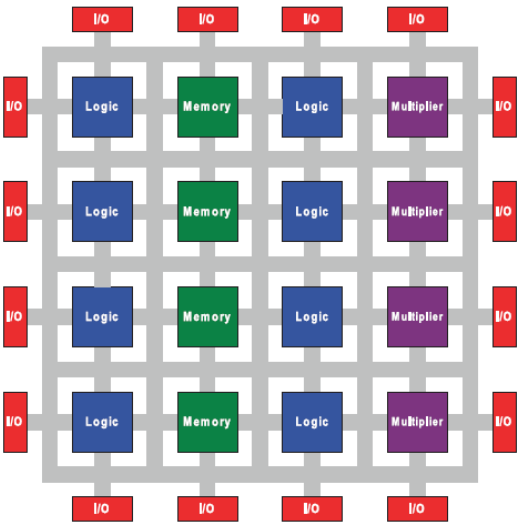
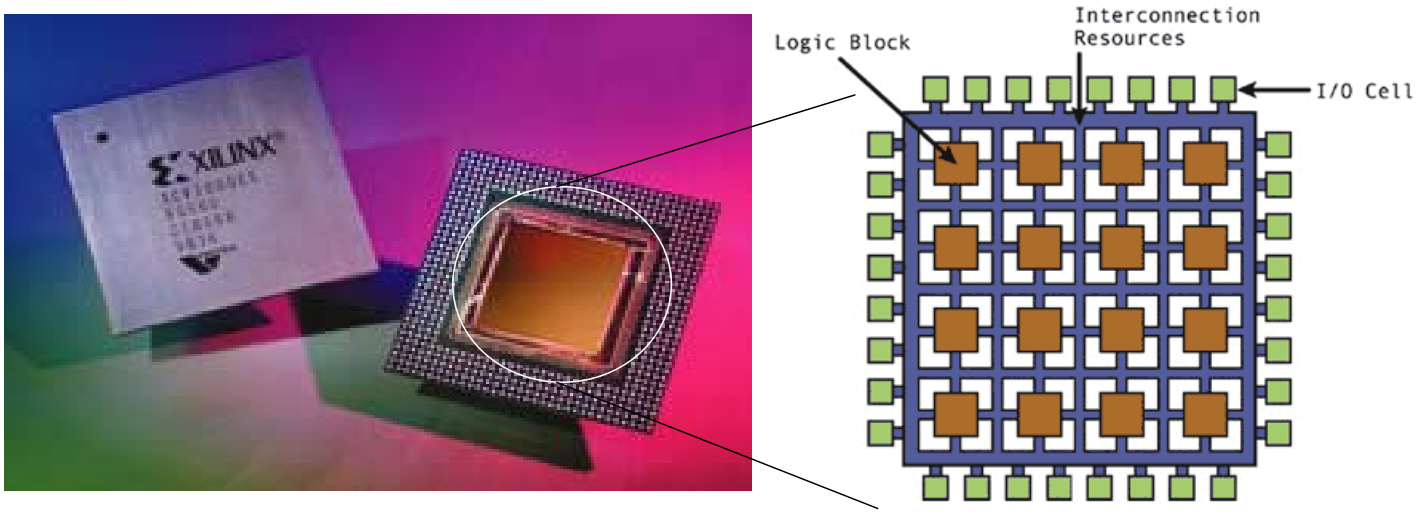
# *Classification and Evolution of Field Programmable Logic Devices*

## Topics

- Distinction from ASIC
- Classification & evolution of FPLDs
- FPLD markets



# Field-Programmable Gate Array (FPGA)




# Field-Programmable Devices

- *User-configurable* ICs.
- They are standard parts, not designed for any particular application.
- Unlike traditional ASIC, logic function is specified by the user *after* the device is manufactured.

- They are programmed/configured by the users to implement their designs *at their own sites*.
- *Instant configuration* (in minutes) at users' site.

# Advantages of Field-Programmable Logic Devices

- Short turnaround time for new designs
- Low startup cost
- Low inventory cost
- Low risk
- Allow easy design changes

How to make a chip that can realize different circuits and configurable?

What are the essential elements that make up any circuit?

# What do you expect within a FPLD?

1. Substantial amounts of uncommitted combinational logic.
2. Contain flip-flops/latches.
3. Programmable interconnections between the combinational logic, flip-flops, and chip input/outputs.

