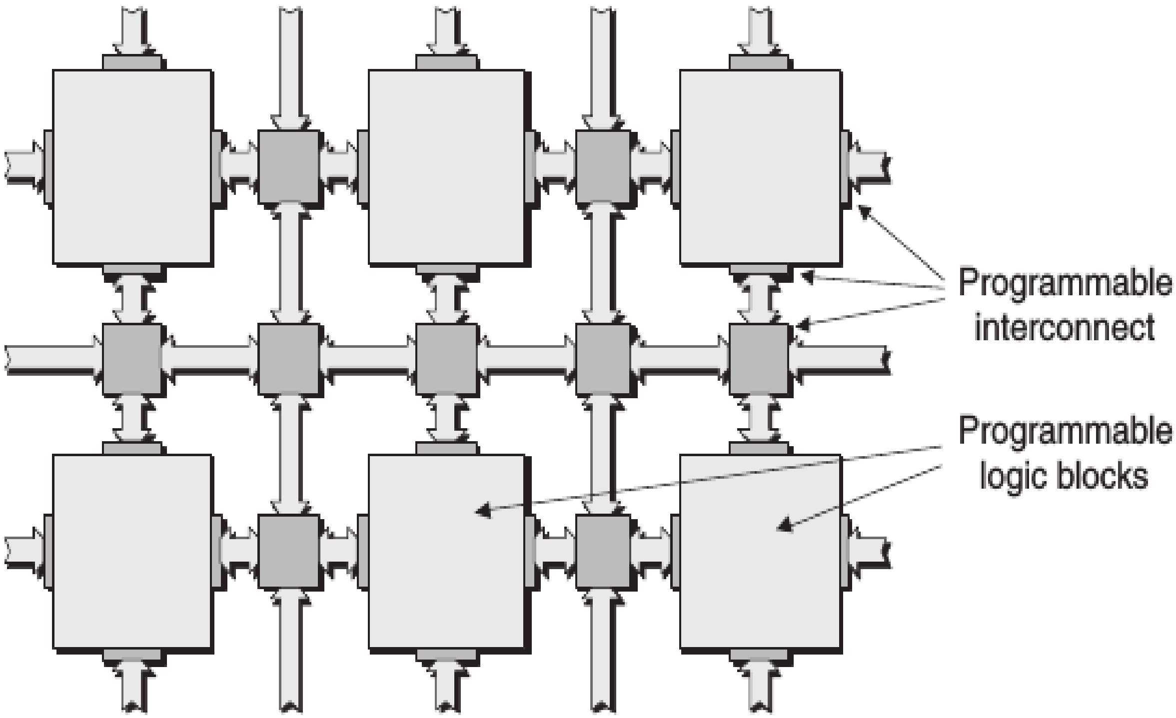
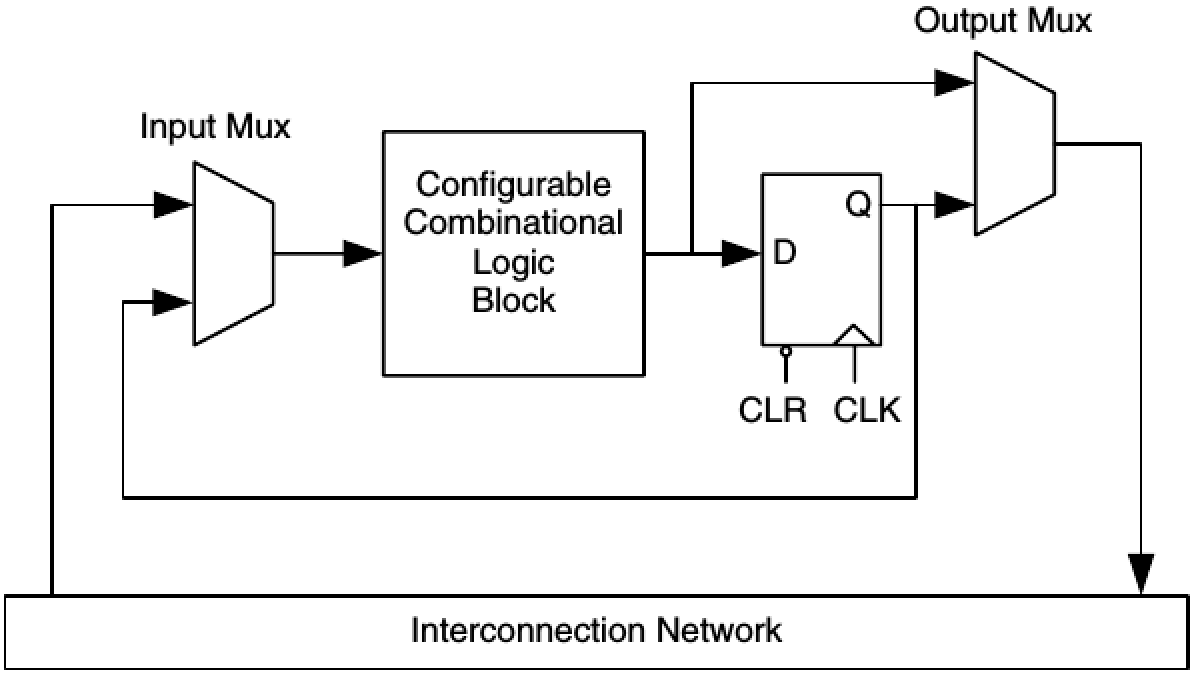
FPGA

