



UNIVERSIDAD DEL BÍO-BÍO  
FACULTAD DE CIENCIAS EMPRESARIALES

# FPGA

## Heterogeneous Computing

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Course website: <http://www.face.ubiobio.cl/~jfuentes/classes/hc>

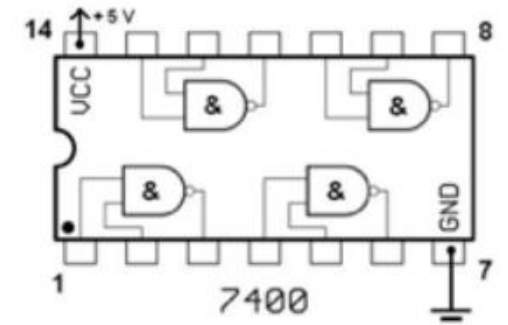
# Contents

- What are FPGAs?
- Logical blocks
- Programmable routes
- Advantages of FPGAs

# Common implementation of digital circuits

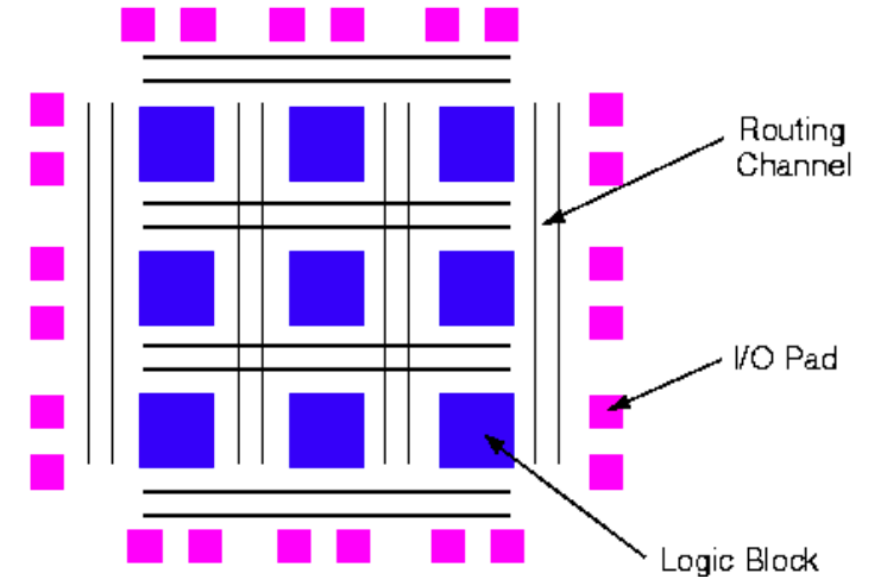
- Basic way to implement digital logic circuits.
- Based on gates or small circuits that function as blocks in larger circuits.
- Morgan's theorem:
  - Theoretically we only need NAND or NOR to build anything.

Tedious, expensive, slow, error-prone wiring fixation.



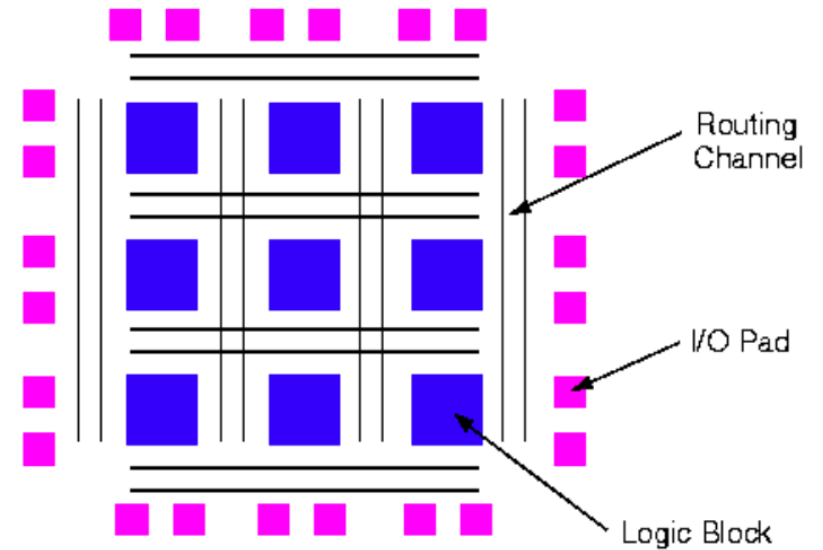
# Field Programmable Gate Array (FPGA)

