Commercial Examples (Part 2) Microsemi(Actel) Antifuse-based & Flash-based FPGAs

Topics

- Antifuse-based FPGA
  - Actel SX-A and Axcelerator (AX) families
- Flash-based FPGA
  - Actel ProASIC3 and IGLOO families

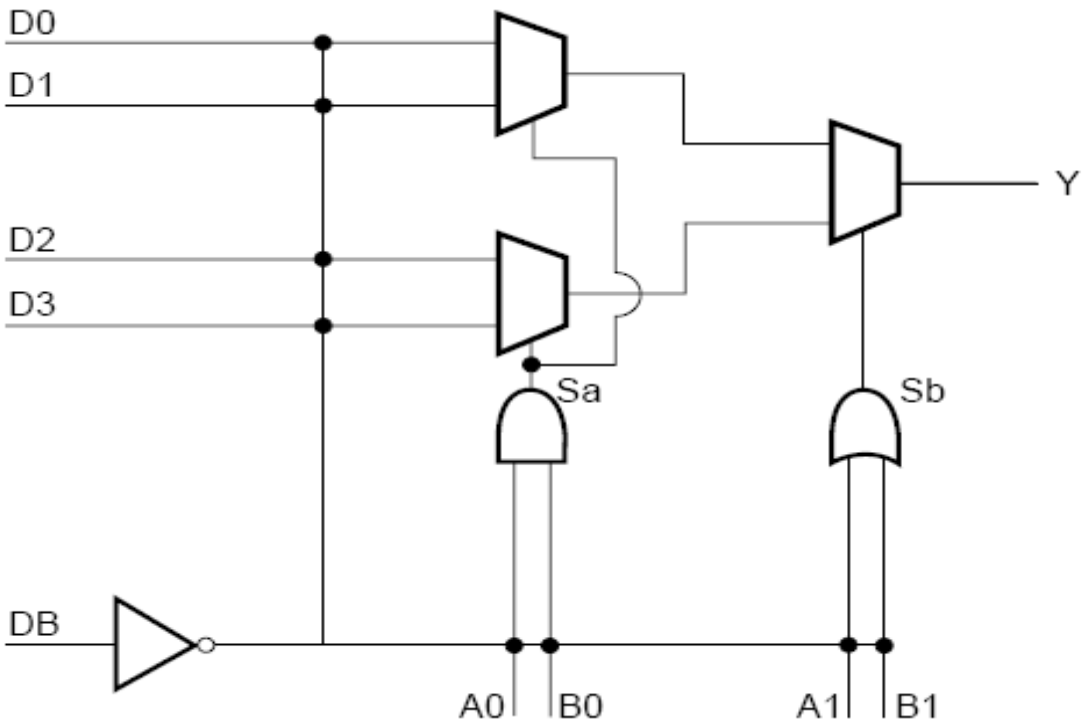
Actel SX-A and AX Overview

- Antifuse-based FPGA
- Metal-to-metal programmable antifuses
- Mux-based logic elements

SX-A Logic Element

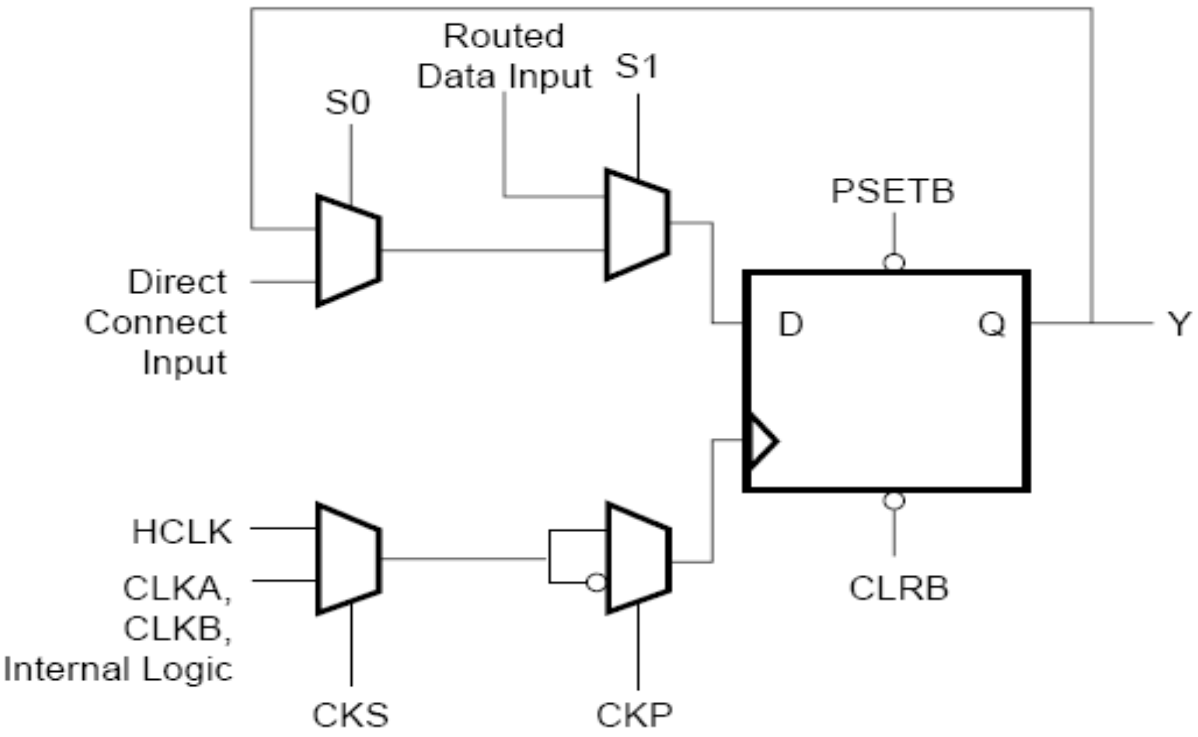
- Mix two types of logic modules
  - Combinatorial cell (C-cell) 2^(2^5)
    - can implement more than 4000 different functions of ≤ 5 inputs. smaller but less powerful
  - Register cell (R-cell)
    - contains a flip-flop.