FPGA: A Field-Programmable Gate Array (FPGA) is a semiconductor device containing programmable logic components called "logic blocks", and programmable interconnects. Logic blocks can be programmed to perform the function of basic logic gates such as AND, and XOR, or more complex combinational functions such as decoders or mathematical functions.

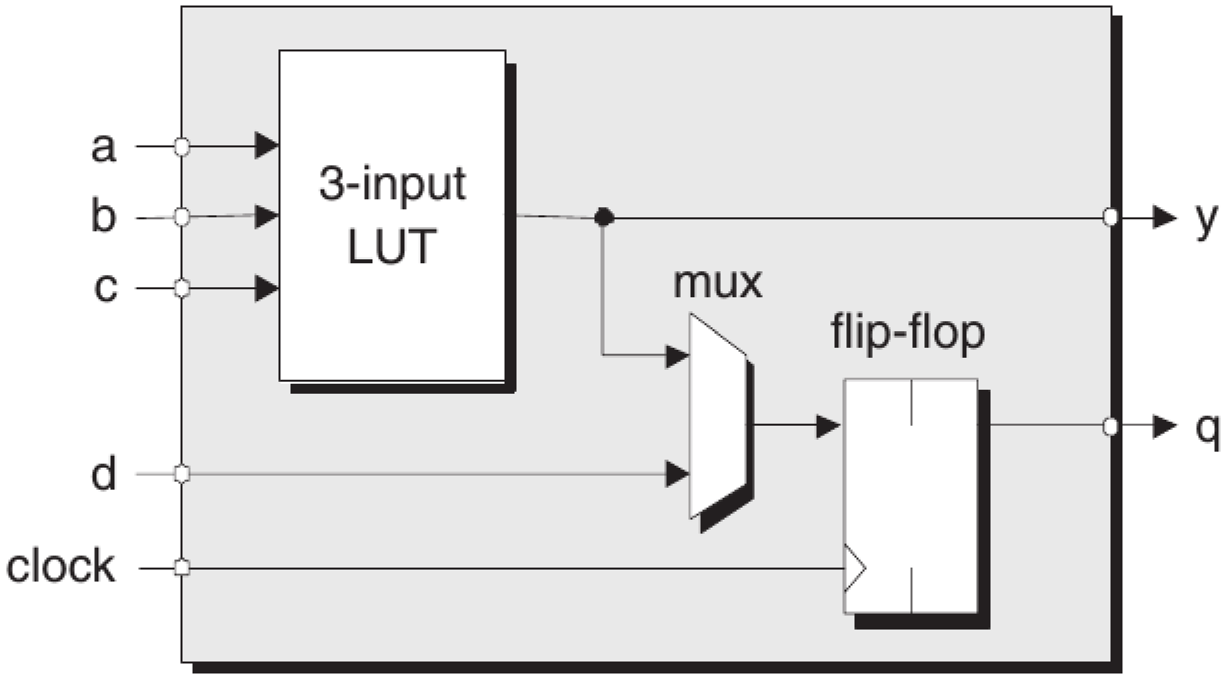
Fine-, Medium-, and Coarse-Grained Architectures