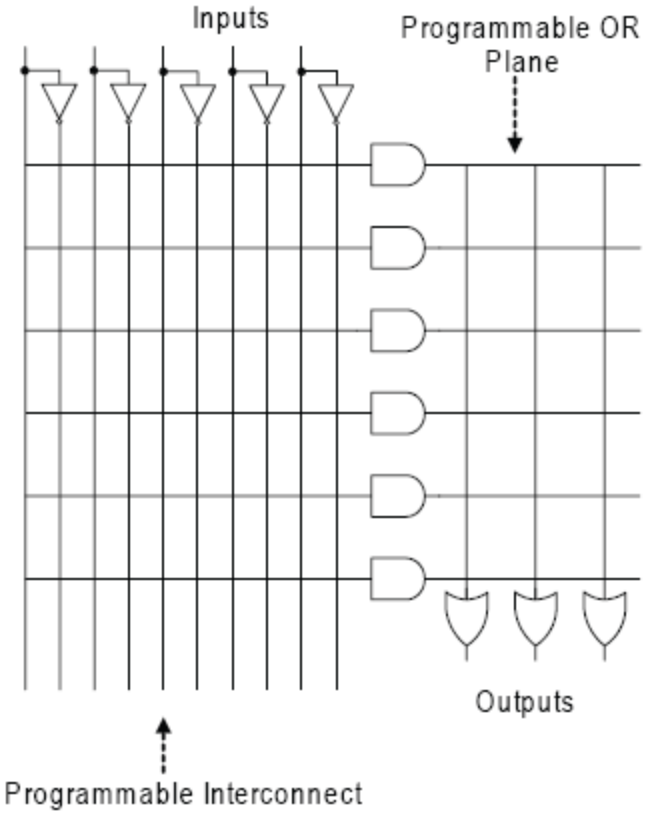
# Types of Field-Programmable Devices

- *Simple Programmable Logic Devices* (SPLDs)
- *Complex Programmable Logic Devices* (CPLDs)
- *Field-Programmable Gate Arrays* (FPGAs)

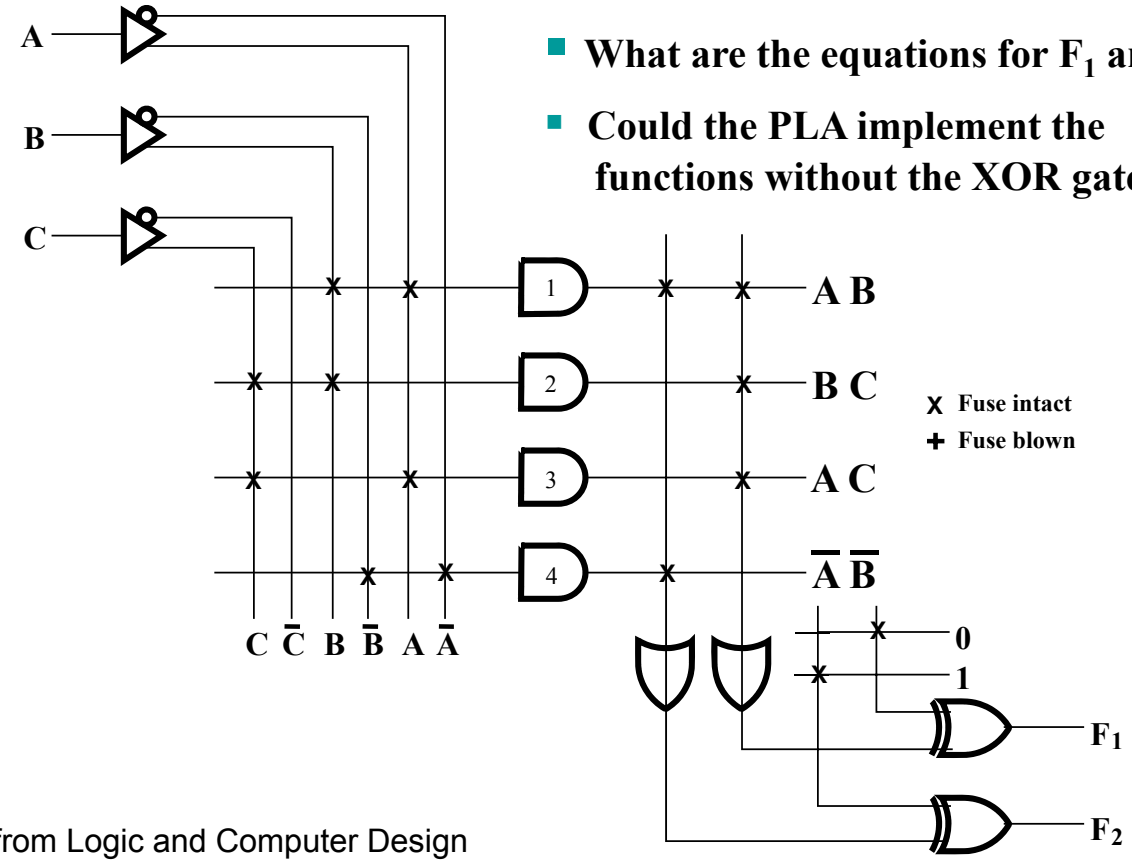
# Programmable Logic Array (PLA)

- A simple programmable logic device (SPLD).
- The first programmable logic device introduced in the early 1970s by Philips.
- Use a *2-level logic* structure to implement programmed logic.
- Based on idea that logic functions can be realized in *sum-of-products* form.
- A programmable array of AND gates feeding a programmable array of OR gates.

# PLA Structure



# Function Implementation by PLA




- What are the equations for $F_1$ and $F_2$?
- Could the PLA implement the functions without the XOR gates?