C-Cell



Source: Actel Corp.

R-Cell

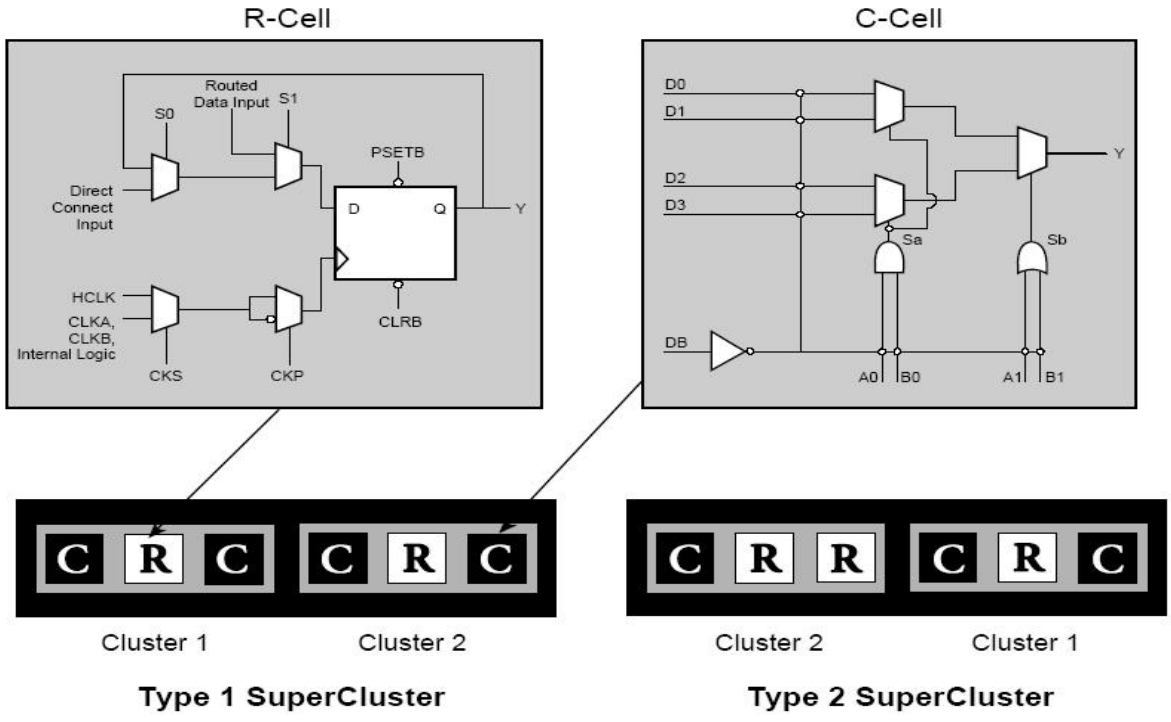


Source: Actel Corp.

Clusters and Superclusters (1/2)

- C/R cells organized into clusters.
  - Type 1 cluster: CRC.
  - Type 2 cluster: CRR.
- Clusters grouped into superclusters.
  - Type 1: two type 1 clusters.
  - Type 2: one type 1, one type 2.
  - Majority is Type 1 superclusters

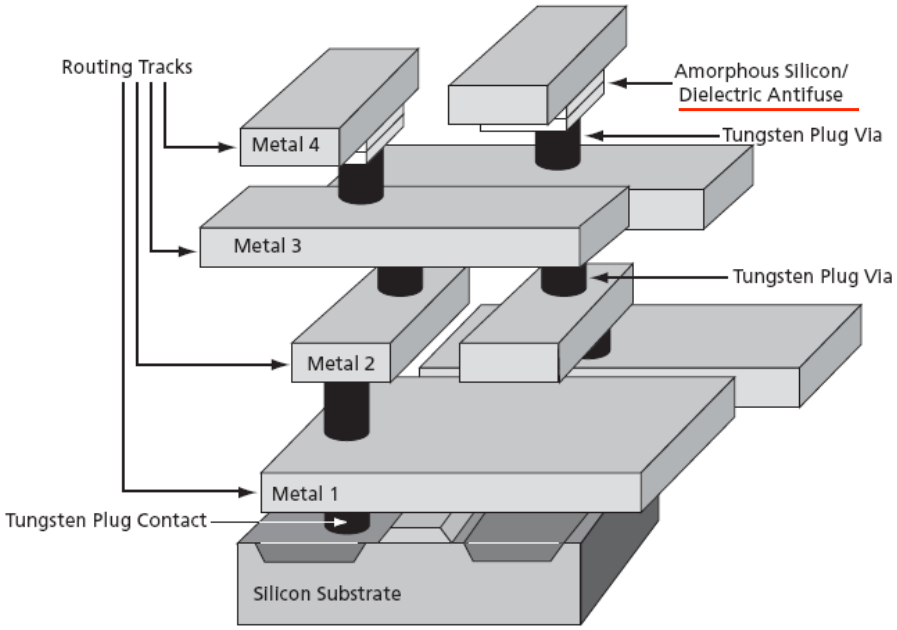
Clusters and Superclusters (2/2)



Source: Actel Corp.

