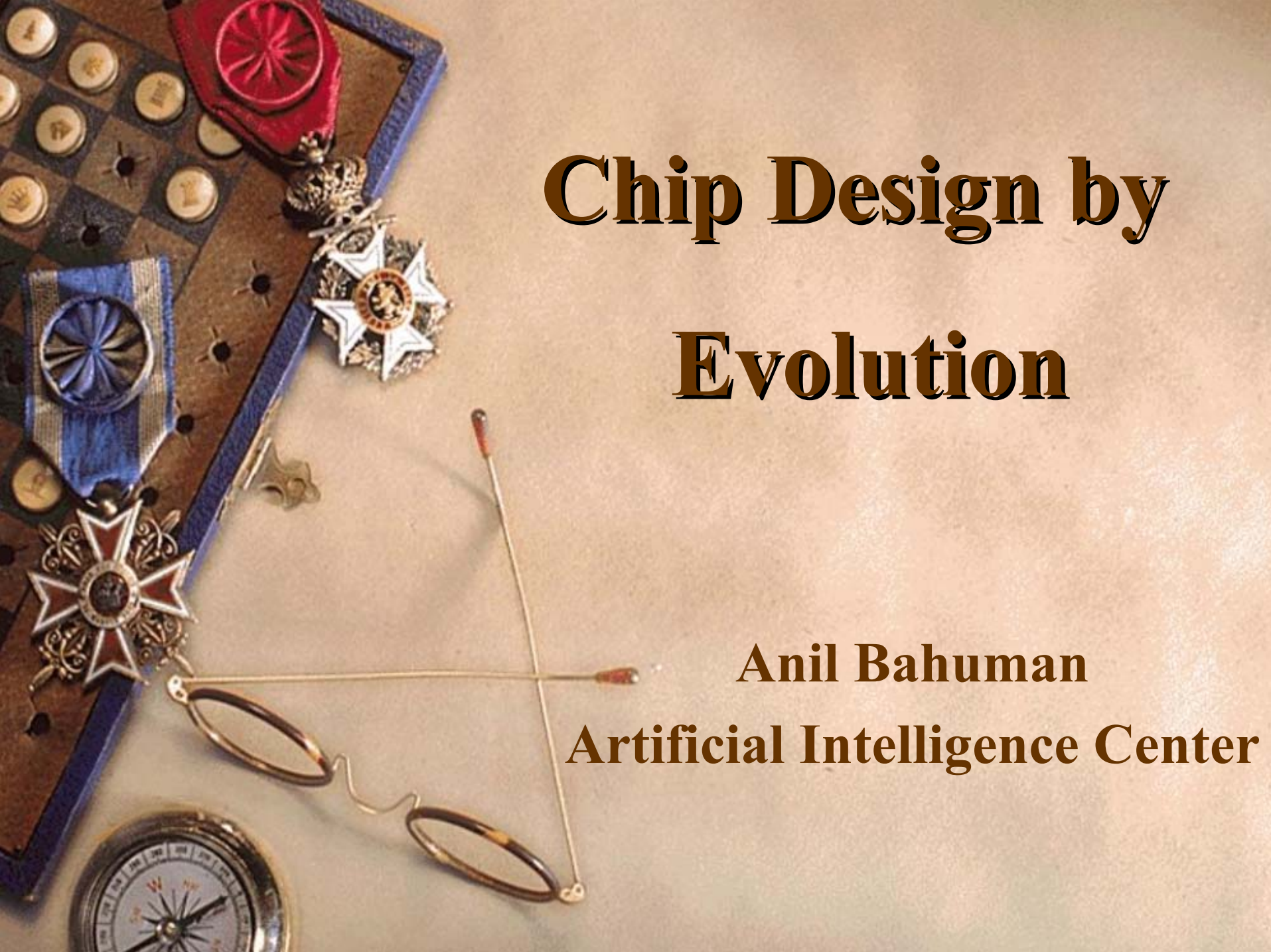


Chip Design by Evolution

Anil Bahuman
Artificial Intelligence Center

Electronic Design Automation

Design of Very Large Scale Integrated Circuits: VLSI