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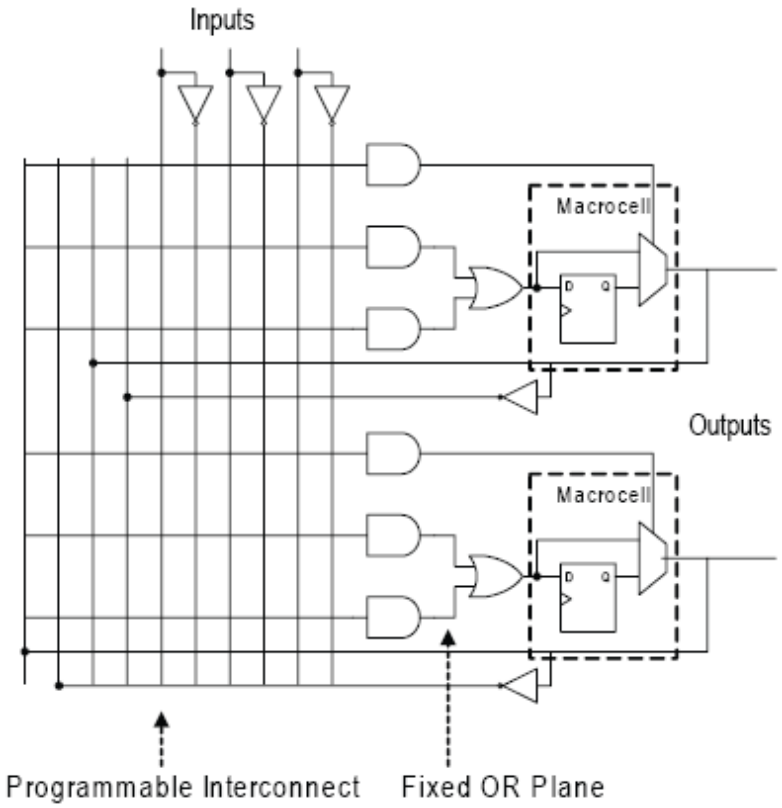
# Programmable Array Logic (PAL)

- Introduced to overcome the weaknesses of PLAs (programmable switches were hard to fabricate correctly and introduced significant propagation delays).
- A programmable array of AND gates feeding a fixed array of OR gates.
- PAL usually contains flip-flops connected to the OR gate outputs to implement sequential circuits. (*Macrocell:* an OR gate combined with a flip-flop and extra circuitry in a PAL.)
- PLAs and PALs are useful for implementing small digital circuits, typically $\leq 32$ combined inputs and outputs.

# PAL Structure




# Function Implementation by PAL

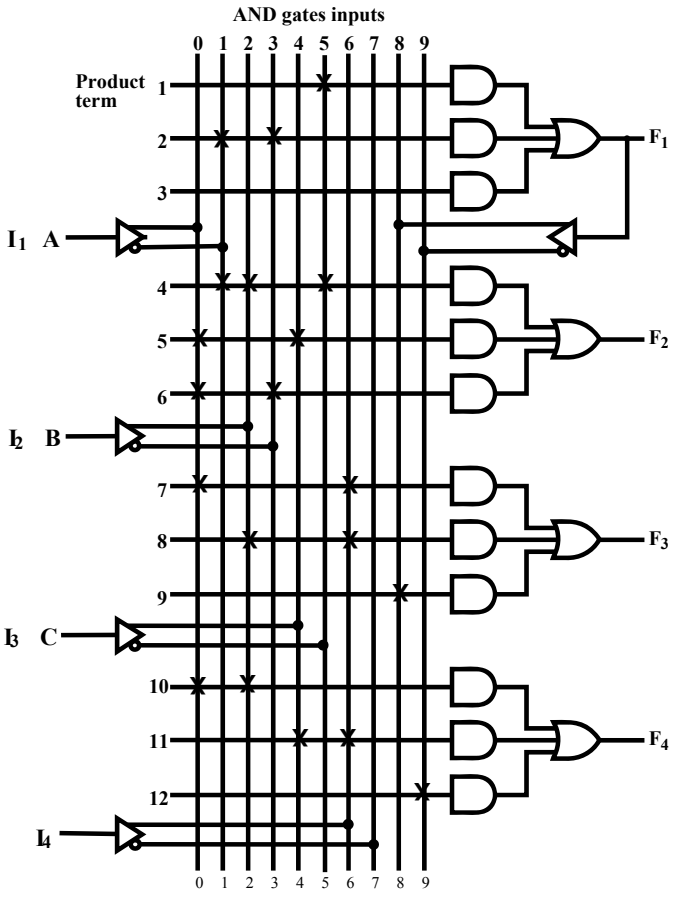
- 4-input, 4-output PAL with fixed, 3-input OR terms
- What are the equations for F1 through F4?