SX-A Routing

- Programmable antifuses between the top two metal layers

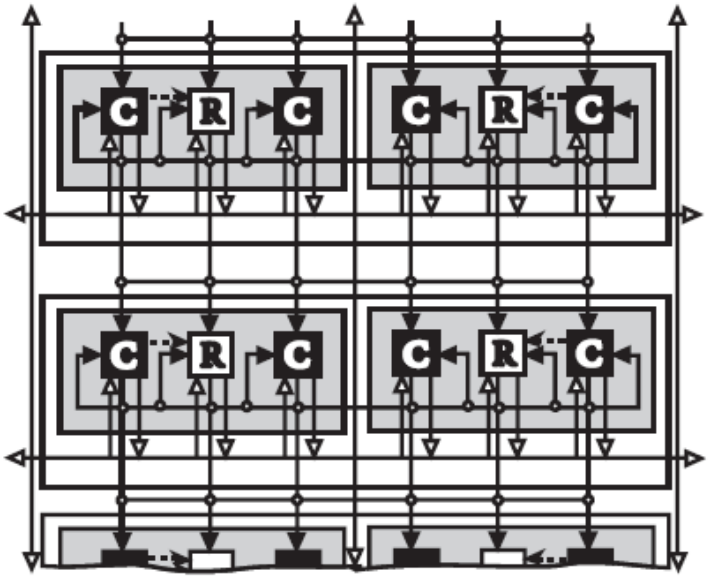


Source: Actel Corp.

Routing Architecture (1/2)

- Local routing resources
  - DirectConnect is within a supercluster
    - connects C-cell to R-cell neighbor.
  - FastConnect provides horizontal connections between logic modules
    - within a supercluster.
    - to the supercluster below.
- Generic global wiring in segmented channels.

Routing Architecture (2/2)



DirectConnect
- No Antifuses
- 0.1 ns Maximum Routing Delay

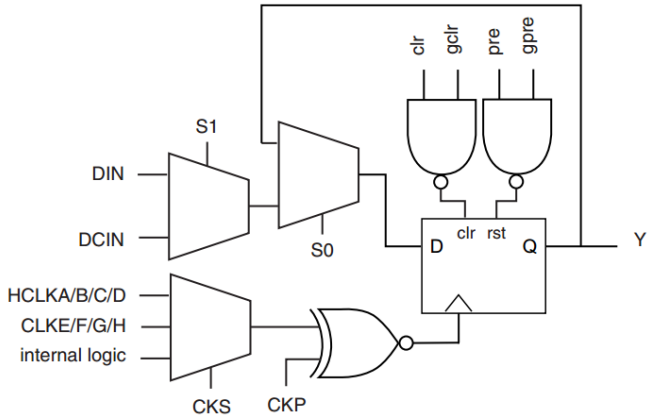
FastConnect
- One Antifuse
- 0.3 ns Maximum Routing Delay

Routing Segments
- Typically Two Antifuses
- Max. Five Antifuses

Source: Actel Corp.

