

A collection of historical artifacts is arranged on a light-colored surface. In the top left, a portion of a wooden chessboard with a checkered pattern and several chess pieces is visible. Below the chessboard, there are two ornate medals. The top medal features a red ribbon with a circular rosette. The bottom medal has a blue ribbon with a circular rosette. To the right of the medals is a pair of round-rimmed glasses with thin metal frames. In the bottom left corner, a small, round, silver-colored compass with a white face and black markings is visible. The background is a plain, light-colored surface.

Chip Design by Evolution

**Anil Bahuman
Artificial Intelligence Center**

A collection of objects is arranged on a light-colored surface. In the top left, a portion of a chessboard with a checkered pattern and several chess pieces is visible. Below the chessboard, there are two medals: one with a red ribbon and a white star, and another with a blue ribbon and a white star. A small compass is located in the bottom left corner. A pair of glasses with thin frames and a single wire is positioned diagonally across the center. The text "Electronic Design Automation" is overlaid on the right side of the image.

Electronic Design Automation

Design of Very
Large Scale
Integrated Circuits:
VLSI



magic

spice

inverter

NP-hard

GADO

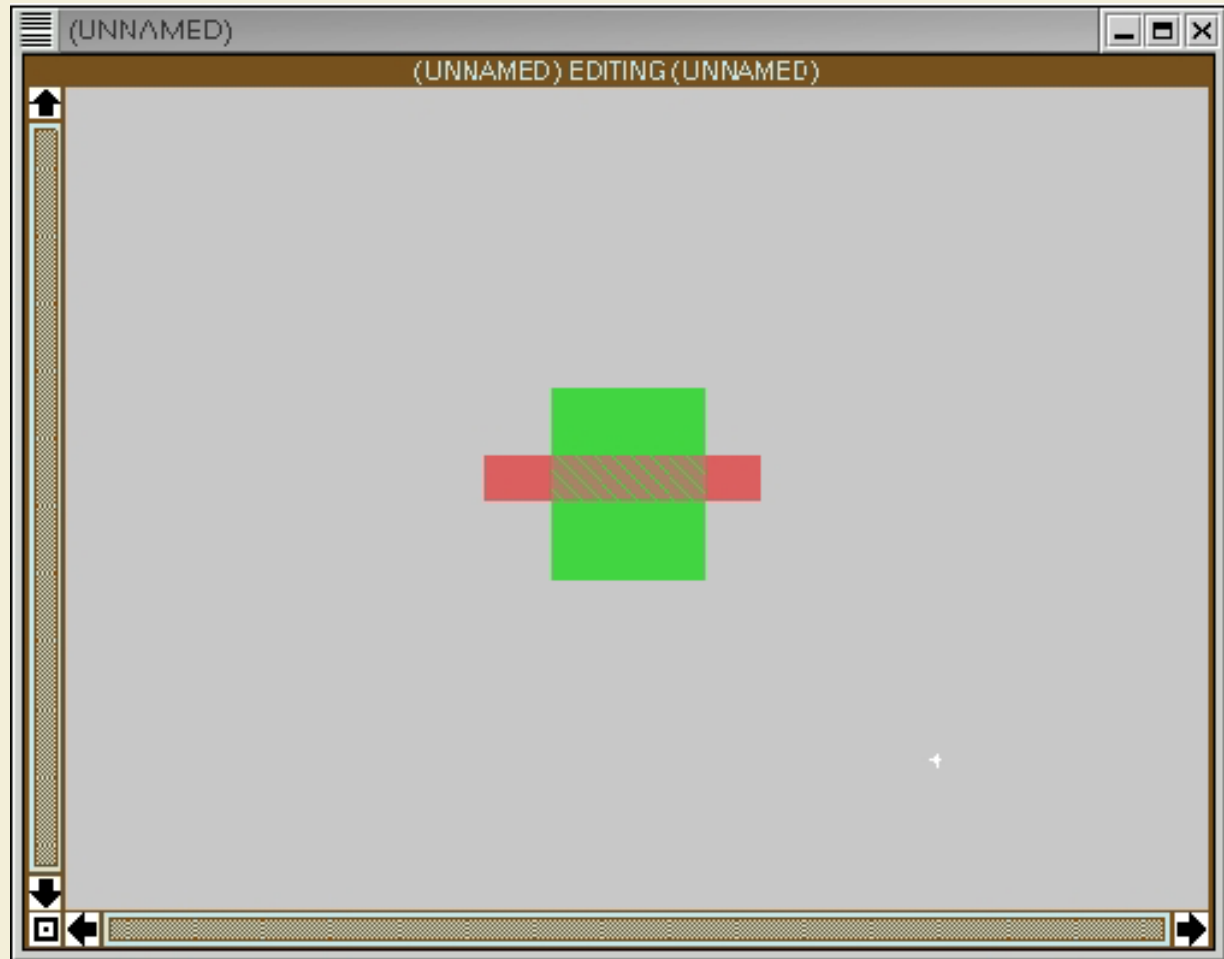
**Standard
Cell**

evolution

GA

optimization

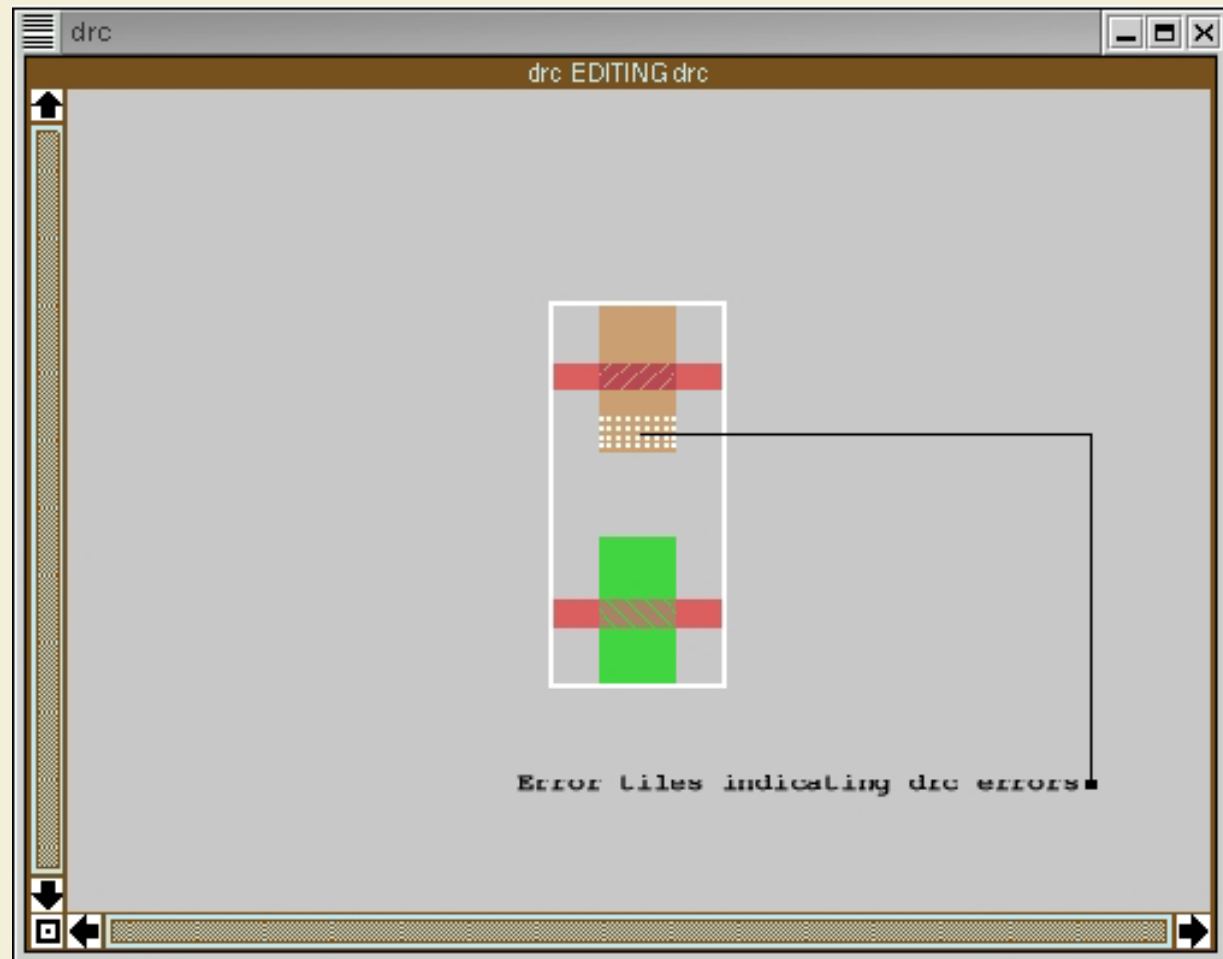
A Transistor in MAGIC



November 2001

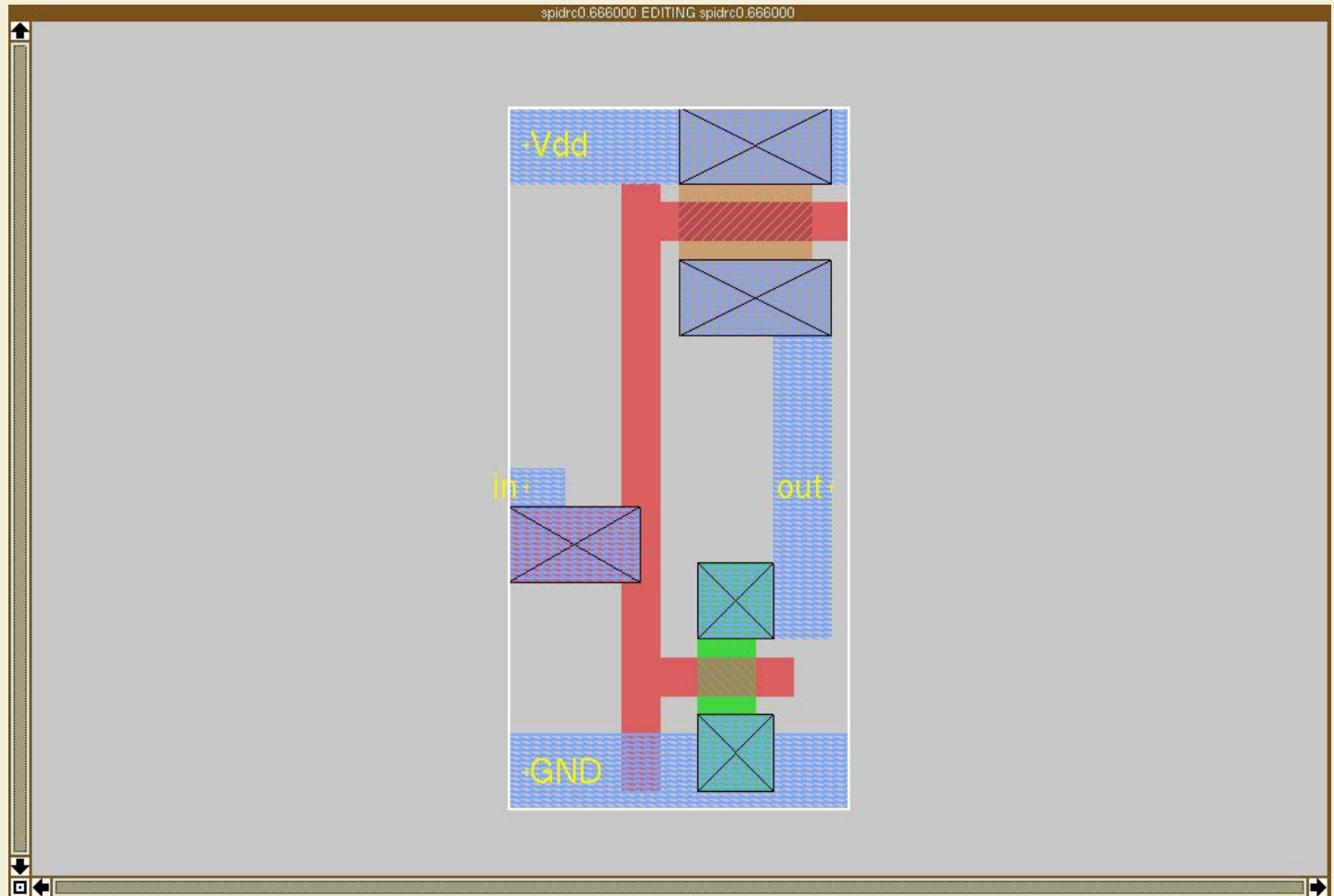
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Error tiles indicating DRC Errors

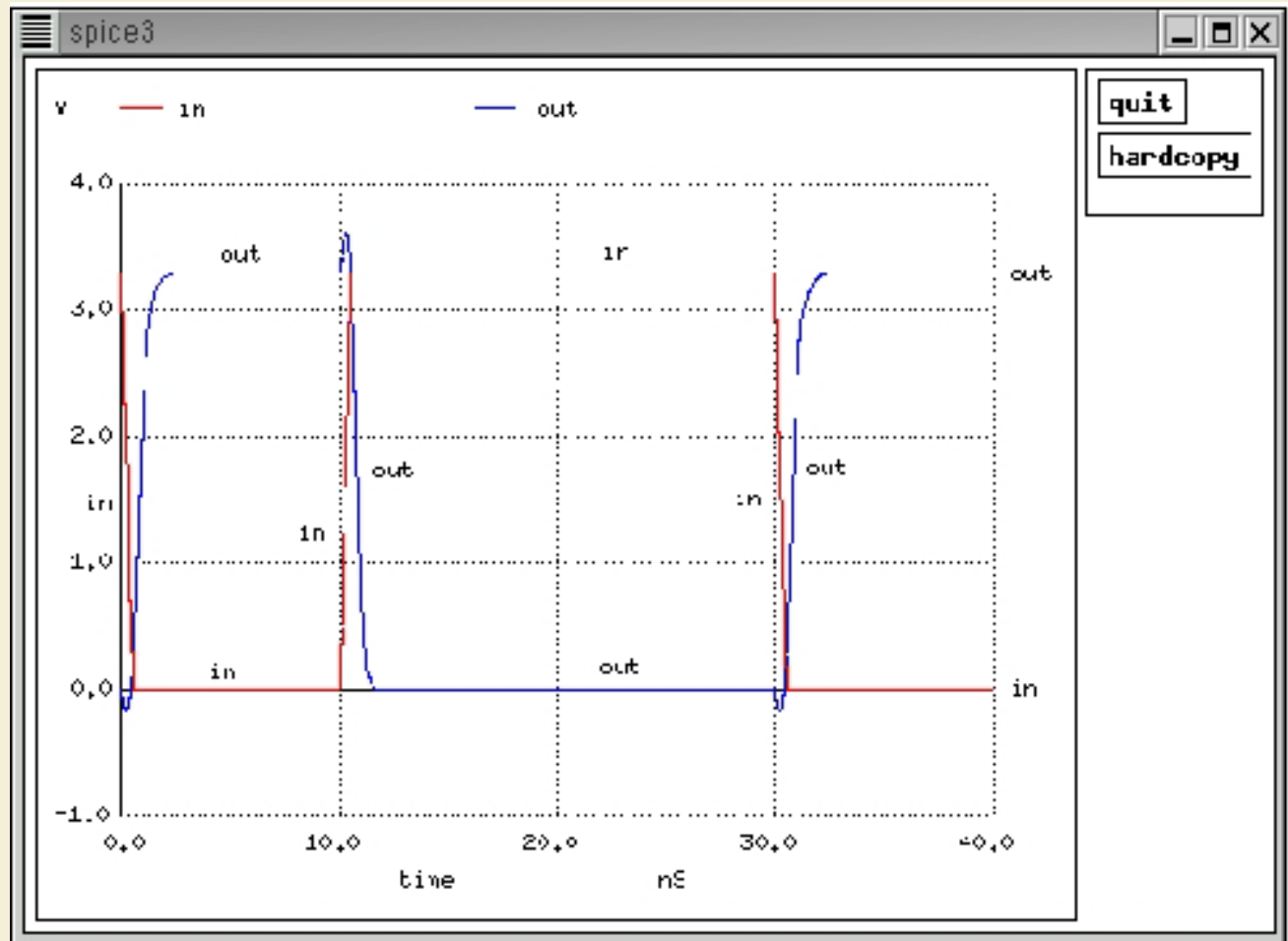


An Inverter in MAGIC

Input, output, labels, gate, terminals, wires, poly, contacts, cell limits, lambda