  F1 = $\overline{A}\ \overline{B} + \overline{C}$

  F2 = $\overline{A}B\ \overline{C} + AC + AB$

  F3 =

  F4 =

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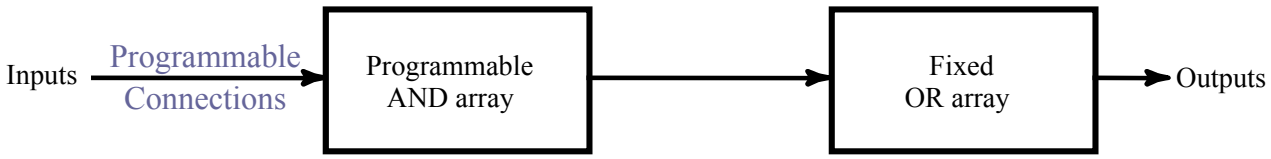
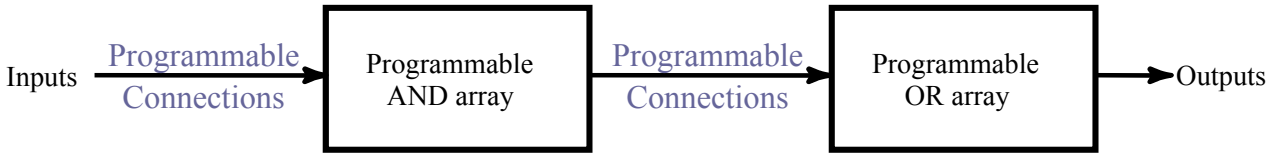
# PAL and PLA Comparison




(a) Programmable array logic (PAL) device




(b) Programmable logic array (PLA) device

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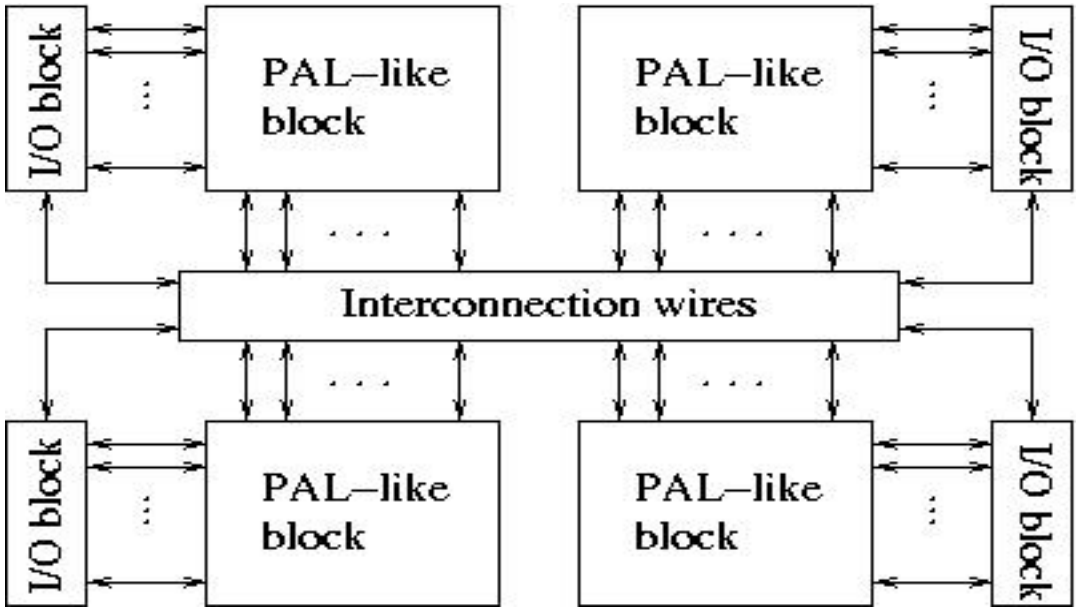
*How to get larger capacity?*

# Complex Programmable Logic Device (CPLD)

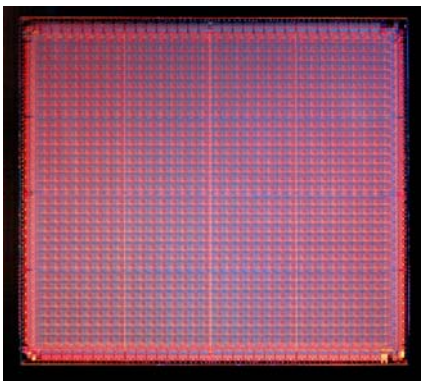



# Complex Programmable Logic Device

- Combines multiple PAL-like blocks with programmable interconnect network.
- Provides much larger capacity than SPLDs.

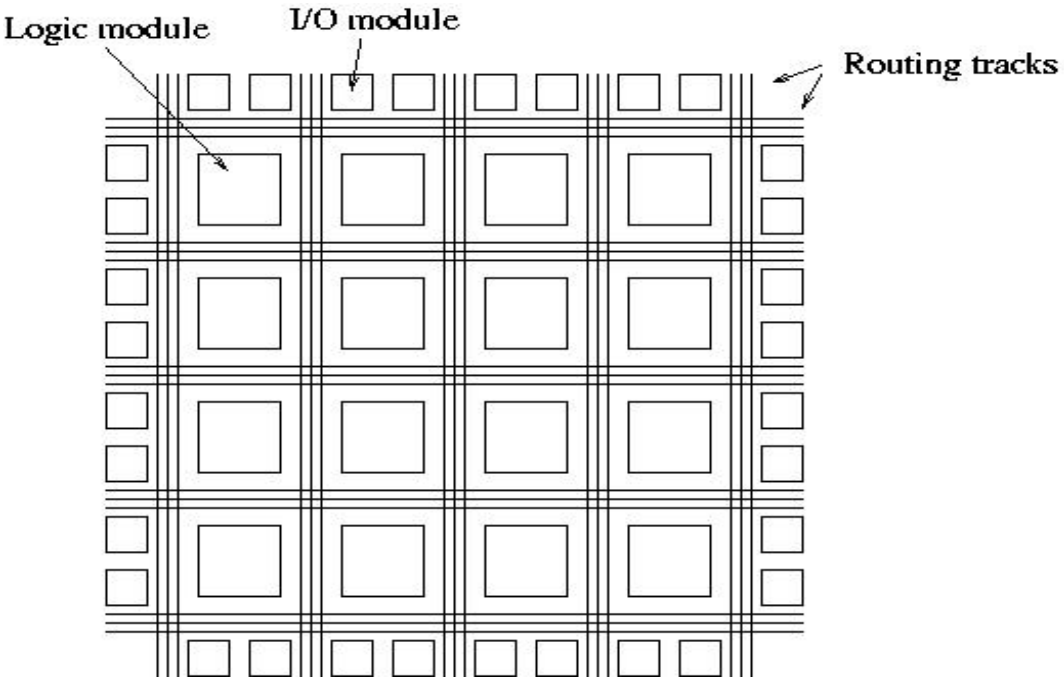
# Field-Programmable Gate Array (FPGA)