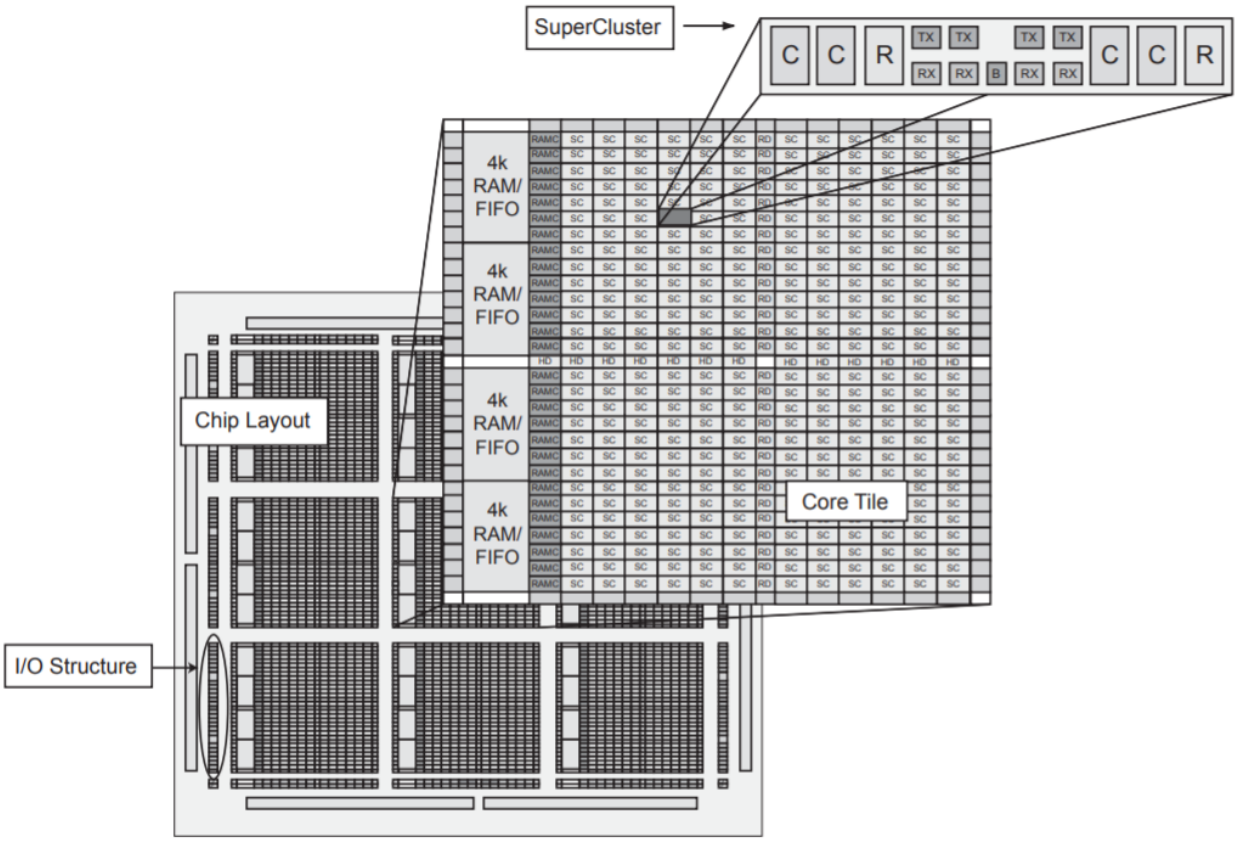
Axcelerator (AX) Family

- Successor of SX-A
  - Higher capacity, 7 metal layers, 8 I/O banks, embedded SRAM
  - Enhance C-cell with addition of carry-chain logic
  - Modified R-cell