SPICE simulation of the Inverter





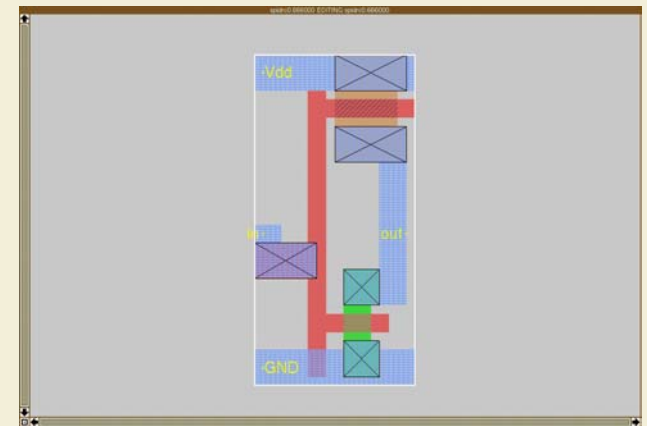
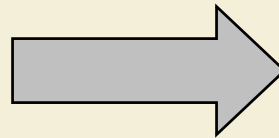
Standard Cell Design

- ◆ Building blocks for chips.
- ◆ Frequently used logics.
- ◆ NAND, full adder, latch etc.
- ◆ Costly (time + money) to redesign.
- ◆ Automation is NP hard or harder.
- ◆ Can we design on-the-fly?

Research Goal – Inverter

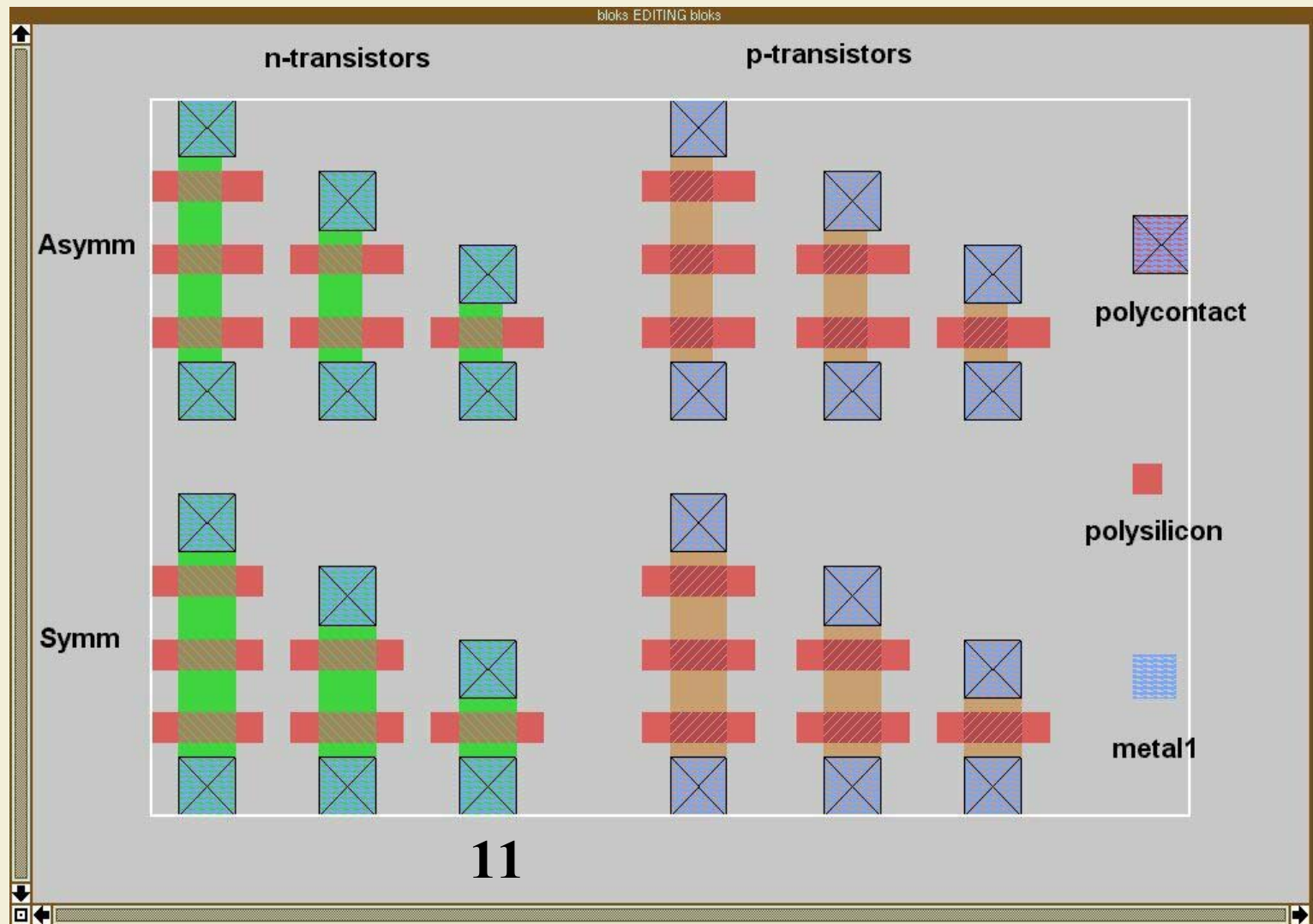
In	Out
0	1
1	0

Truth Table



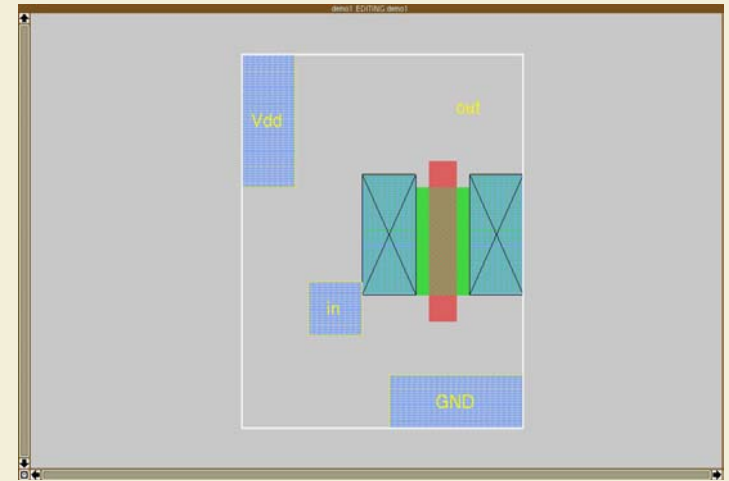
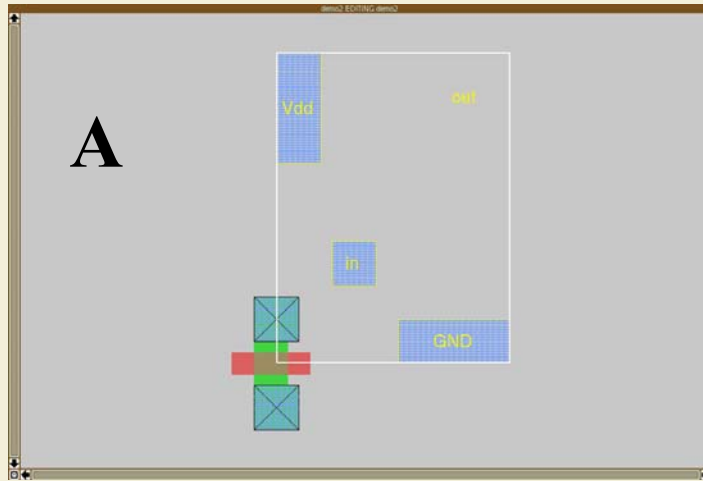
Layout with minimum area