- It combines the idea of programmable logic devices (PLDs) and logic gates.
- Initially proposed by Xilinx in 1985
- Consists of logical block arrays for implementing logical functions
- Contains programmable cabling on router channels
- Flexible I/O interface



# Field Programmable Gate Array (FPGA)

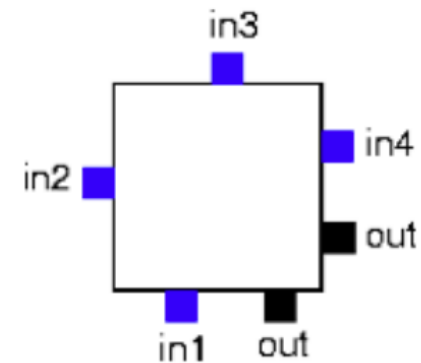
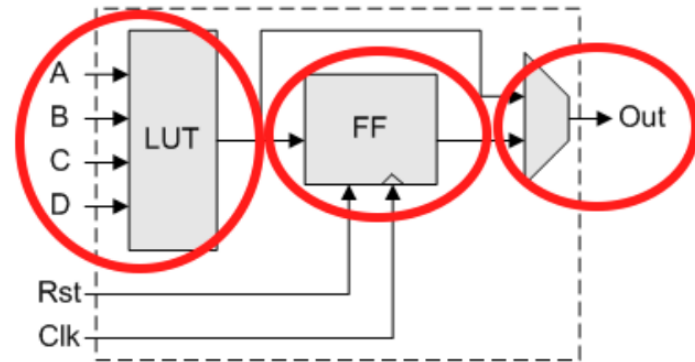
- The programmer can define how the logic gates are connected to each other.
- Unlike a microprocessor, where the program contains instructions for a certain hardware, with FPGA it is possible to program the hardware.



# Logical blocks

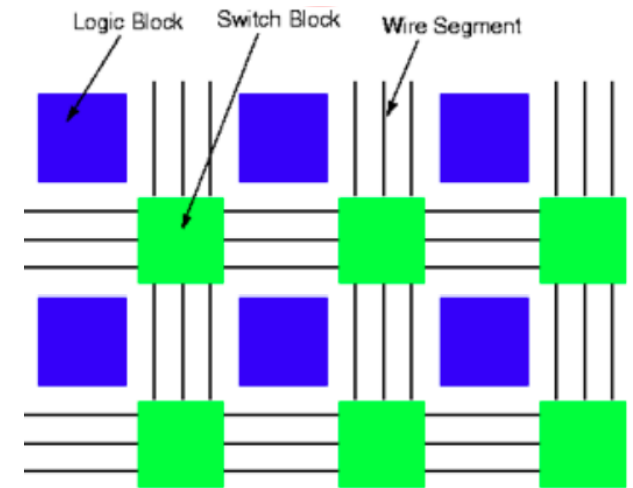
- Also known as Logical Elements.
- Based on Look-up tables (LUTs) with usually 4 inputs.
- You can include D-flipflop in the LUT output.
- The 4-input LUT can implement ANY Boolean equation.
- Each block has easily accessible pins (input/output).

