Antifuse Routing

(a) routing in unconstrained channel.

(b) routing in fully segmented channel.

(c) routing in non-segmented channel.

(d) segmented for 1-segment routing.

(e) segmented for 2-segment routing.

Antifuse Routing (cont.)

- Fully segmented
  - Switch at every cross point normally passes signals through vertically and horizontally, but can connect the vertical and horizontal tracks
  - Antifuse connects or disconnects the segments of the horizontal channel

- Non-segmented
  - Excessive area requirements

- 1-segment routing
  - Divides the tracks into segments of varying lengths, which allows each net to be routed in a track of more or less the appropriate size

- 2-segment routing
  - Allows track segments to be joined

Actel ACT Routing Architecture

An Actel FPGA has rows of cells, with horizontal channels between them, and vertical “channels” called columns

Cell inputs must come from one of the 2 adjacent horizontal tracks (either figure)

Cell outputs can attach to:
- A dedicated vertical track called the “output stub” (see bottom figure)
- Output stub spans only two channels above and below the cell
- Long vertical tracks— see top figure, where output goes to LVT instead of its dedicated output segment
- These are vertical segments of varying lengths that can be joined together to form vertical segmented tracks
Actel ACT Routing Architecture (cont.)

- Input segments connect to uncommitted horizontal segment by antifuses
  - Horizontal segments connect by antifuses
- Vertical segments pass over the cells

Figure from *Field-Programmable Gate Array Technology*, Trimberger, Kluwer, 1994

Actel Act1

- Fairly simple, fine-grained logic module
  - Low delay, small area, very flexible
  - Implements basic gates, D latches, etc.
    - Can implement many functions using Shannon’s Expansion Theorem
      - Any combinatorial function of 2 inputs
      - Almost any function of 3 inputs, many functions of 4 inputs, some functions of up to 8 inputs
- I/O modules at end of rows & columns

Actel Act2

- C-module = combinatorial module
  - Act2 c-module provides high fan-in
    - Can implement 16 of the 20 four-input gates in the library (Act1 implements 8)
    - Implements 766 distinct combinational functions, including 13% more four-input macros and 12% more five-input macros than Act1
      - Some loss in ability to implement sequential functions
- S-module = sequential module
  - C-module plus two latches
    - Can provide rising- or falling-edge-triggered D flip-flop, or high- or low-level transparent D latch, with clear
    - Can make it look like a c-module by tying C1 to 1 and C2 to 0
    - Need two or more s-modules to build J-K or more complex flip-flops

Figure from *Application-Specific Integrated Circuits*, Smith, Addison-Wesley, 1997

Figure from *Application-Specific Integrated Circuits*, Smith, Addison-Wesley, 1997