magic

spice

inverter

NP-hard

GADO

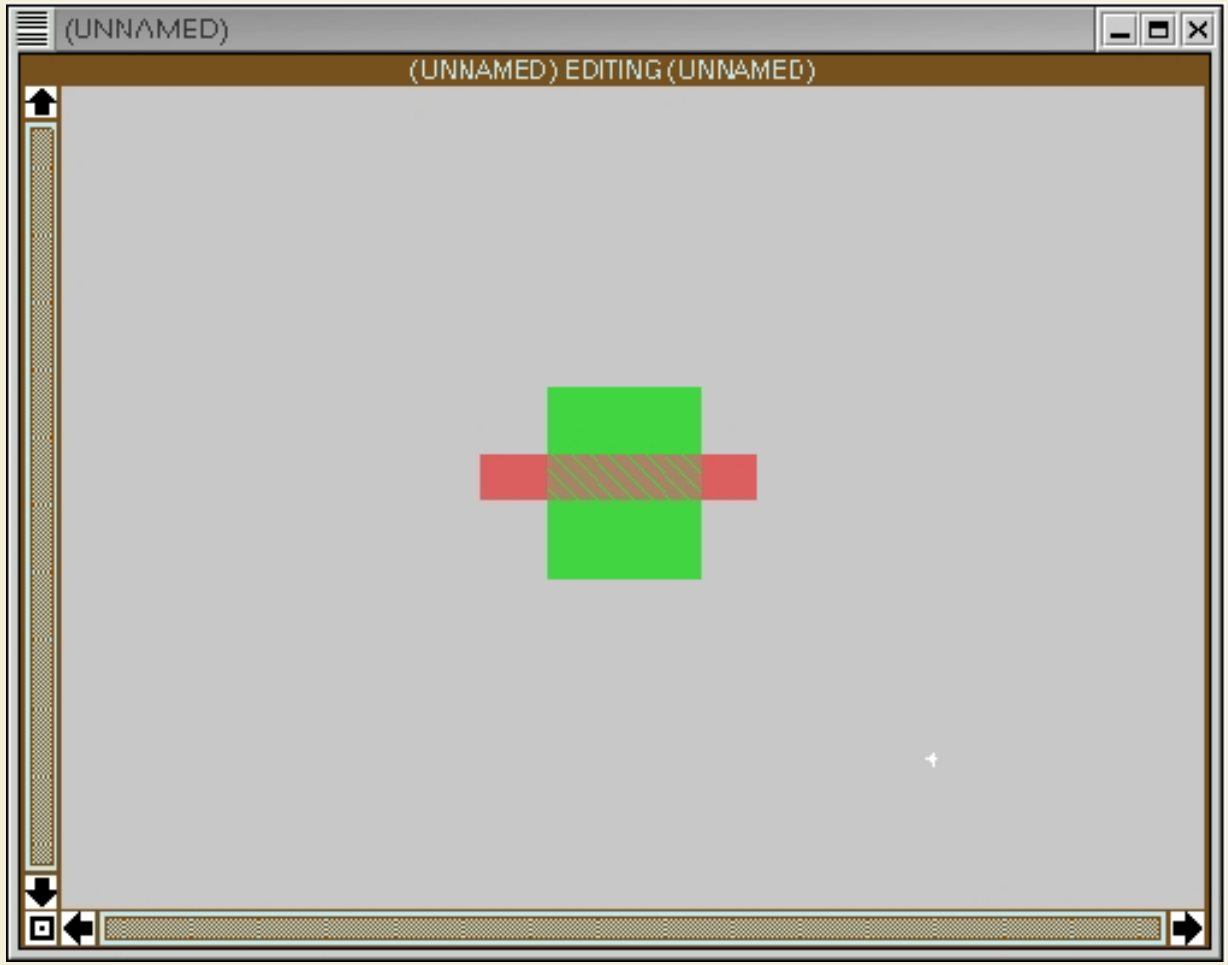
Standard Cell

GA

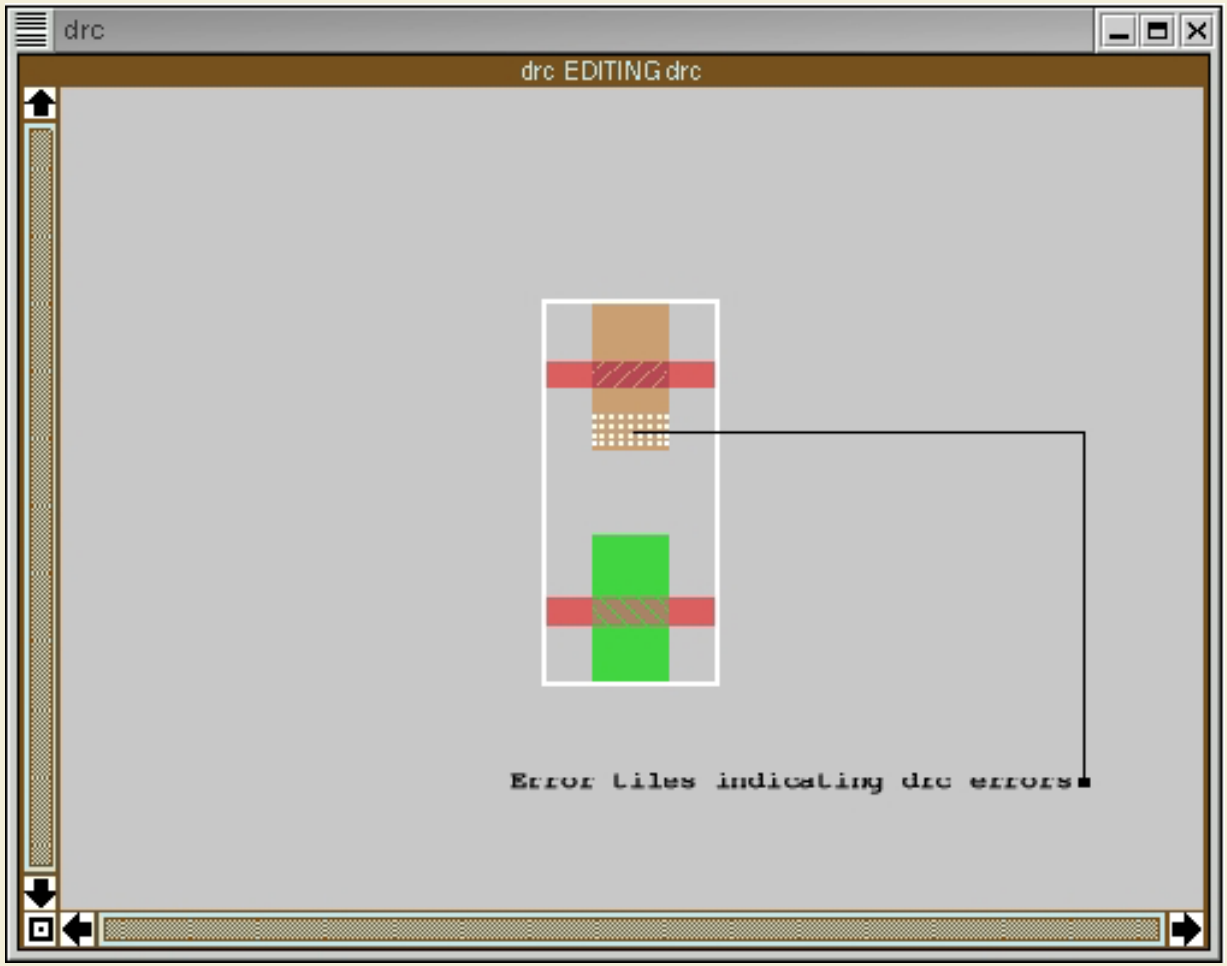
evolution

optimization

A Transistor in MAGIC