- A high-capacity programmable logic device providing multi-level logic.
- Introduced in 1985 by Xilinx.
- Classic FPGA consists of an *array of programmable logic blocks* surrounded by programmable interconnect.

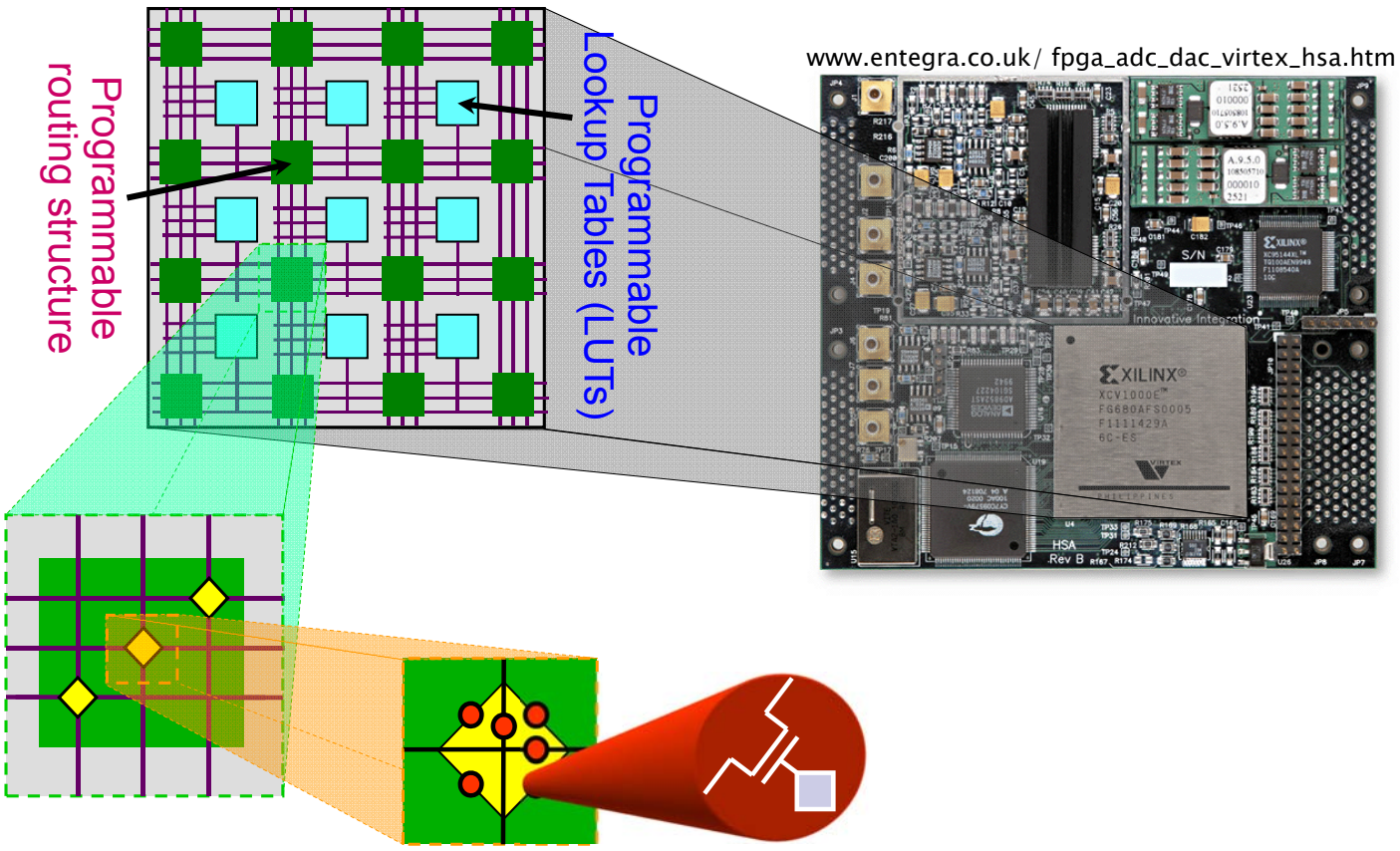


Xilinx XC4000ex

# Field-Programmable Gate Array

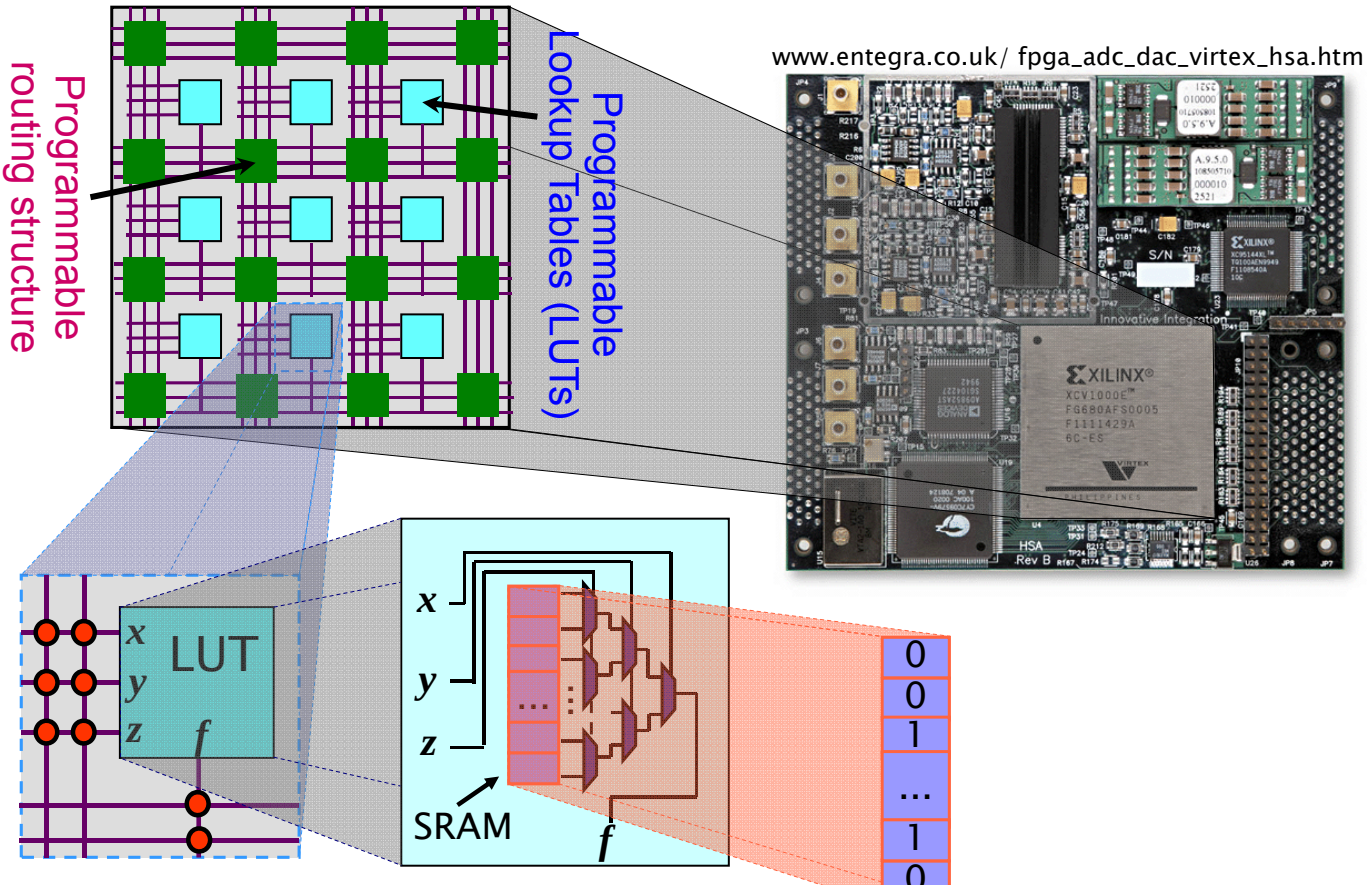


# SRAM-Based FPGA




K. Bazargan

# SRAM-Based FPGA




K. Bazargan

# Microprocessor vs Custom Chip vs FPGA

- Microprocessor
  - Rely on software to implement functions
  - Slowest, most power-hungry
  - Re-programmable (load different software)
- Custom Chip
  - Designed for a particular purpose
  - Fastest, most power-efficient
  - Not re-programmable
- FPGA
  - Not designed for any particular function
  - In between microprocessor and custom chip in speed and power
  - Re-programmable (most)