The Set of Objects

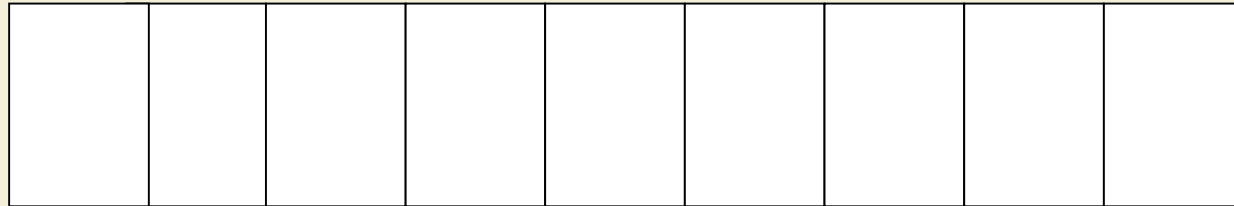


Encoding an Object

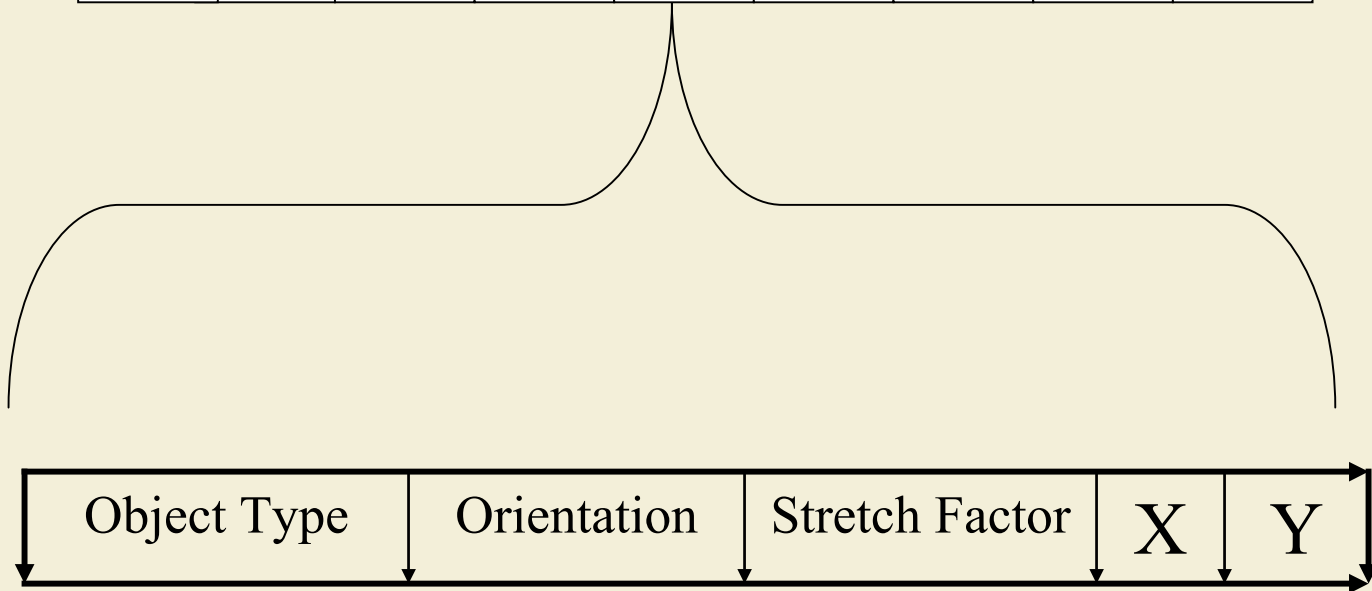
PARAMETER	VALUE	A	B
Object Type	1-15	11	11
Orientation	0-3	0	2
Stretch Factor	Cell limits	0	5
X	Cell limits	0	15
Y	Cell limits	0	14



An Individual



...



Connections b/w Objects



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An Influence Check

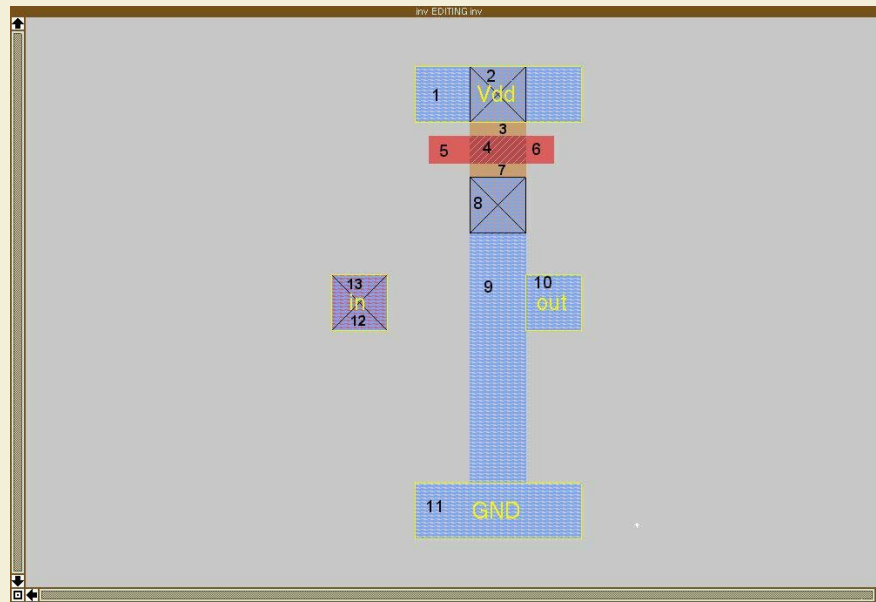
- ◆ Domain specific rules encouraging connectivity
 - The labels must not be shorted
 - Every input must influence at least one output
 - Every output must be influenced by at least one input
 - The gate of a transistor must be influenced by at least one input
 - One terminal of the transistor must be influenced by an input
 - Other terminal of the transistor must influence an output



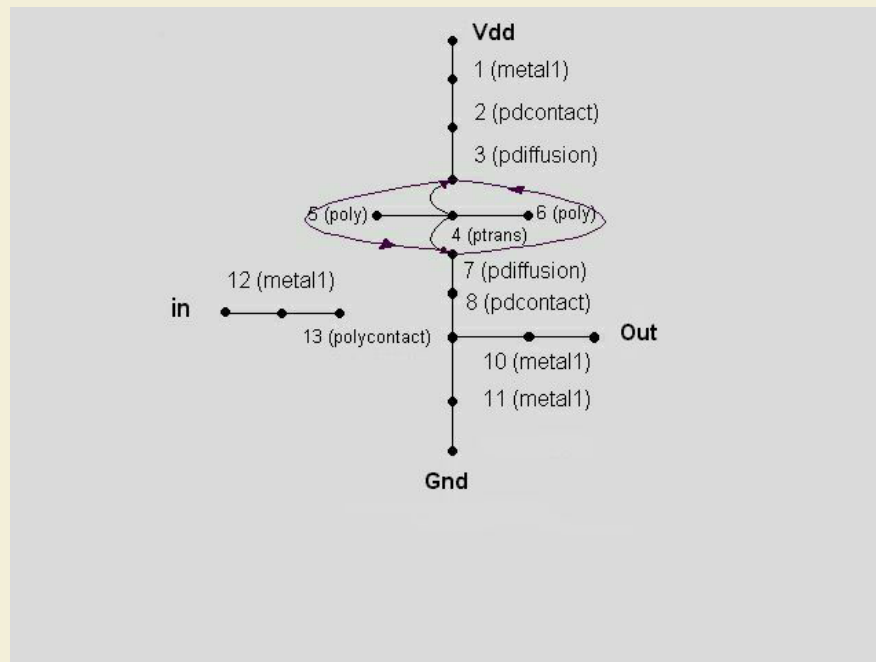
Punch line

“If you have some label that is not being influenced by any other label, we want to know how close it is to some label that can influence it.”