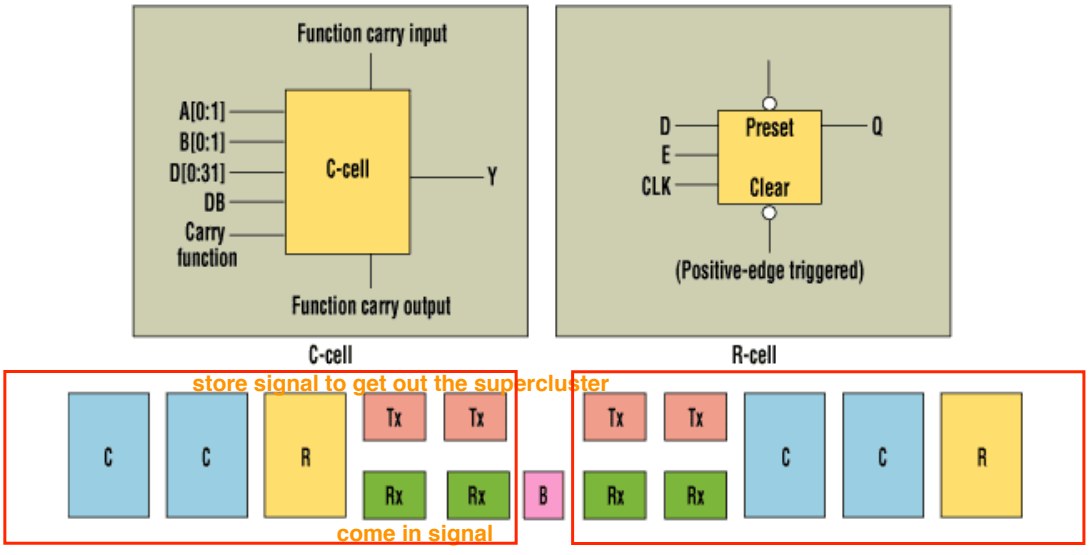


  - Use pattern CCR in all clusters

AX Architecture



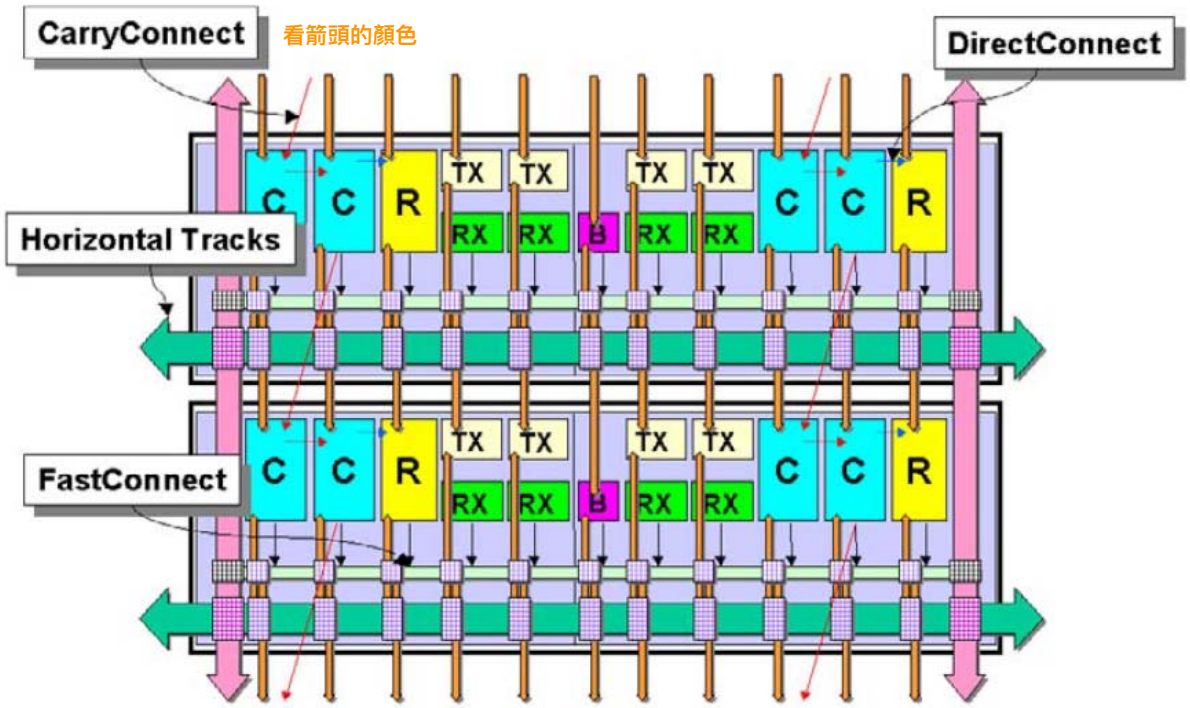
SuperCluster in AX Architecture



- Cluster = CCR + 2 transmit buffers + 2 receive buffers
- SuperCluster = 2 clusters + an additional buffer

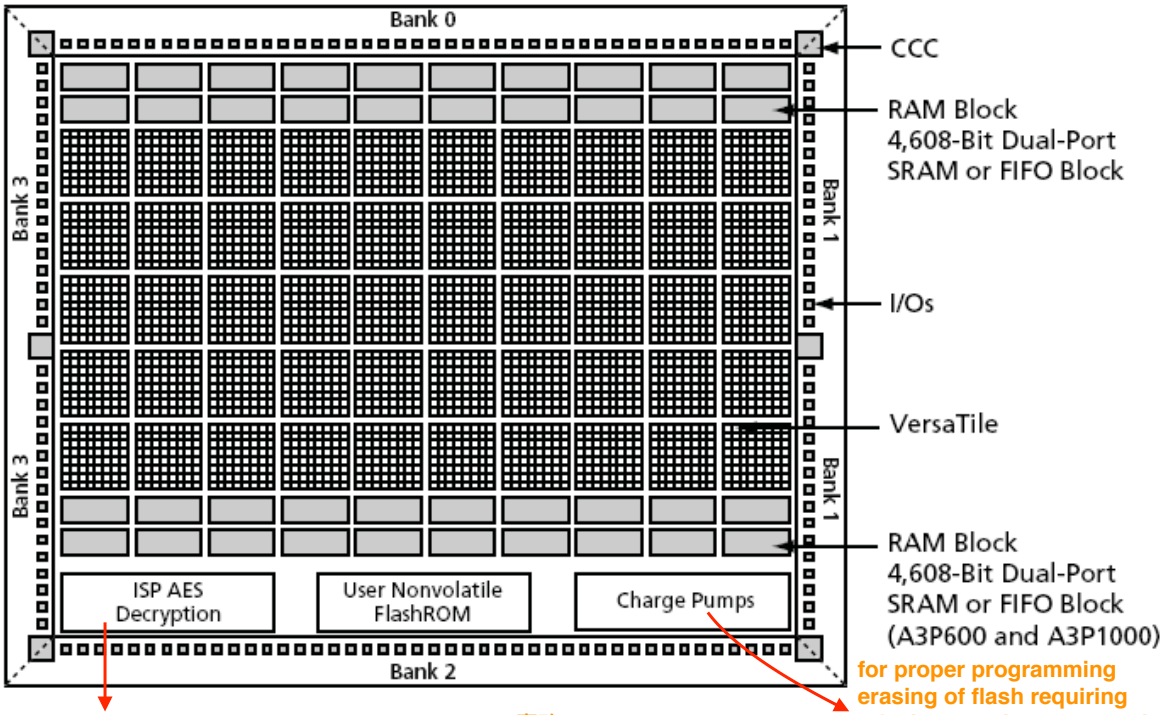
AX Routing

- CarryConnect for routing carry logic vertically without passing any antifuse



ProASIC3 and IGLOO Overview

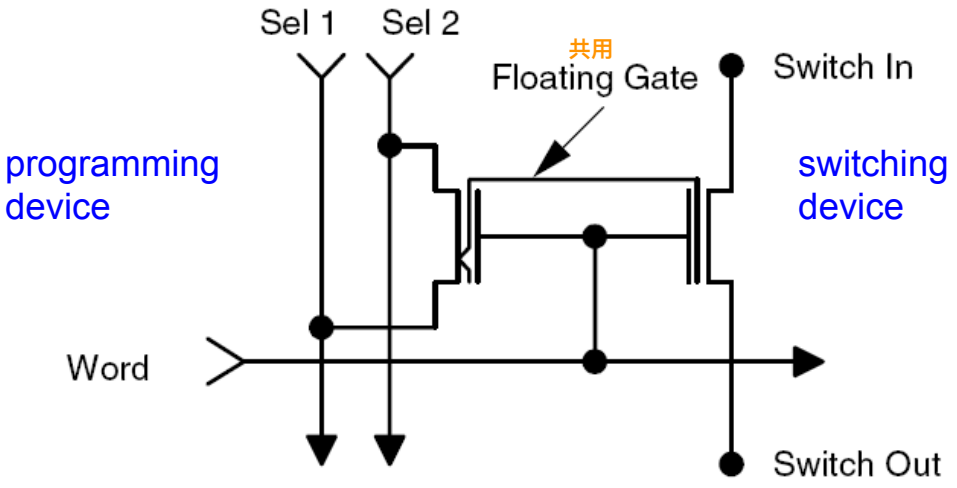
- Flash-based FPGAs



Flash-based Switch

- Each switch has two transistors sharing the floating gate.
- One transistor as programming device and the other as switching device.