FPGA Internal Diagram



Basic Logic Slice

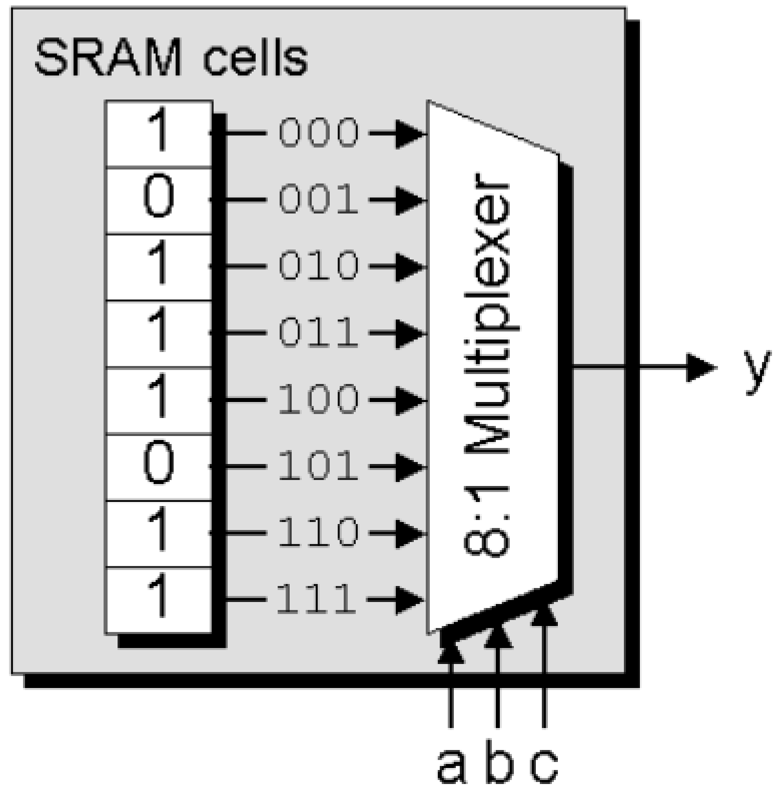


SRAM based LUT

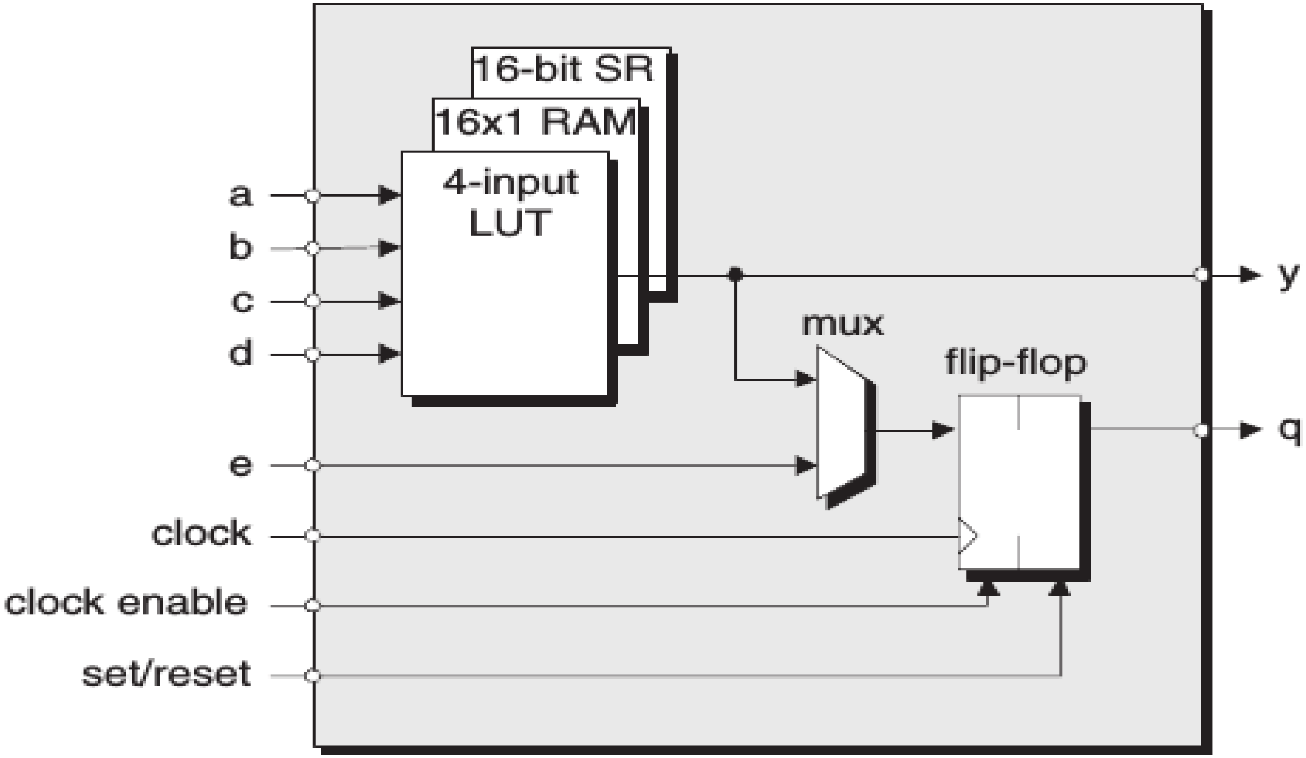
Truth table

a	b	c	y
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

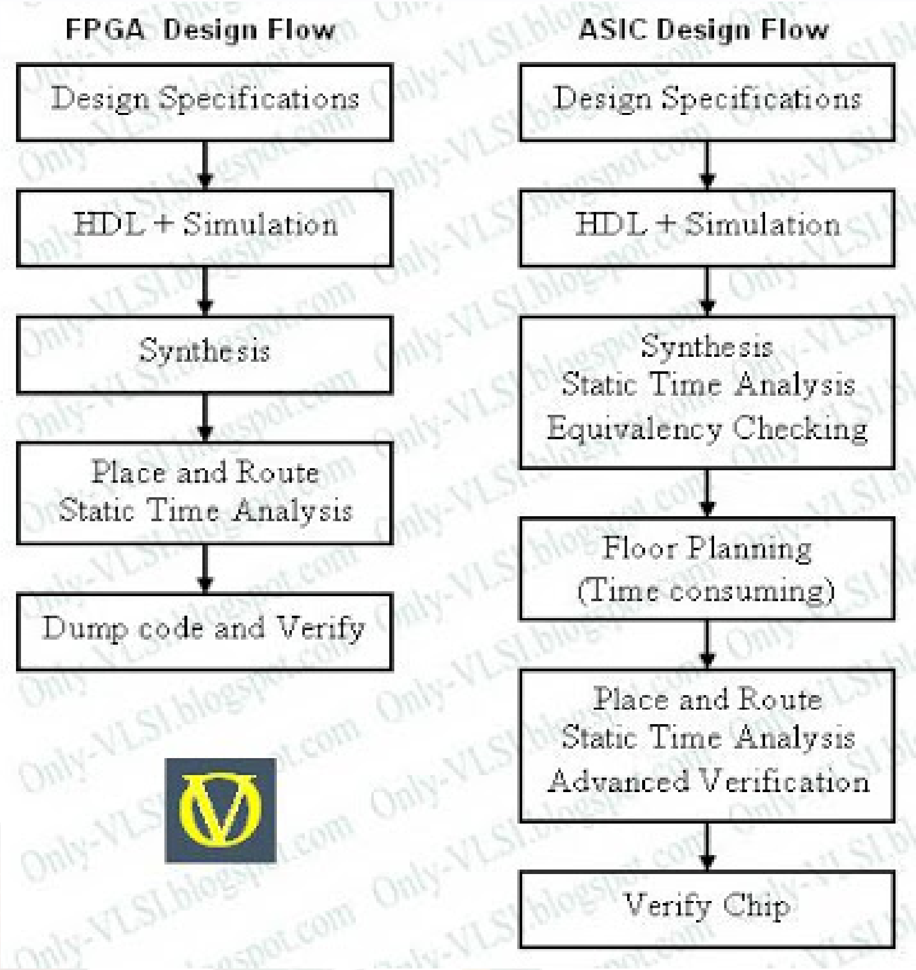
Programmed LUT



Xilinx Logic Cell



Design Flow



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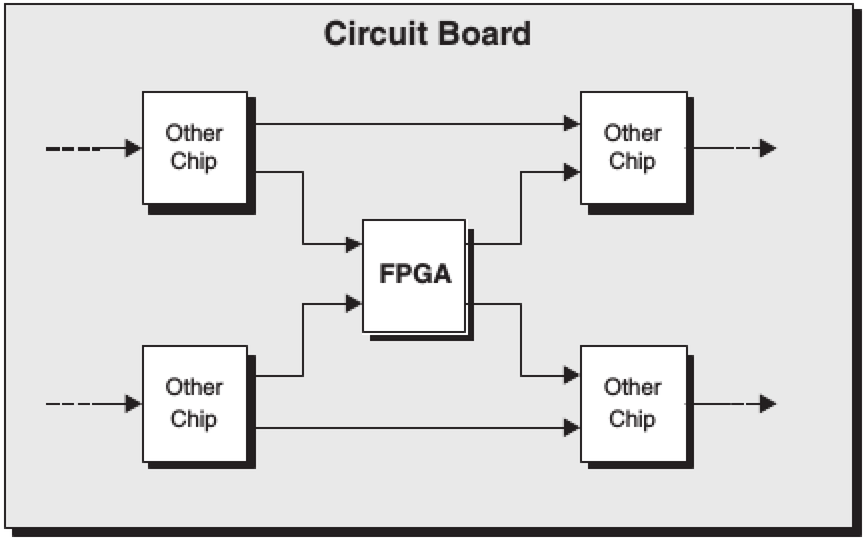
Synthesis

Synthesis is a process by which an abstract form of desired circuit behavior, typically at register transfer level (RTL), is turned into a design implementation in terms of logic gates.

Floorplan



Floorplan of an integrated circuit is a schematic representation of tentative placement of its major functional blocks.

Place and Route

Placement involves deciding where to place all electronic components, circuitry, and logic elements in a generally limited amount of space.

Routing decides the exact design of all the wires needed to connect the placed components.

ASIC Vs FPGA

Speed

ASIC rules out FPGA in terms of speed. As ASIC are designed for a specific application they can be optimized to maximum, hence we can have high speed in ASIC designs. ASIC can have hight speed clocks.

Cost

FPGAs are cost effective for small applications. But when it comes to complex and large volume designs (like 32-bit processors) ASIC products are cheaper.

Size/Area