- ◆ MAGIC
- ◆ SPICE

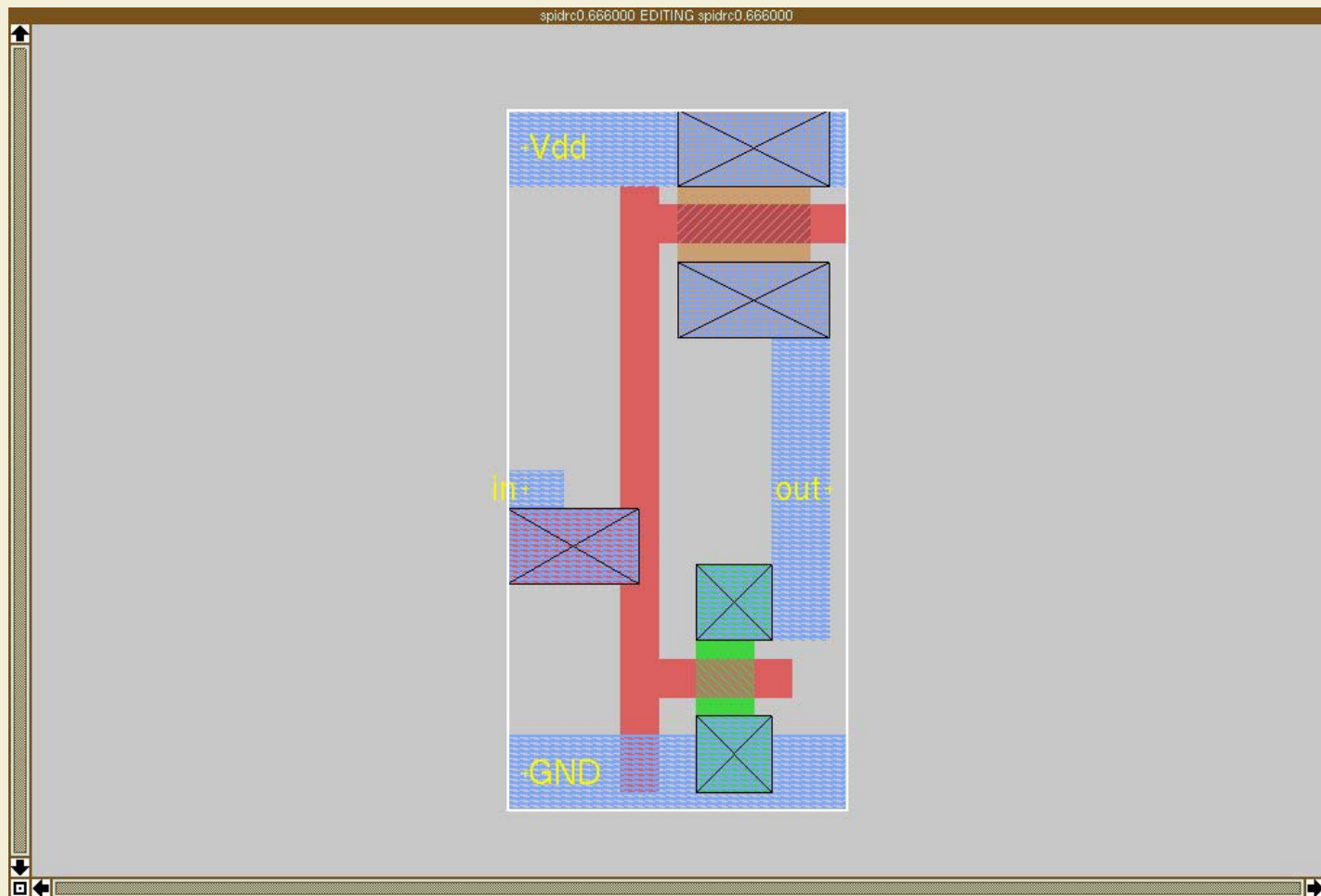


Sample Cell



Corresponding Graph

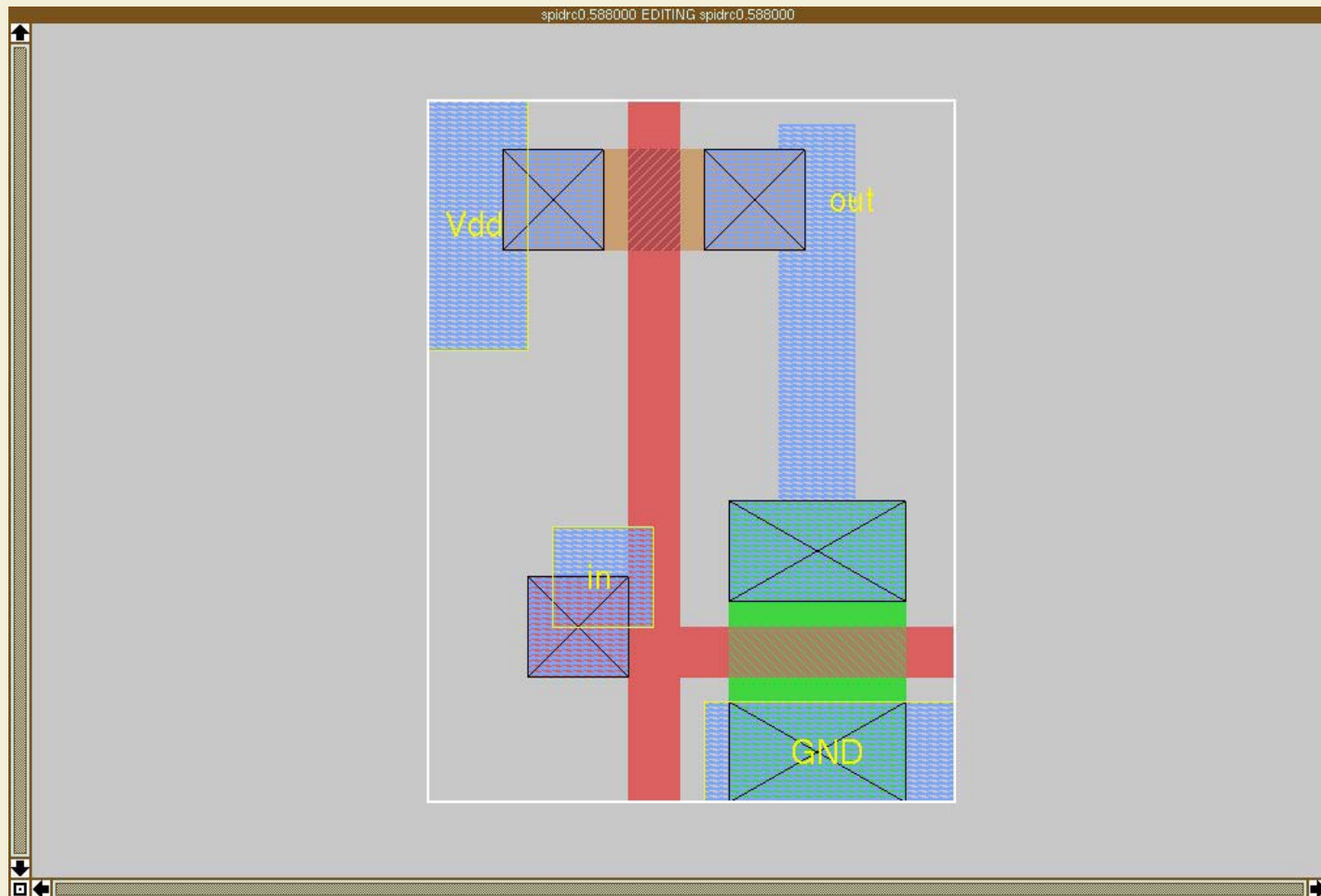