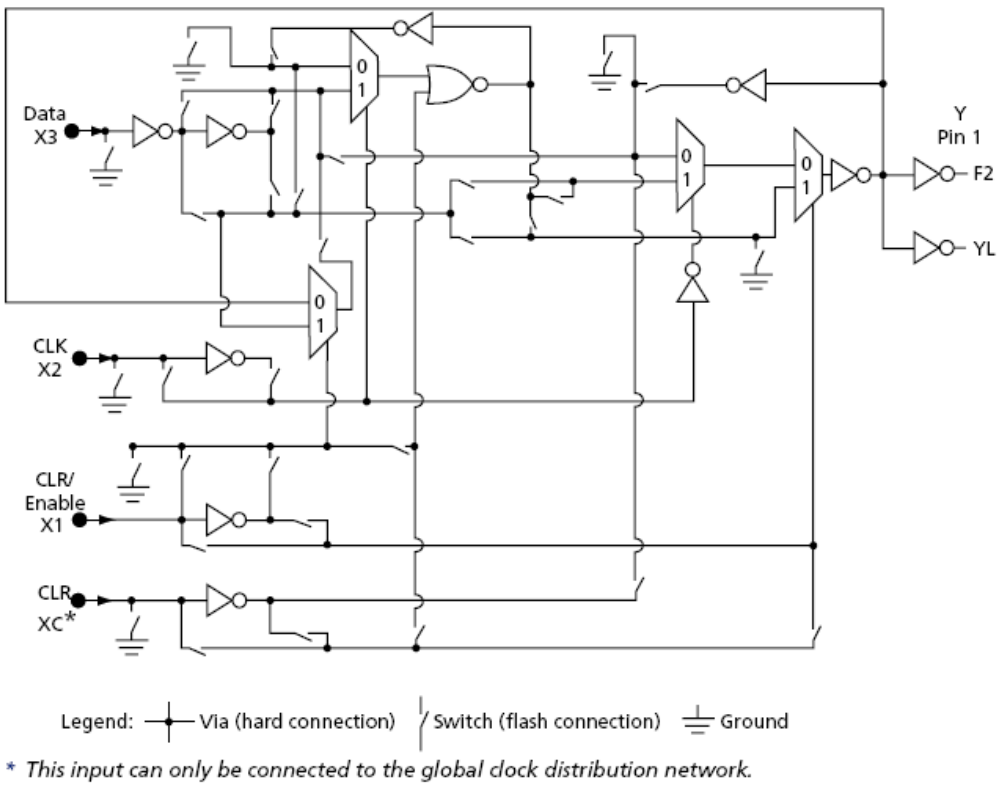
program左邊 影響右邊



Source: Actel Corp.

Logic Cell (1/2)

- Logic element is a 4-input cell

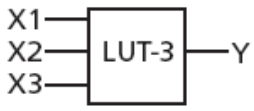


Source: Actel Corp.

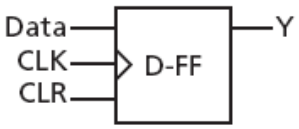
Logic Cell (2/2)

- Each logic cell can be configured as
  - any 3-input function
  - latch
  - D-flip-flop with or without enable