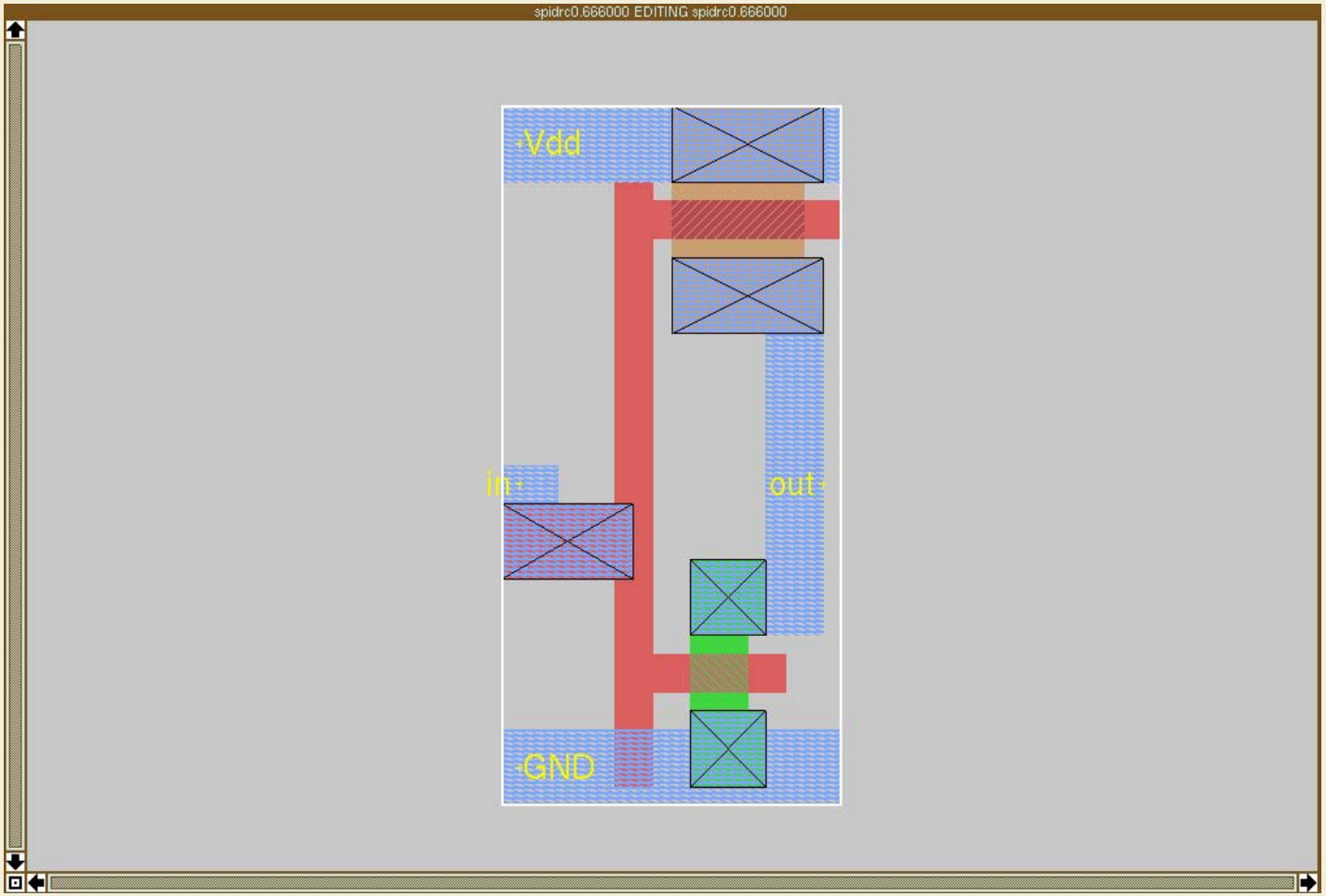


Error tiles indicating DRC Errors

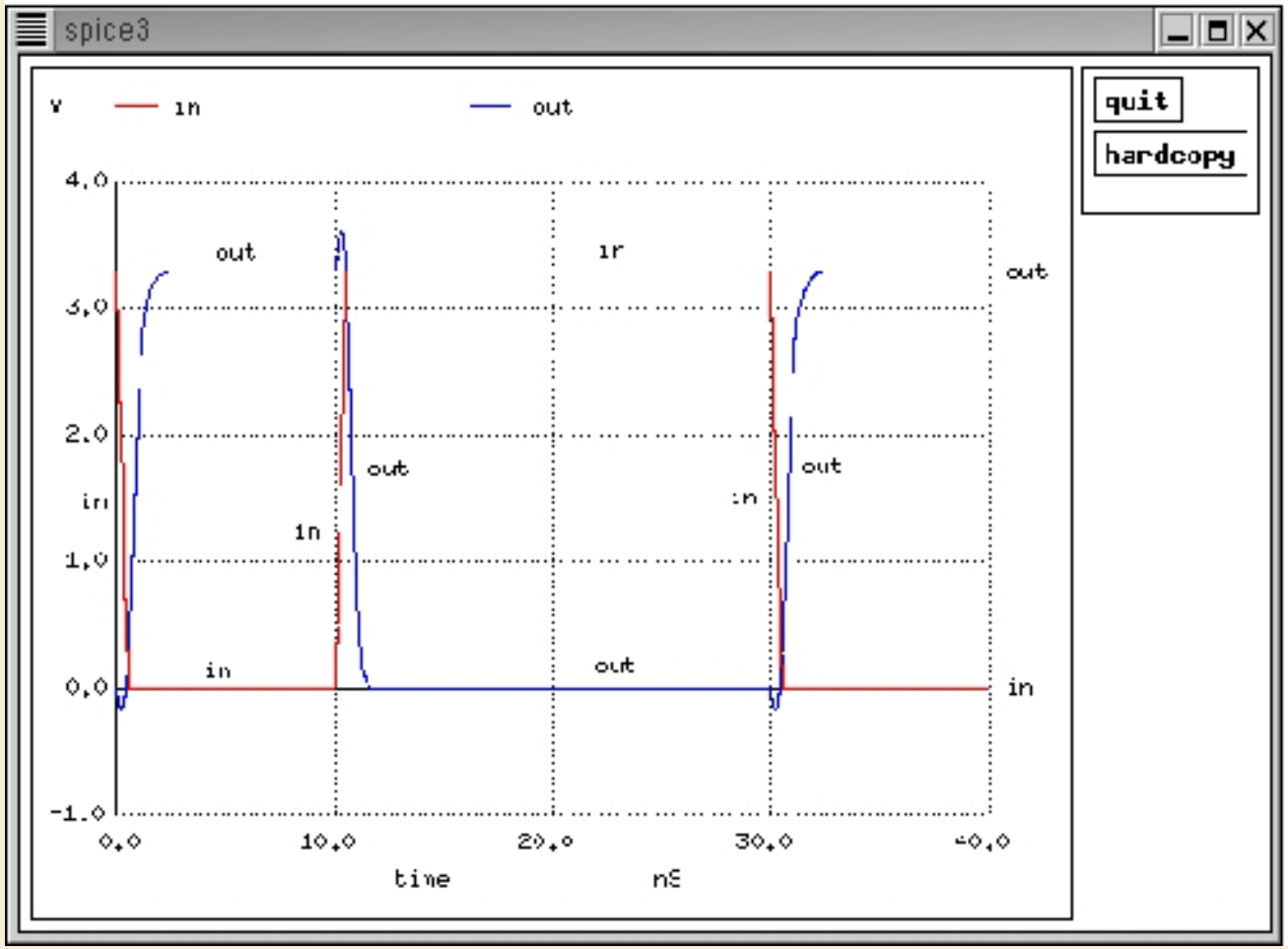


An Inverter in MAGIC

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



