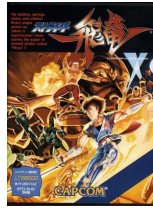


Hardware Construction

- Let's bring it all together.
- Whether you're producing microcontrollers, personal computers or mainframes, the design process is still the same.
 - Logic Design
 - Software Implementation & Testing
 - PLA Implementation & Testing
 - Semiconductor Fabrication & Testing



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Design & Simulation

- VHDL and Verilog most commonly used in industry for creation of hardware logic
- Completed designs are simulated and tested on virtual hardware platforms
 - Behaviour modeling emulates the physics of the semiconductor devices and the effects of heat and random errors.
 - Testbenches are used to verify the sanity of a design, to make sure that working components don't break because of a modification to the design.
 - Timing and layout issues are simulated as well, to ensure that race conditions and sympathetic current issues are eliminated

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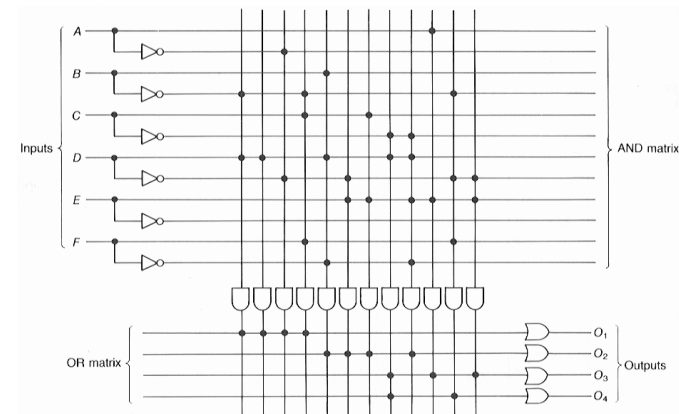
Programmable Logic Arrays

- Once the design has been simulated and tested, it is implemented in a Programmable Logic Array (PLA) or a Programmable Gate Array (PGA).
 - Many jobs in Field-Programmable Gate Array (FPGA) design.
- PLAs and PGAs are physical chips which can implement most sum-of-product circuit models.
 - Typically composed of three large logic blocks, each of which feeds into the next:
 - inverter block
 - AND-gate block
 - OR-gate block.
 - Each of the gates in the AND- and OR-gate blocks can be "programmed" to take in any combination of outputs from the previous stage (see illustration, next slide).

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Programmable Logic Arrays



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Programmable Logic Arrays

- The circles on the diagram indicate connections between the inputs and the AND gates. These connections are implemented one of two ways:
 - Each AND gate starts off connected to all inputs, and fuses are blown where connections are no longer needed
 - AND gates are unconnected, and programmable transistors (i.e. EPROM technology) are used to make connections from inputs to AND gates as needed (produces chip that is reprogrammable).
- **Advantages:**
 - Hardware simulation possible without fabrication.
 - PLA and PGA chips can be reused.
 - Chips are relatively cheap to produce.
- **Disadvantage:**
 - Space and time usage is not optimal/realistic.



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ASIC Design

- Creating an **Application-Specific Integrated Circuit (ASIC)** is the final step in the design process.
 - Chips for cell phones and PDAs are ASIC-based.
 - ASICs can hold up to 100 million gates, and can feature entire 32-bit CPUs and memory blocks.
 - "System-on-a-chip" (SoC)
- **ASIC design process:**
 - ASIC designers use the PLA-tested design to devise a **netlist**, which outlined connections between components.
 - Location and timing constraints are used to decide on the placement of the ASIC components (heavy use of optimization algorithms).
 - A set of **photomasks** are made for the fabrication process.
 - The design is fabricated and tested, to detect any parasitic resistances, unexpected capacitance, delays or power sinks.
 - The final photomasks are released for mass production.

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The Final Piece of the Puzzle

- Once the hardware has been implemented in a chip, programs are uploaded into its memory to tell it how to behave given inputs from the outside world.
 - Programs are given in opcode format, which are translated from programs written in assembly language.
 - Other languages such as **SystemC** also allow for hardware-level program design.
- These programs are also simulated and tested before and after uploading, and then the process is done.

The End

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