# Rapidly Increasing Logic Capacity

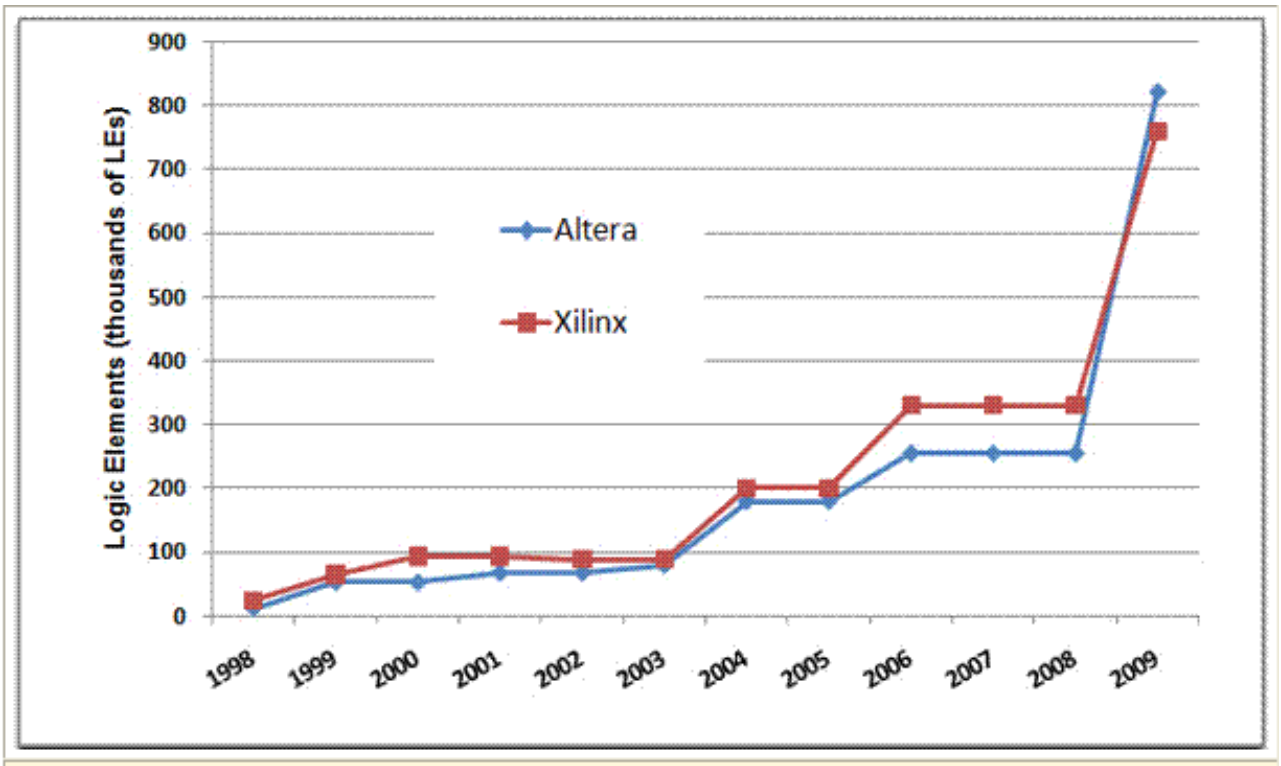


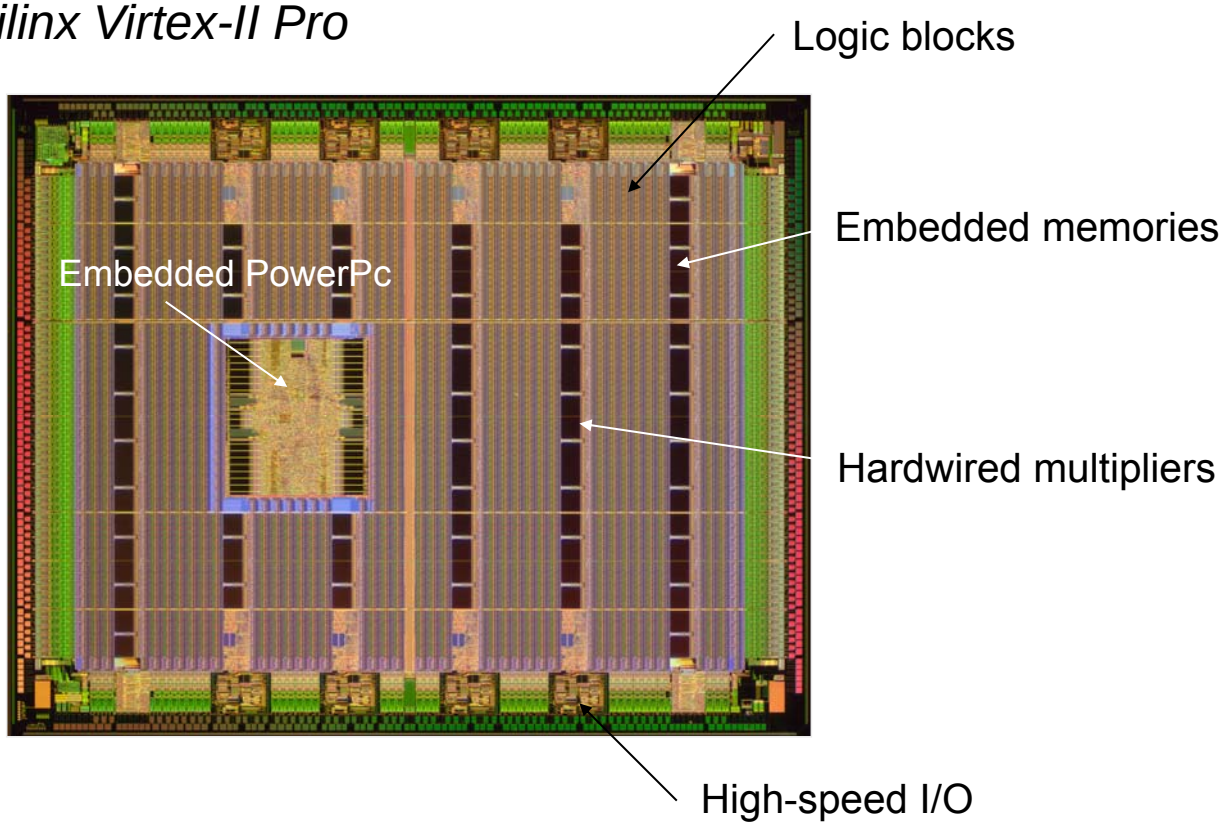

Figure 1. Largest FPGA announced (by equivalent 4-input Logic Elements - LEs).

# Today's FPGAs

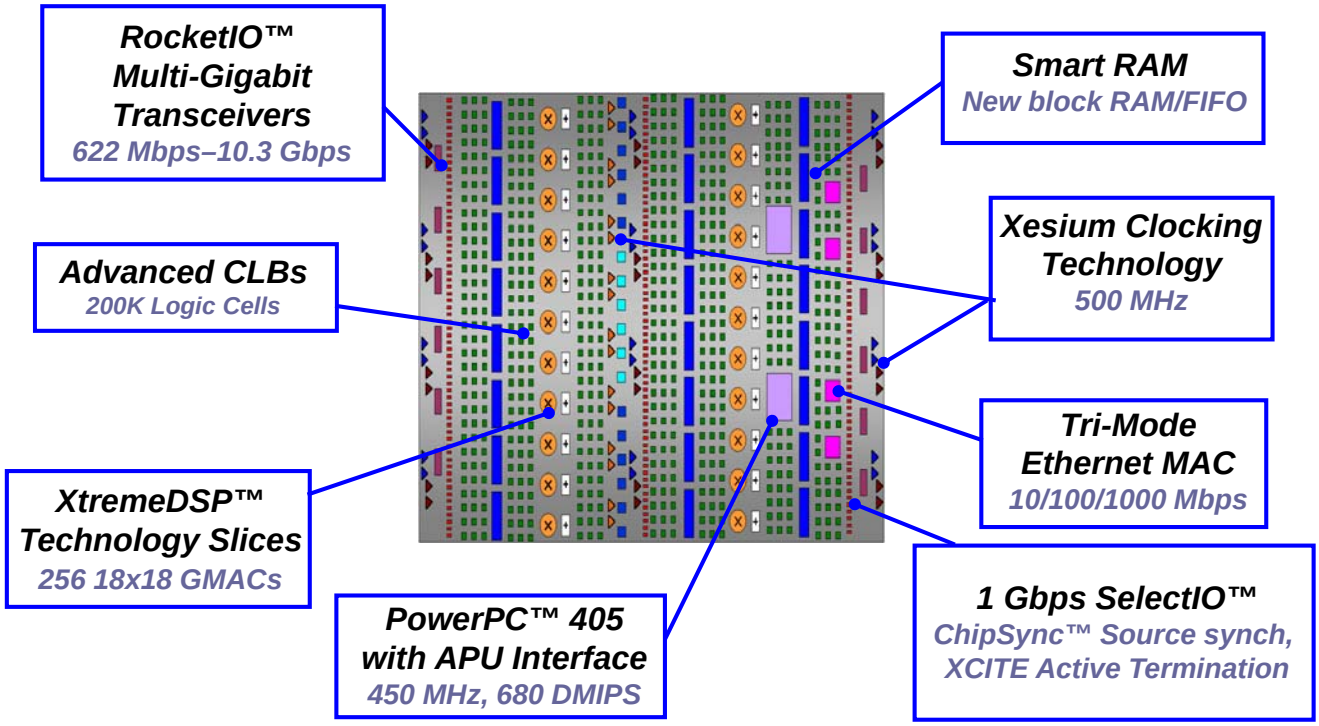
- Additional resources: embedded memory blocks, fast carry logic chains, multipliers
- Versatile programmable I/Os
- Some even contain: DSP blocks, processors
- Applications: audio, video, wireless, industrial equipments, network components, medical, automotive, etc.
- Vendors offer a variety of FPGAs catering for different markets

# Heterogeneous Programmable Platforms

*Xilinx Virtex-II Pro*



# Virtex-4 Advanced Feature Set




# Choices of Platform that Best Fits the Application

| Resource | LX | FX | SX |
|---|---|---|---|
| Logic | 14K–200K LCs | 12K–140K LCs | 23K–55K LCs |
| Memory | 0.9–6 Mb | 0.6–10 Mb | 2.3–5.7 Mb |
| DCMs | 4–12 | 4–20 | 4–8 |
| DSP Slices | 32–96 | 32–192 | 128–512 |
| SelectIO | 240–960 | 240–896 | 320–640 |
| RocketIO | N/A | 0–24 Channels | N/A |
| PowerPC | N/A | 1 or 2 Cores | N/A |
| Ethernet MAC | N/A | 2 or 4 Cores | N/A |