SPICE simulation of the Inverter

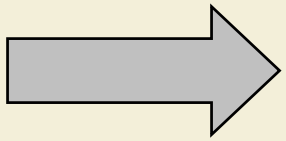


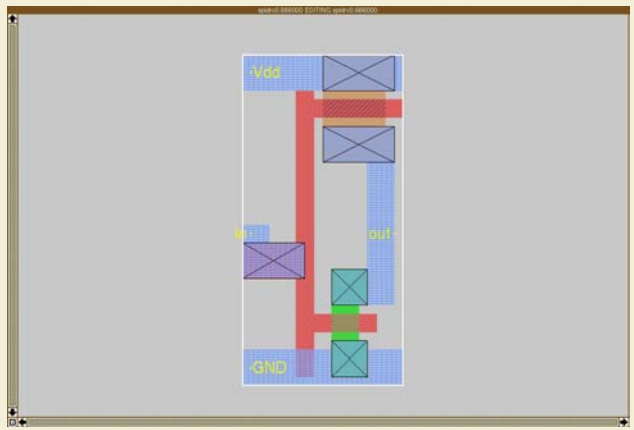
Standard Cell Design

- 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

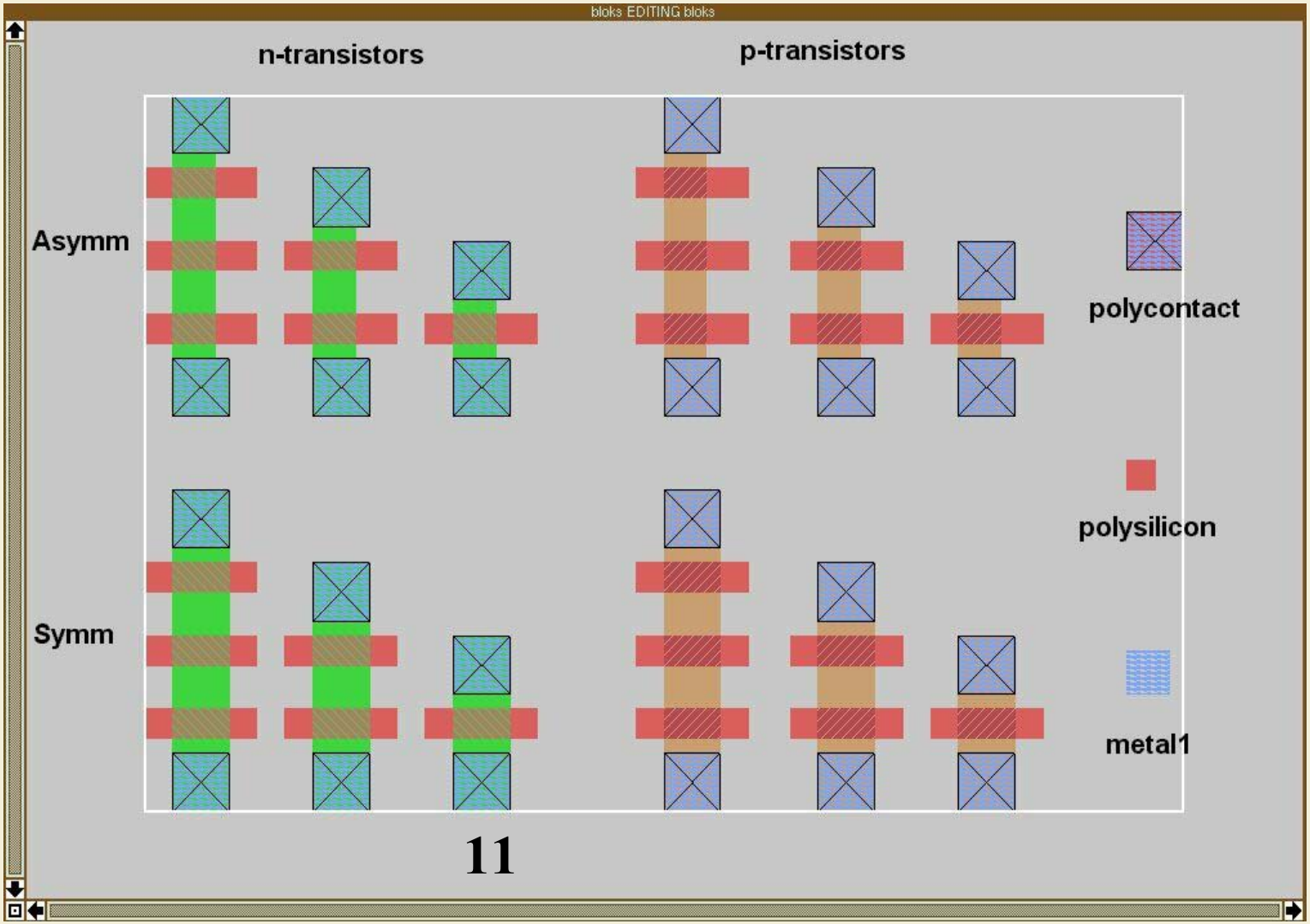




Truth Table

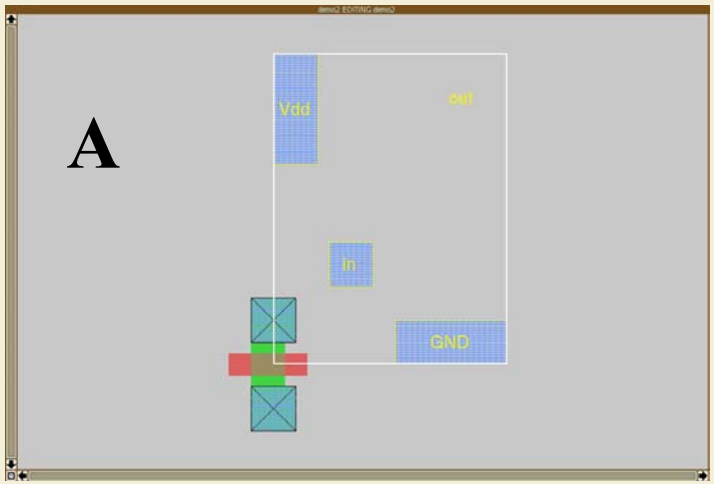
Layout with minimum area

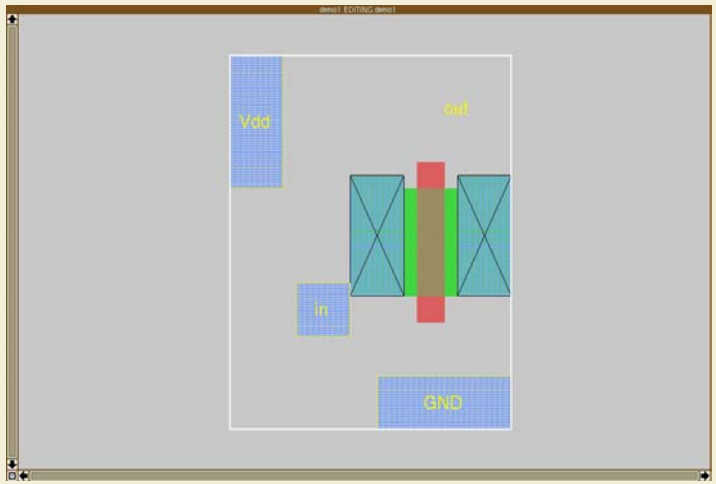
The Set of Objects



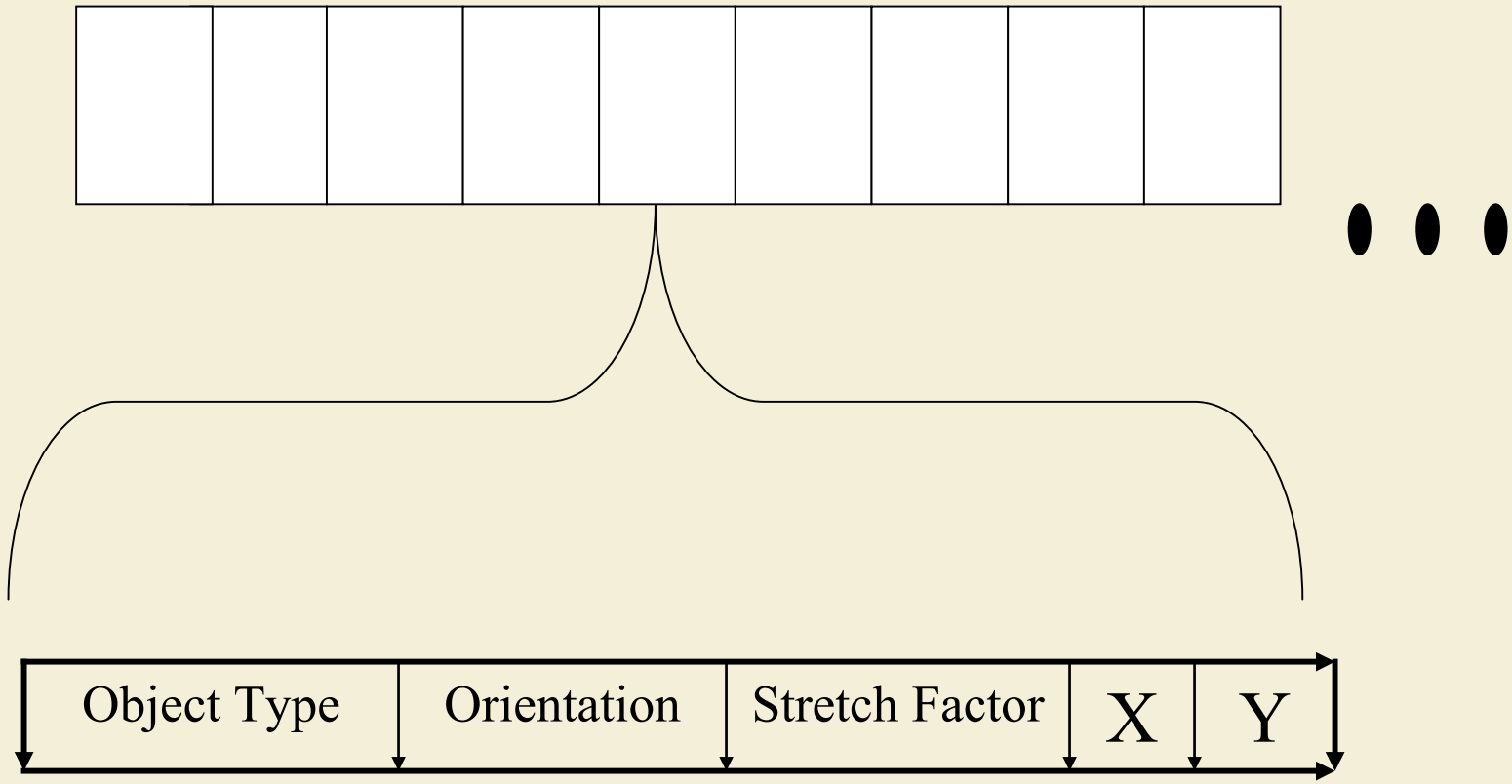