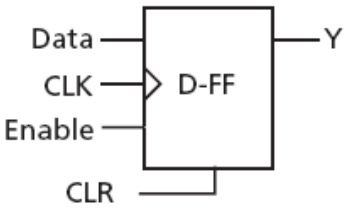
LUT-3 Equivalent



D-Flip-Flop with Clear or Set



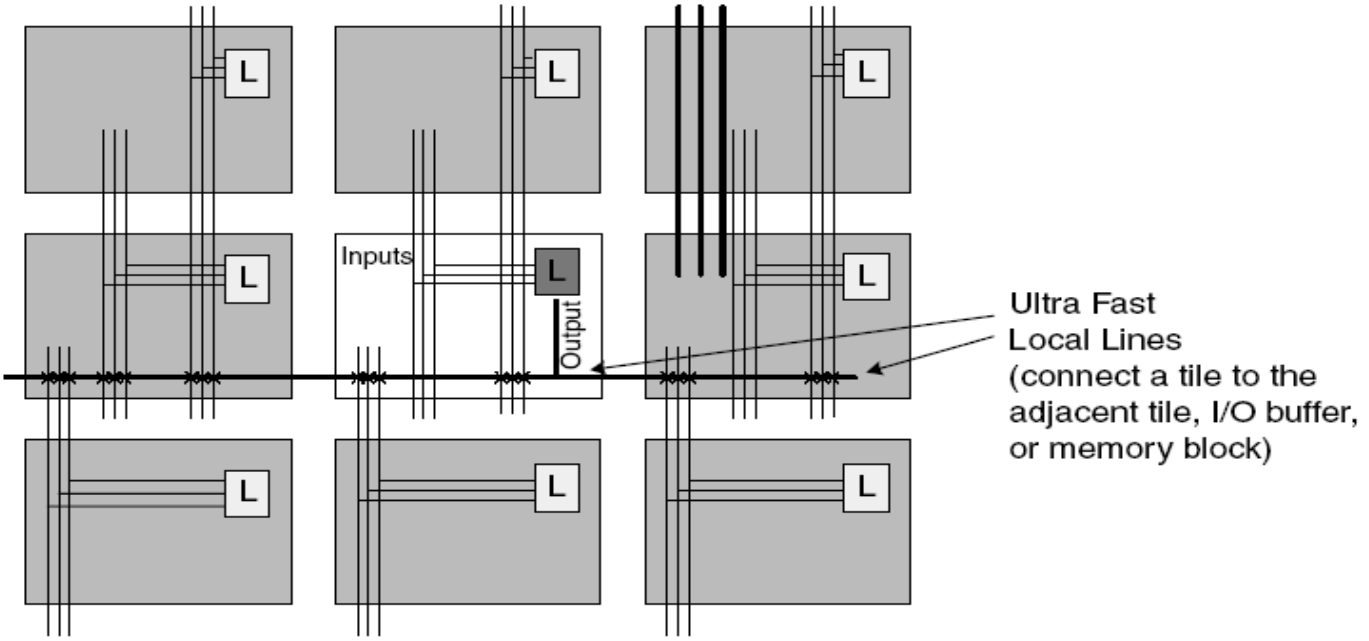
Enable D-Flip-Flop with Clear or Set



Routing Architecture

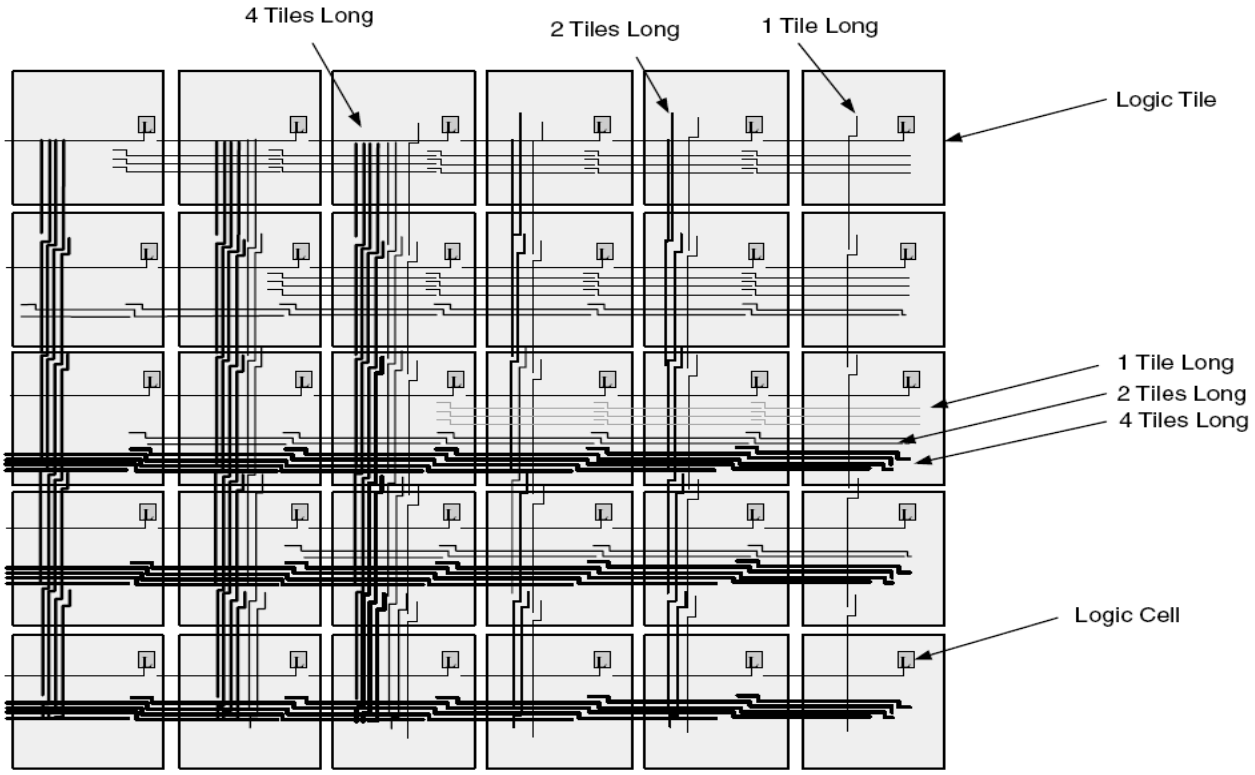
- Fast local lines
  - from a tile to eight surrounding tiles
- Long lines
  - span 1/2/4 tiles vertically or horizontally
- Very long lines
  - span the entire device vertically or horizontally
- Global network
  - global trees
  - for clock and other very high fanout nets