Success 1



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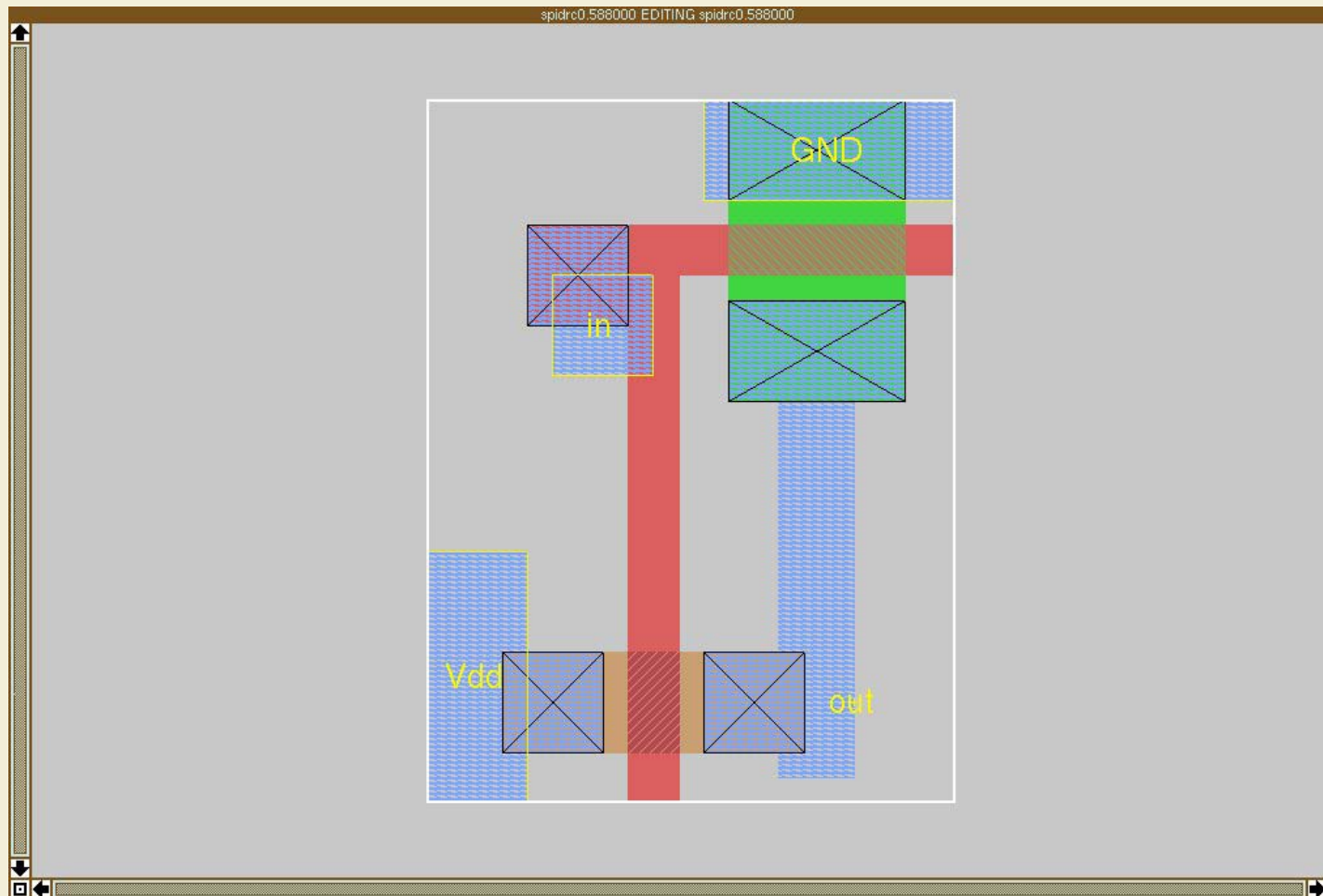
Success 2