Encoding an Object

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

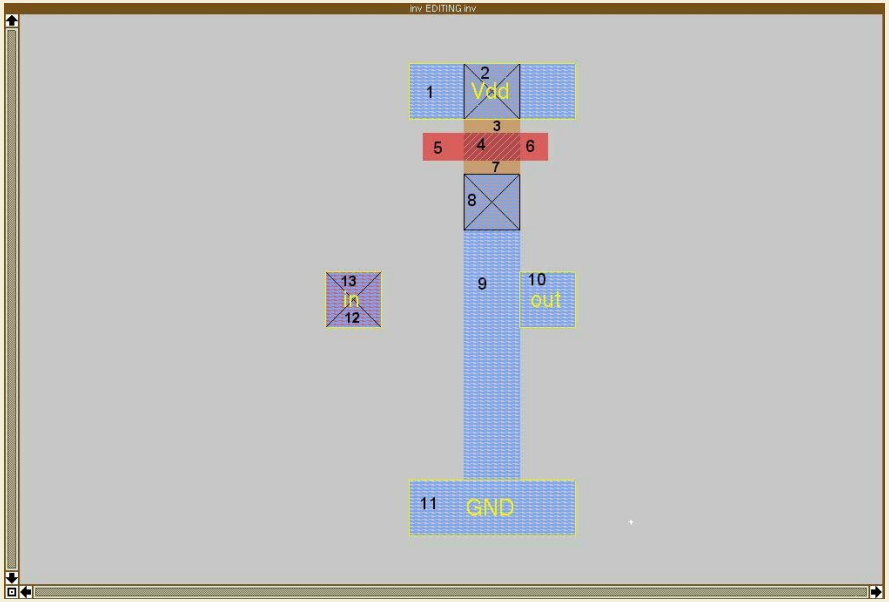
An Influence Check

- 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