Logical Block

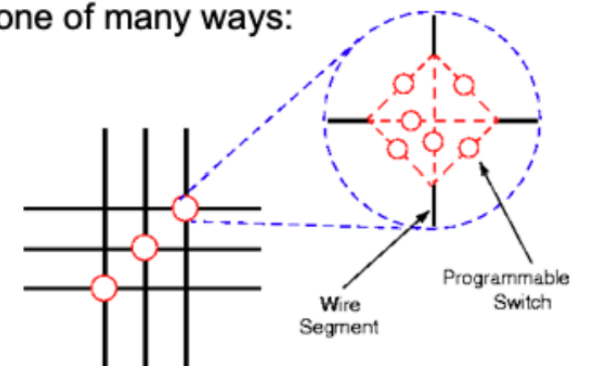


# Programmable routes

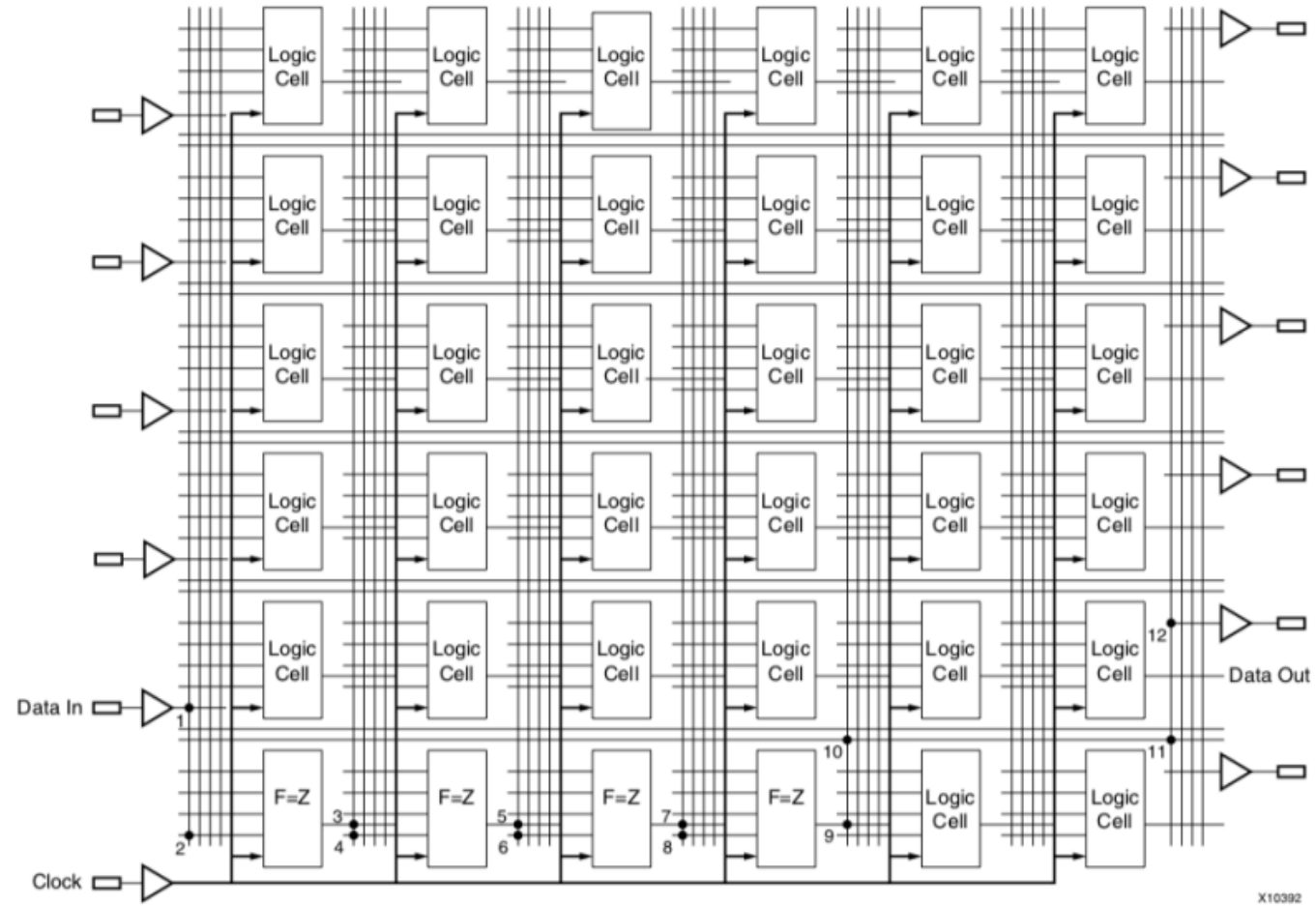
- Between rows and columns of logical blocks are the connection channels.
- Block pins can be connected to one or many connection cables using a programmable switch.
- Each connection can be connected in many possible ways.



one of many ways:



# FPGA



Simplified version of an FPGA's internal architecture



# FPGA Programming

- The programmer can:
  - Define logical block functionality
  - Establish interconnection paths between logical blocks
  - Set other options, such as clock, reset, and I/O.