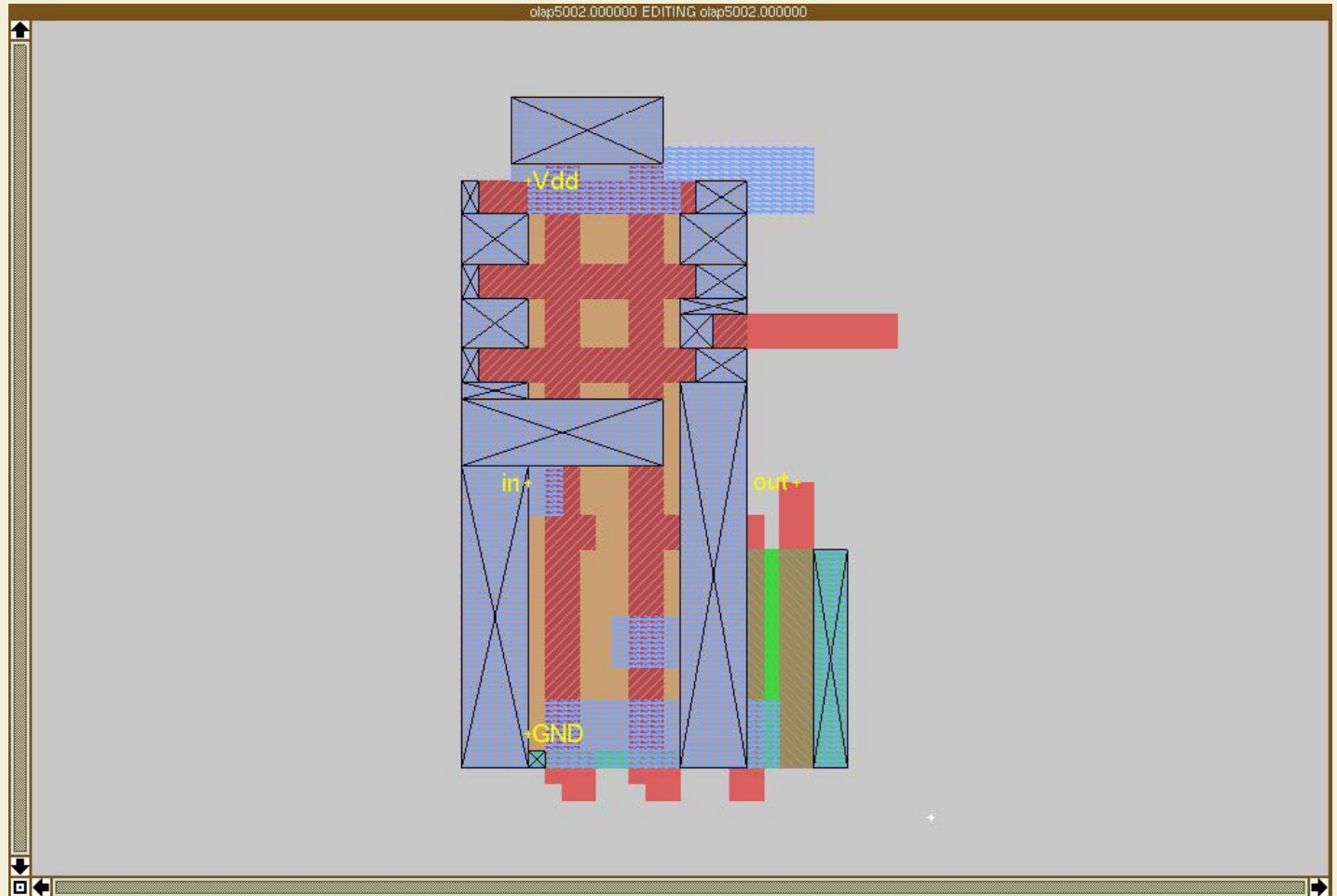
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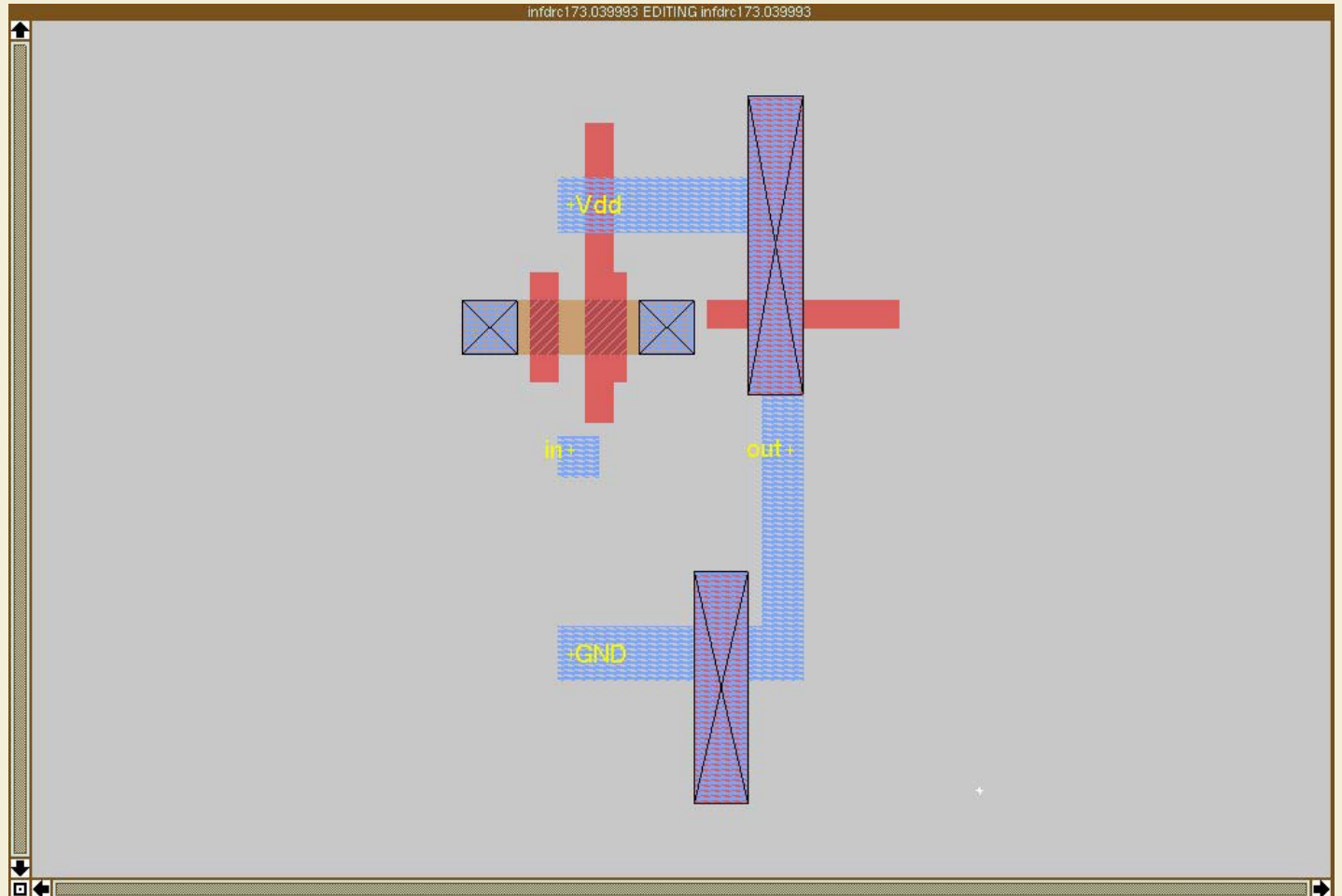
Success 3



Evolving 2



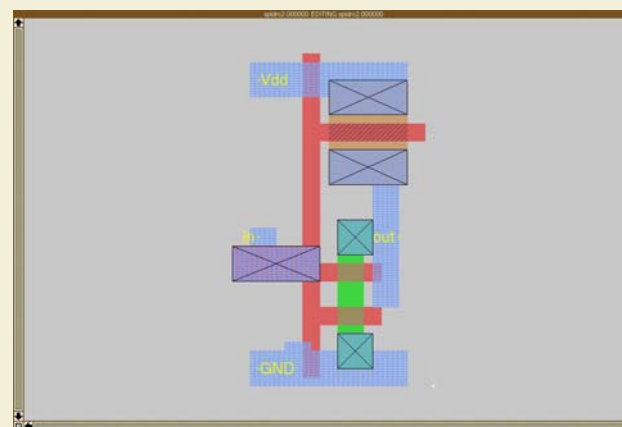
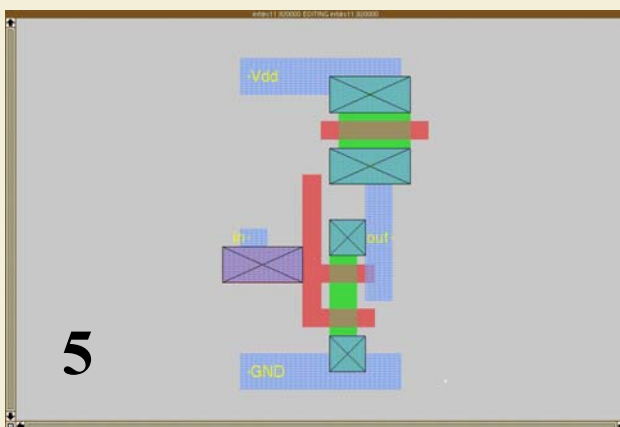
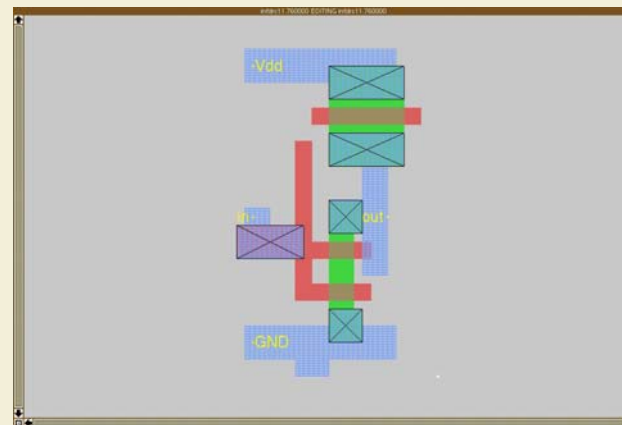
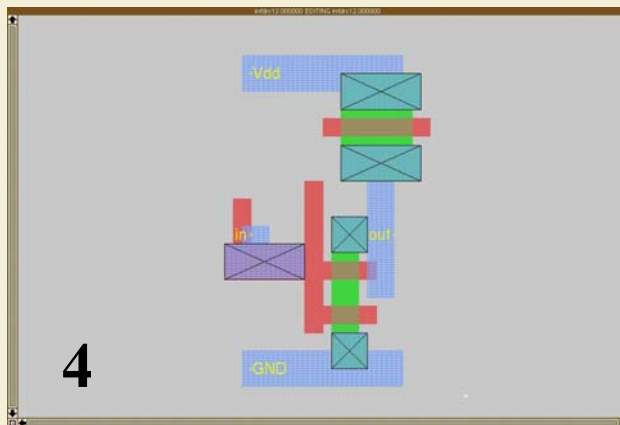
Evolving 3