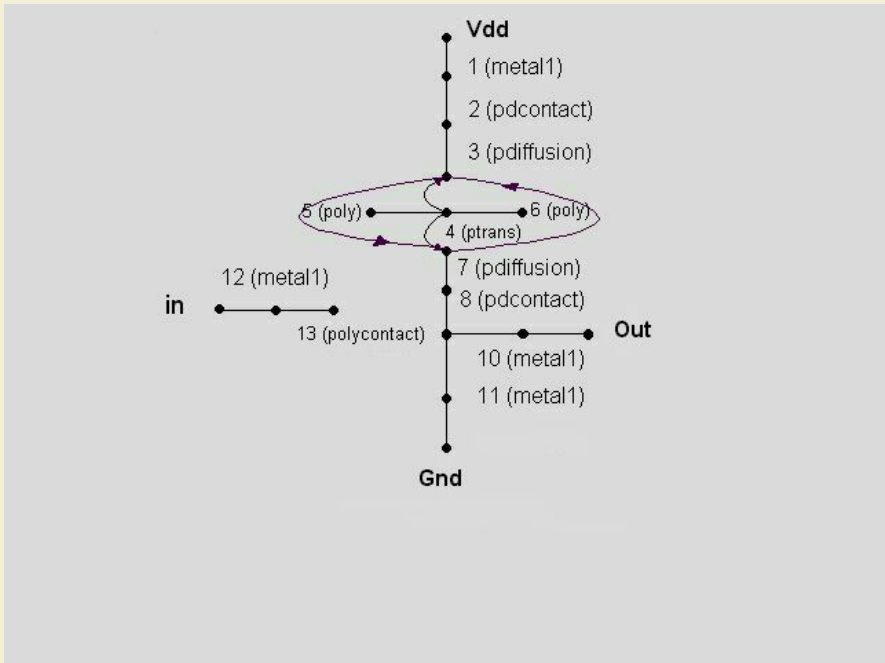
Punch line

“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

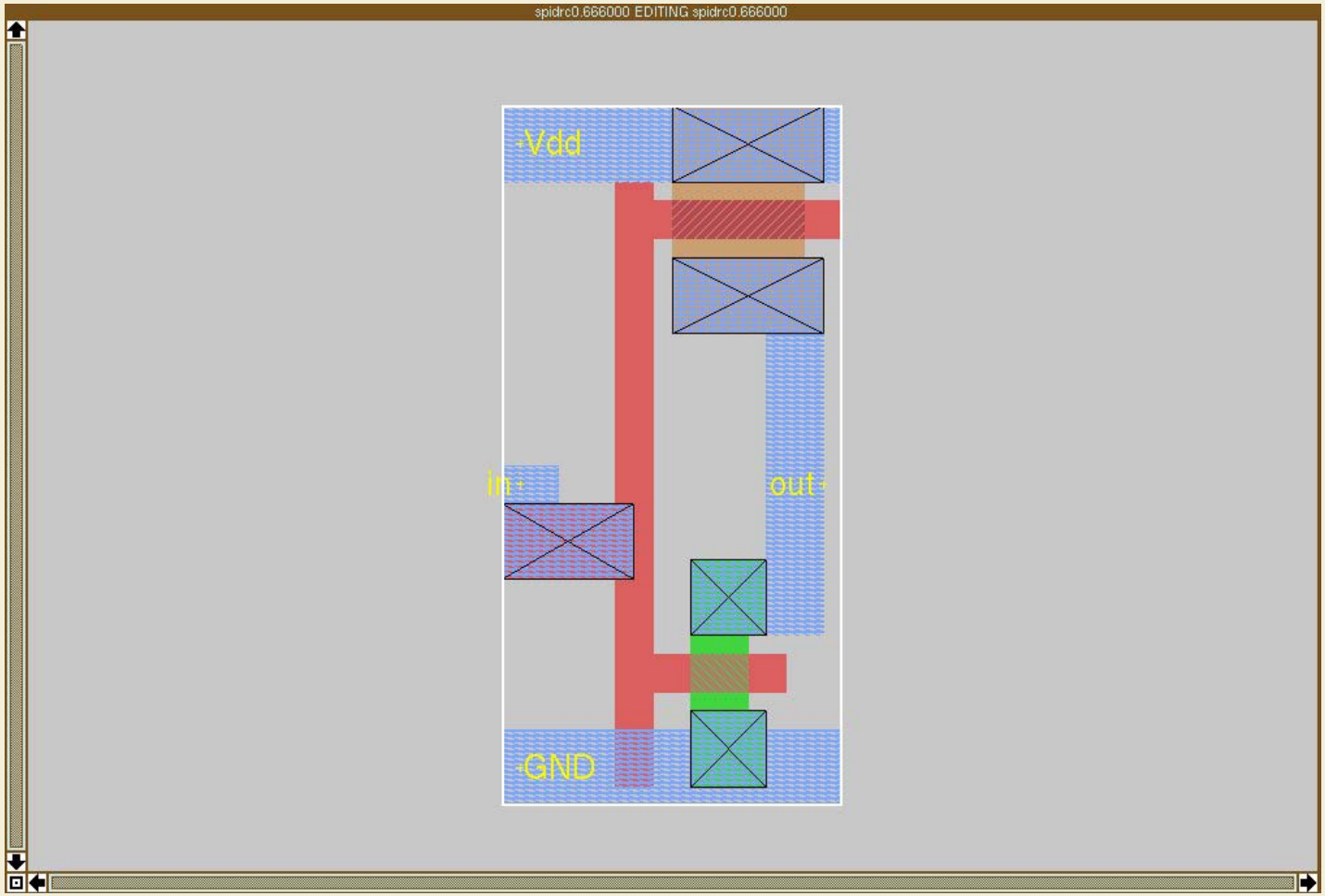


Sample Cell

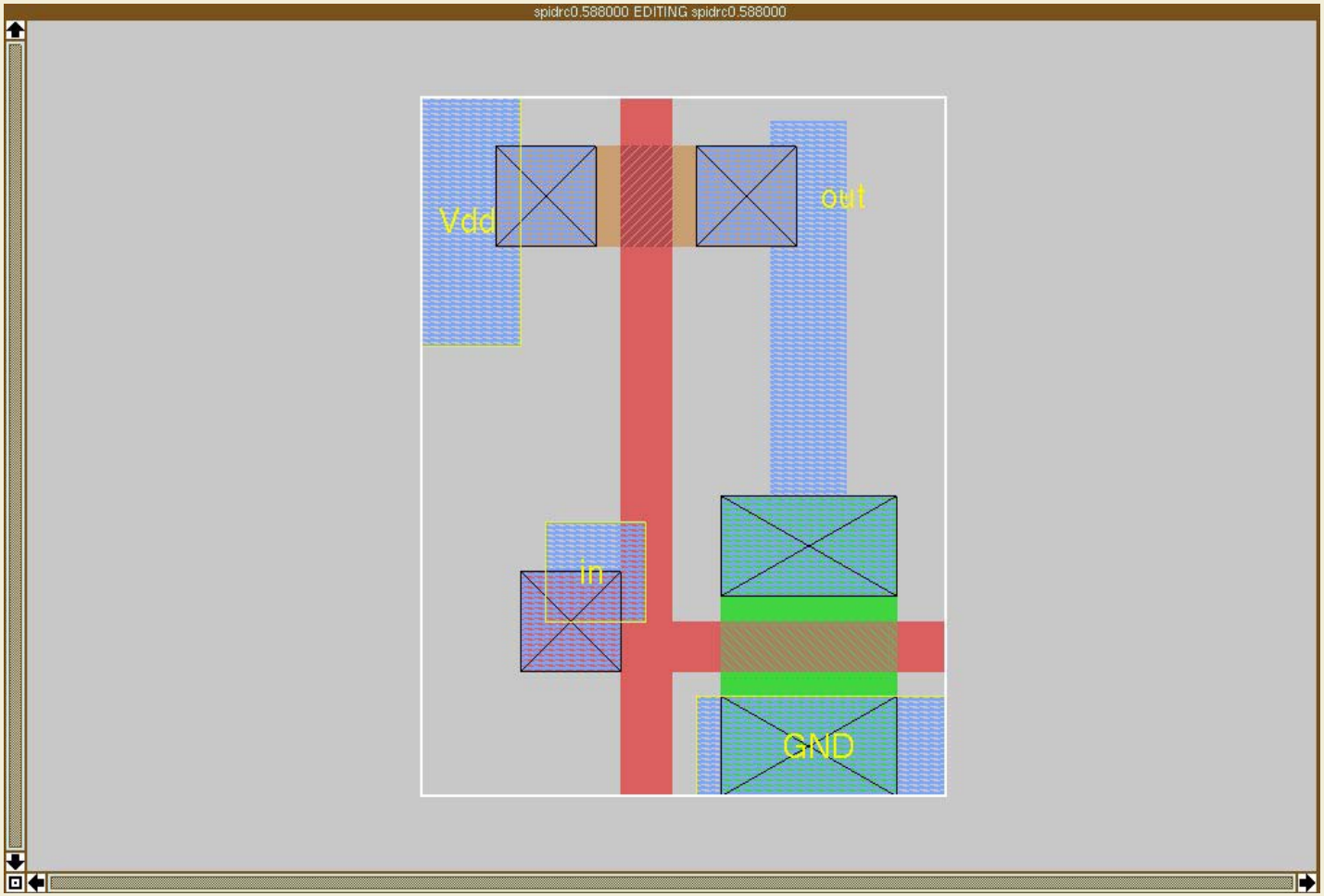