Routing Architecture: Fast Local Lines



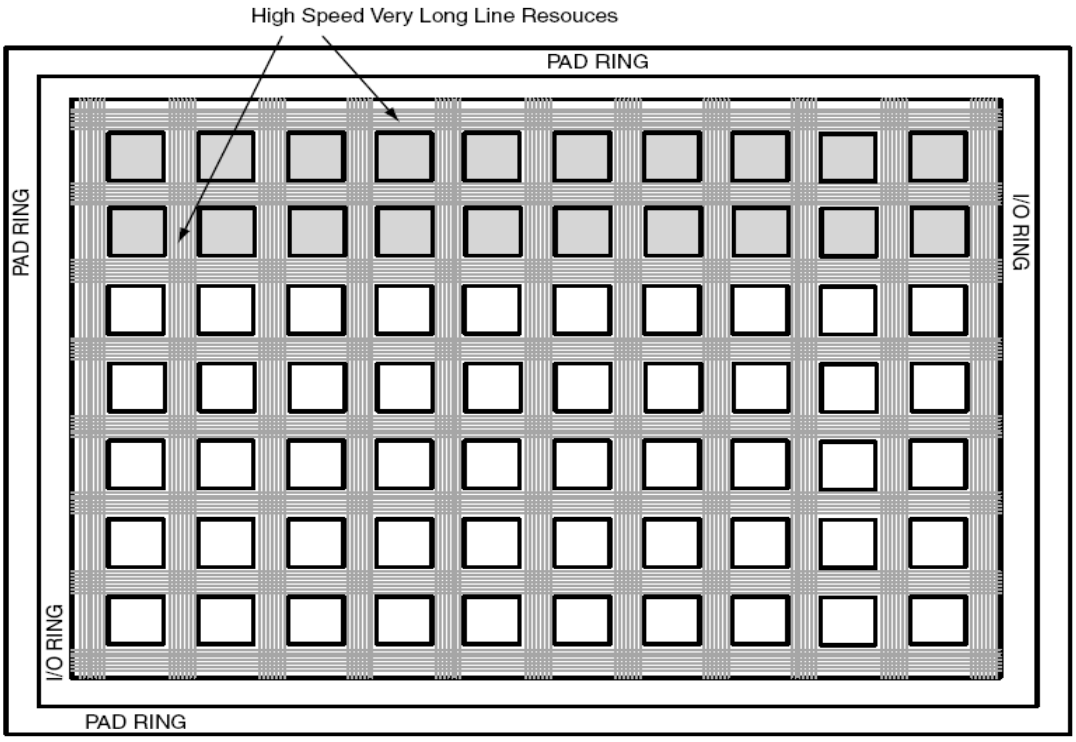
Source: Actel Corp.

Routing Architecture: Long Lines



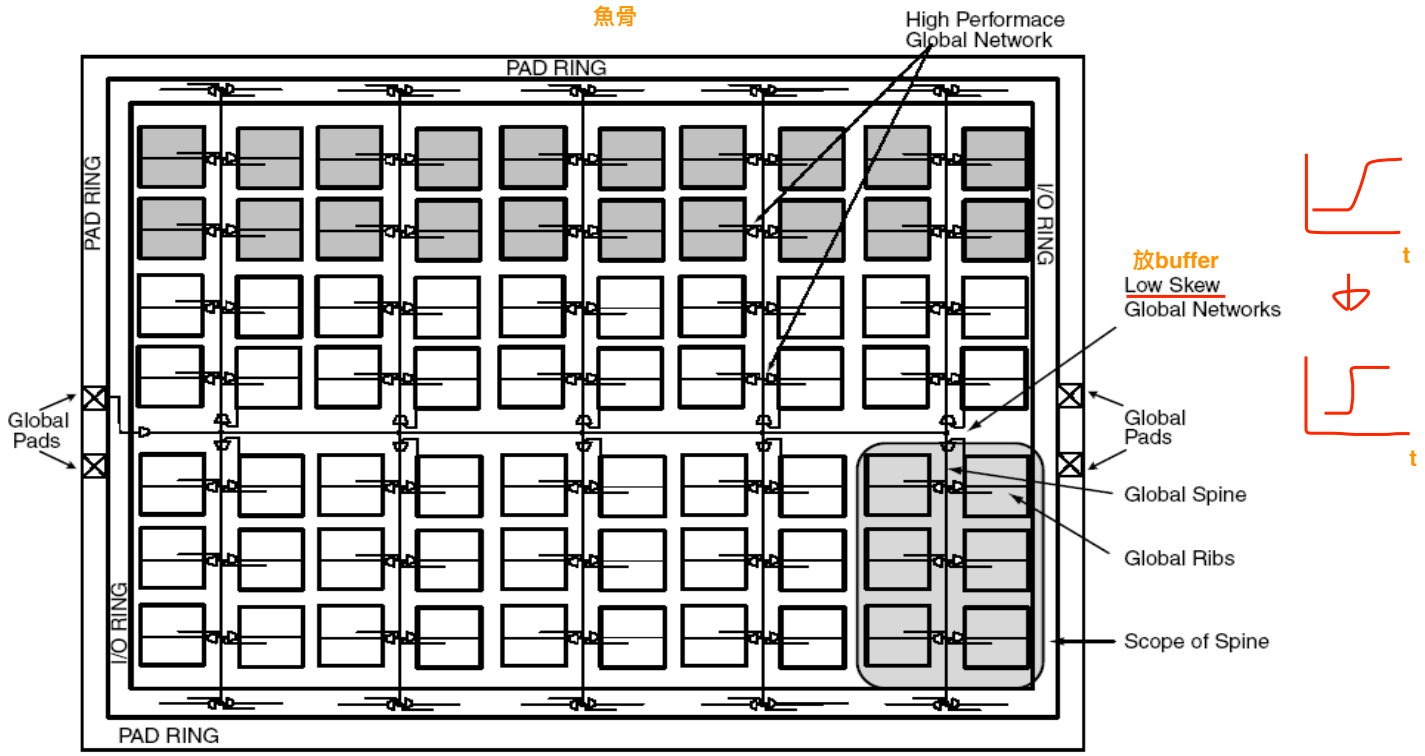
Source: Actel Corp.

Routing Architecture: Very Long Lines



Source: Actel Corp.

Routing Architecture: Global Network



Source: Actel Corp.

Appendix: Security