FPGA are contains lots of LUTs, and routing channels which are connected via bit streams(program). As they are made for general purpose and because of re-usability. They are in-general larger designs than corresponding ASIC design. For example, LUT gives you both registered and non-register output, but if we require only non-registered output, then its a waste of having a extra circuitry. In this way ASIC will be smaller in size.

ASIC Vs FPGA

Power

FPGA designs consume more power than ASIC designs. As explained above the unwanted circuitry results wastage of power. FPGA wont allow us to have better power optimization. When it comes to ASIC designs we can optimize them to the fullest.

Time to Market

FPGA designs will till less time, as the design cycle is small when compared to that of ASIC designs. No need of layouts, masks or other back-end processes. Its very simple: Specifications -- HDL + simulations -- Synthesis -- Place and Route (along with static-analysis) -- Dump code onto FPGA and Verify. When it comes to ASIC we have to do floor planning and also advanced verification. The FPGA design flow eliminates the complex and time-consuming floor planning, place and route, timing analysis, and mask / re-spin stages of the project since the design logic is already synthesized to be placed onto an already verified, characterized FPGA device.

Type of Design

ASIC can have mixed-signal designs, or only analog designs. But it is not possible to design them using FPGA chips.

ASIC Vs FPGA

Customization

ASIC has the upper hand when comes to the customization. The device can be fully customized as ASICs will be designed according to a given specification. Just imagine implementing a 32-bit processor on a FPGA!

Prototyping

Because of re-usability of FPGAs, they are used as ASIC prototypes. ASIC design HDL code is first dumped onto a FPGA and tested for accurate results. Once the design is error free then it is taken for further steps. Its clear that FPGA may be needed for designing an ASIC.

Non Recurring Engineering/Expenses

NRE refers to the one-time cost of researching, designing, and testing a new product, which is generally associated with ASICs. No such thing is associated with FPGA. Hence FPGA designs are cost effective.

ASIC Vs FPGA

Simpler Design Cycle

Due to software that handles much of the routing, placement, and timing, FPGA designs have smaller designed cycle than ASICs.

More Predictable Project Cycle

Due to elimination of potential re-spins, wafer capacities, etc. FPGA designs have better project cycle.

Tools

Tools which are used for FPGA designs are relatively cheaper than ASIC designs.

Re-Usability

A single FPGA can be used for various applications, by simply reprogramming it (dumping new HDL code). By definition ASIC are application specific cannot be reused.