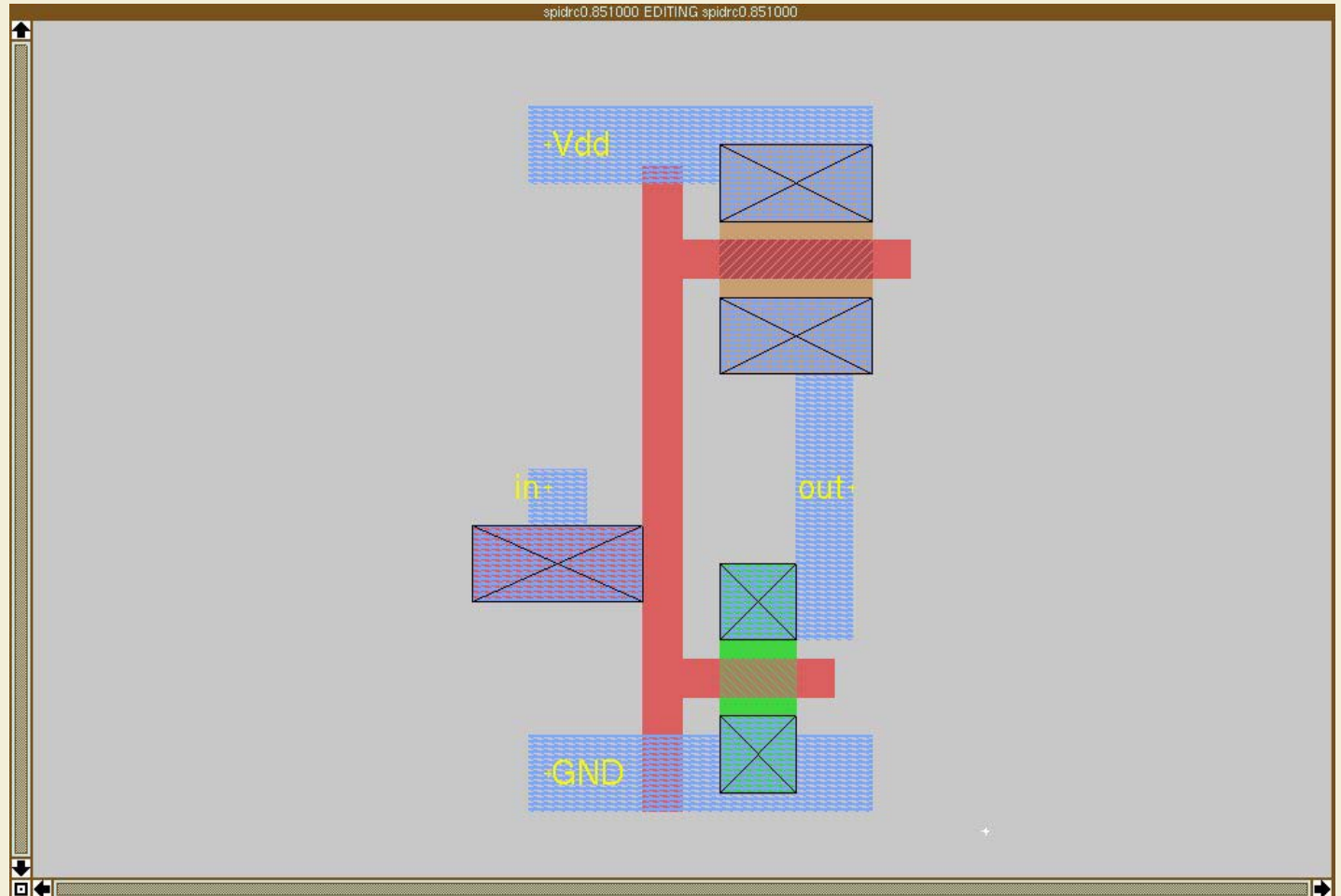
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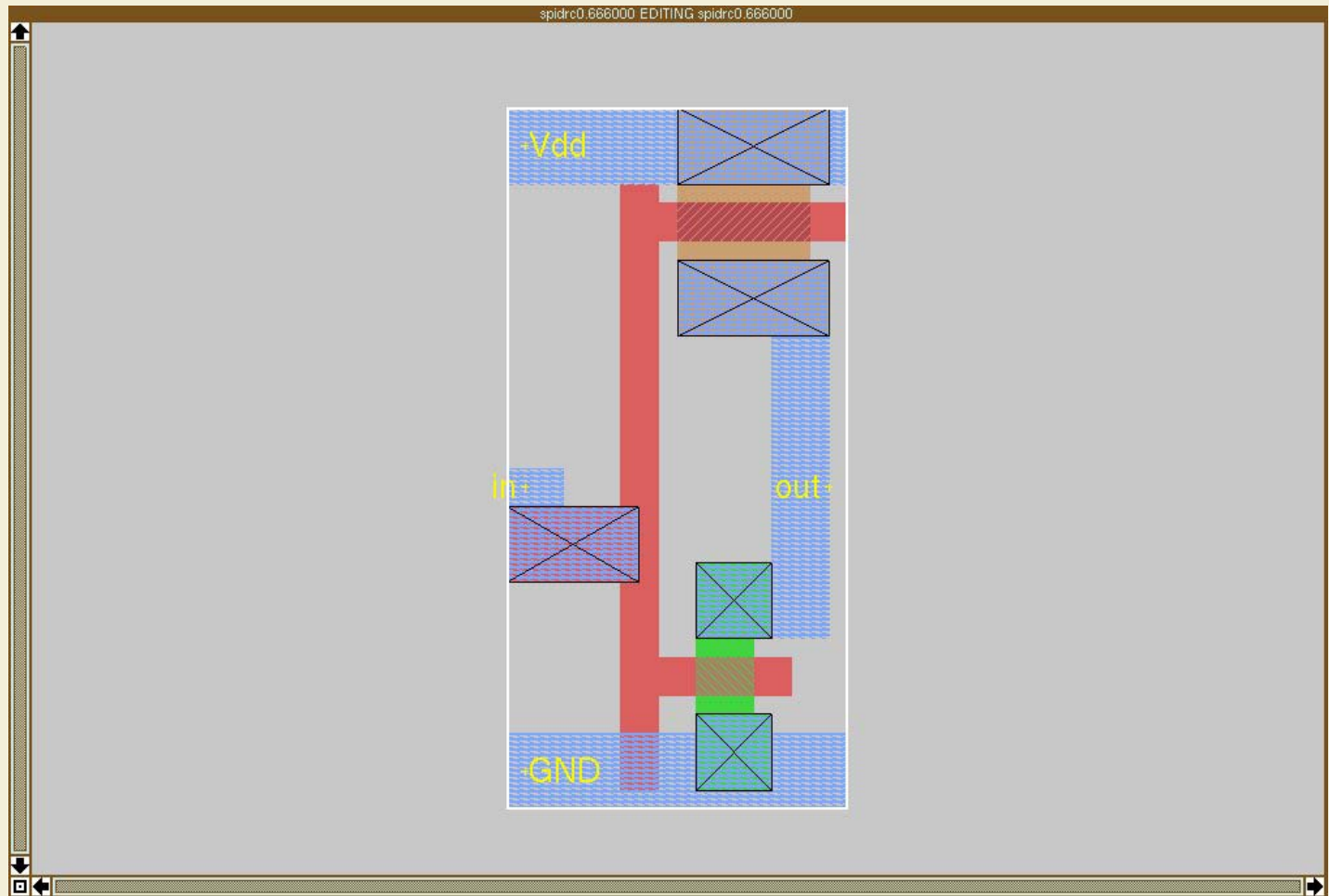
Evolving 4-7



Evolving 8: Aha! Inverter



Evolving – Success 1



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Limitations

- ◆ Does not always find global optima – Acceptable?
- ◆ Search space too large for more complex standard cells