# FPGA Programming

- After defining logical blocks



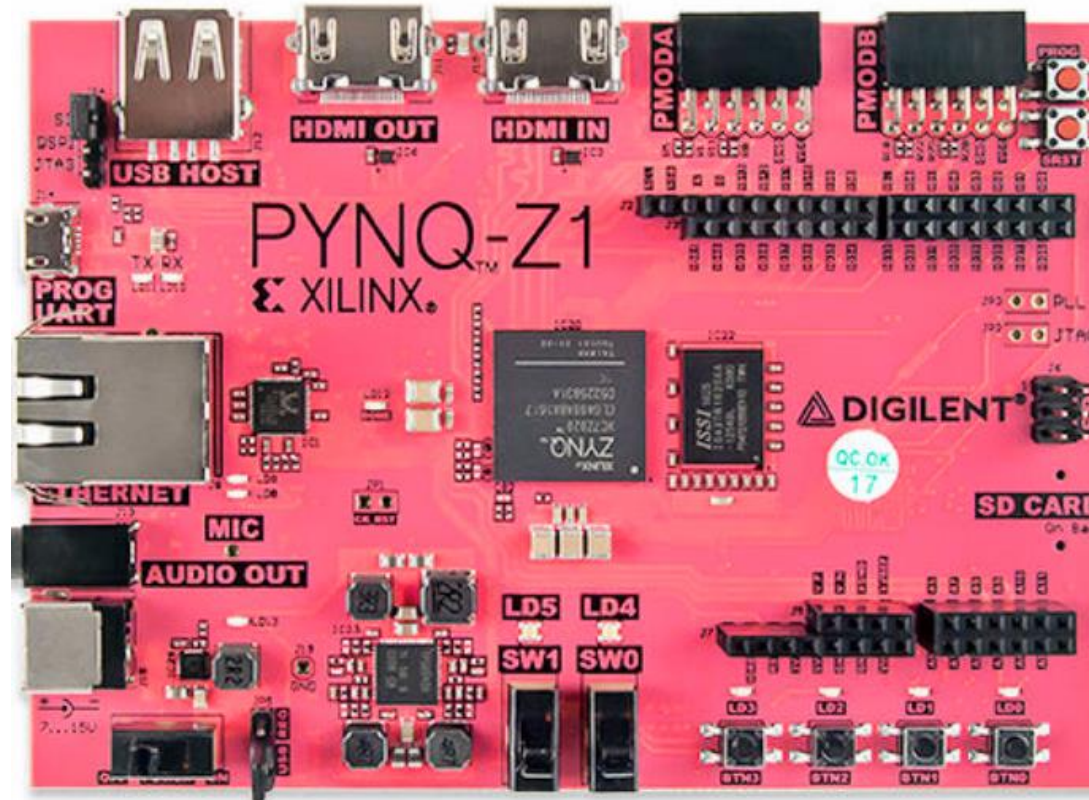
# FPGA Programming

- After defining interconnection paths



# FPGA

- Main manufacturers: Xilinx and Altera
- Xilinx PYNQ-Z1



# Why are FPGAs a good idea?

- Reconfigurable hardware for different uses
- Dynamic reconfiguration in a computer system
- Hardware that modifies itself
- Hardware that evolves over time
- FPGAs have followed Moore's Law better than any other device.
- They are very energy efficient
- Energy Efficiency ASIC vs CPU vs FPGA



- FPGA is 70x more energy efficient than CPU

# References

- Xilinx <https://www.xilinx.com/>
- Intel Altera <https://www.intel.com/content/www/us/en/products/programmable.html>