Corresponding Graph

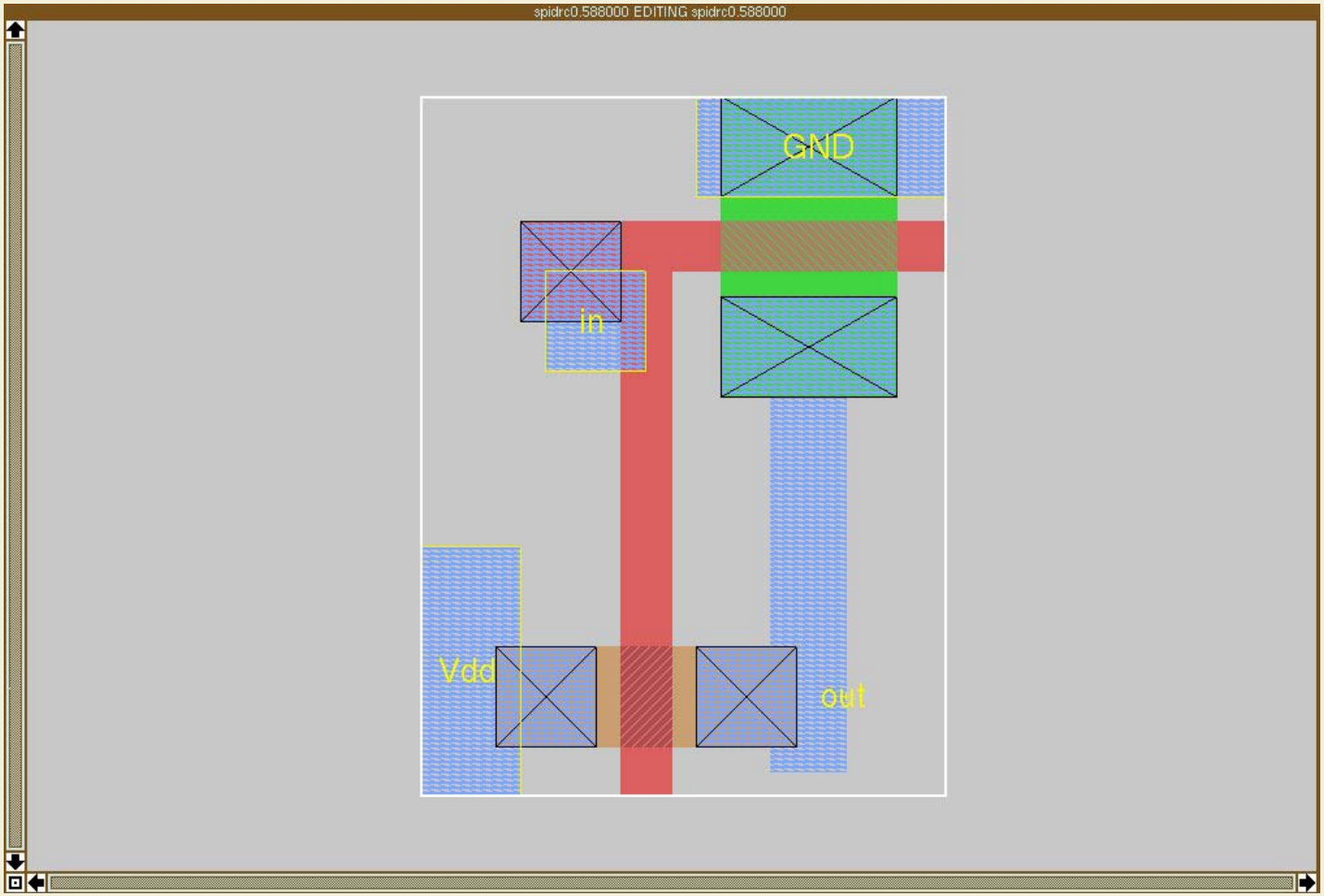
Success 1



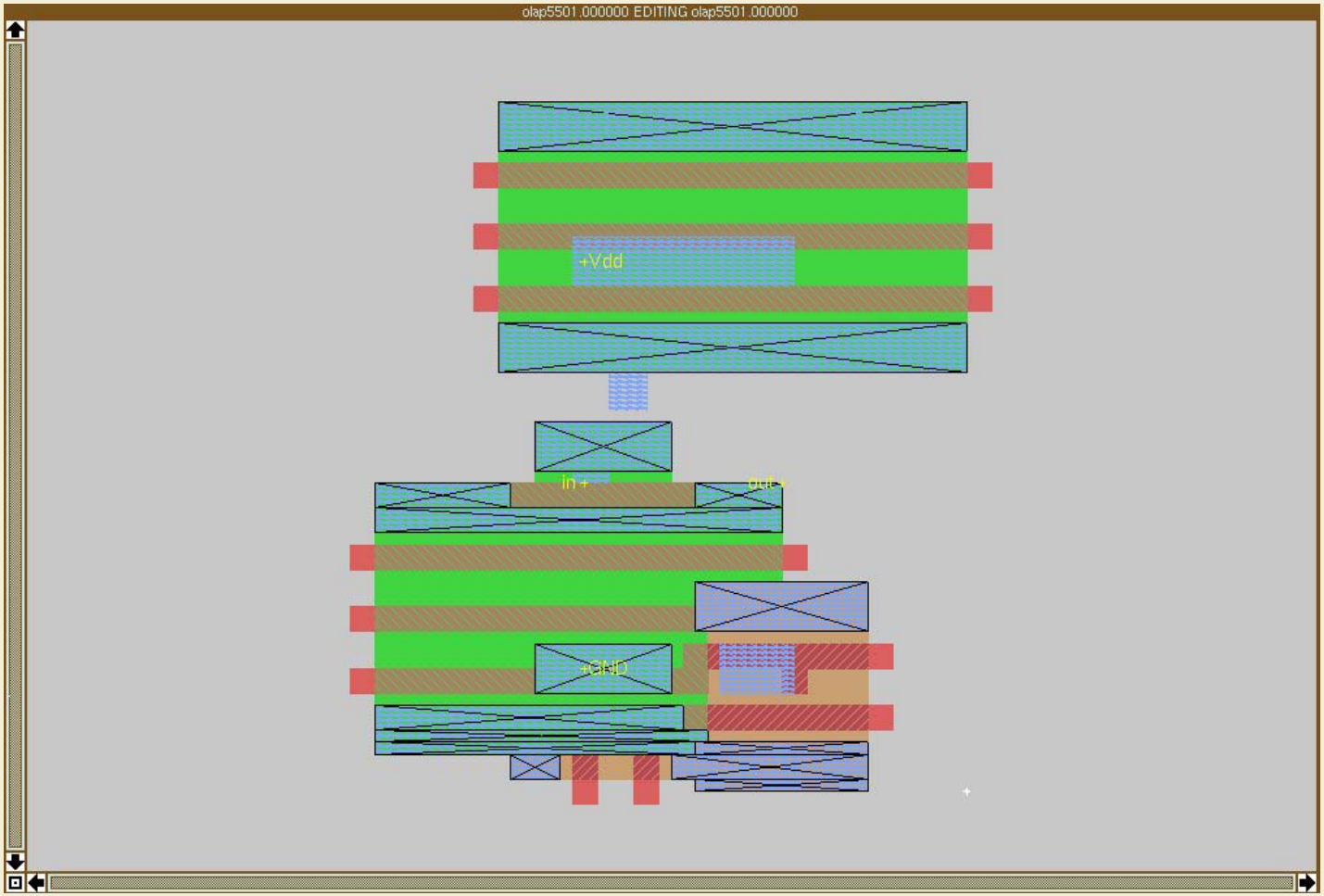
Success 2



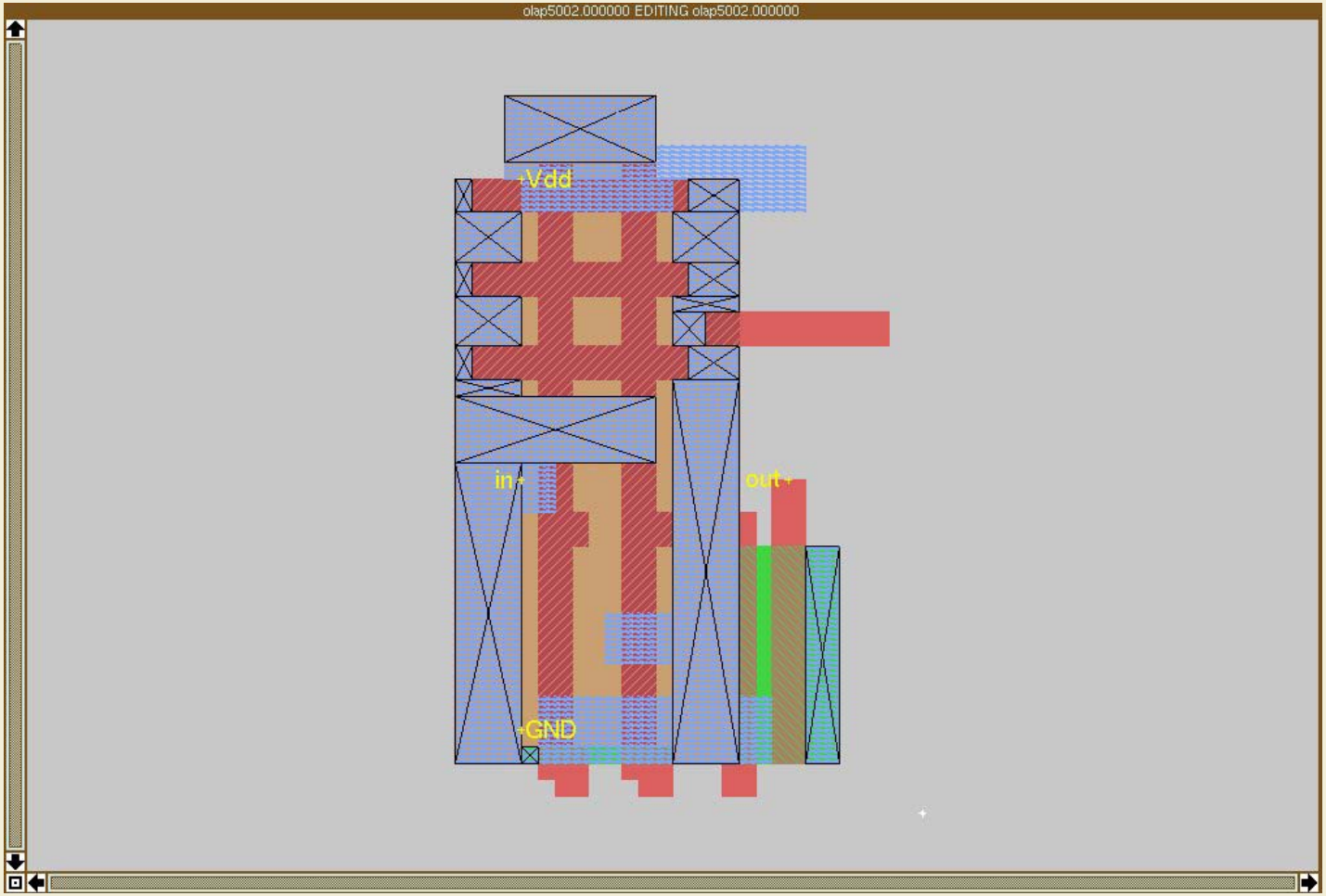
Success 3



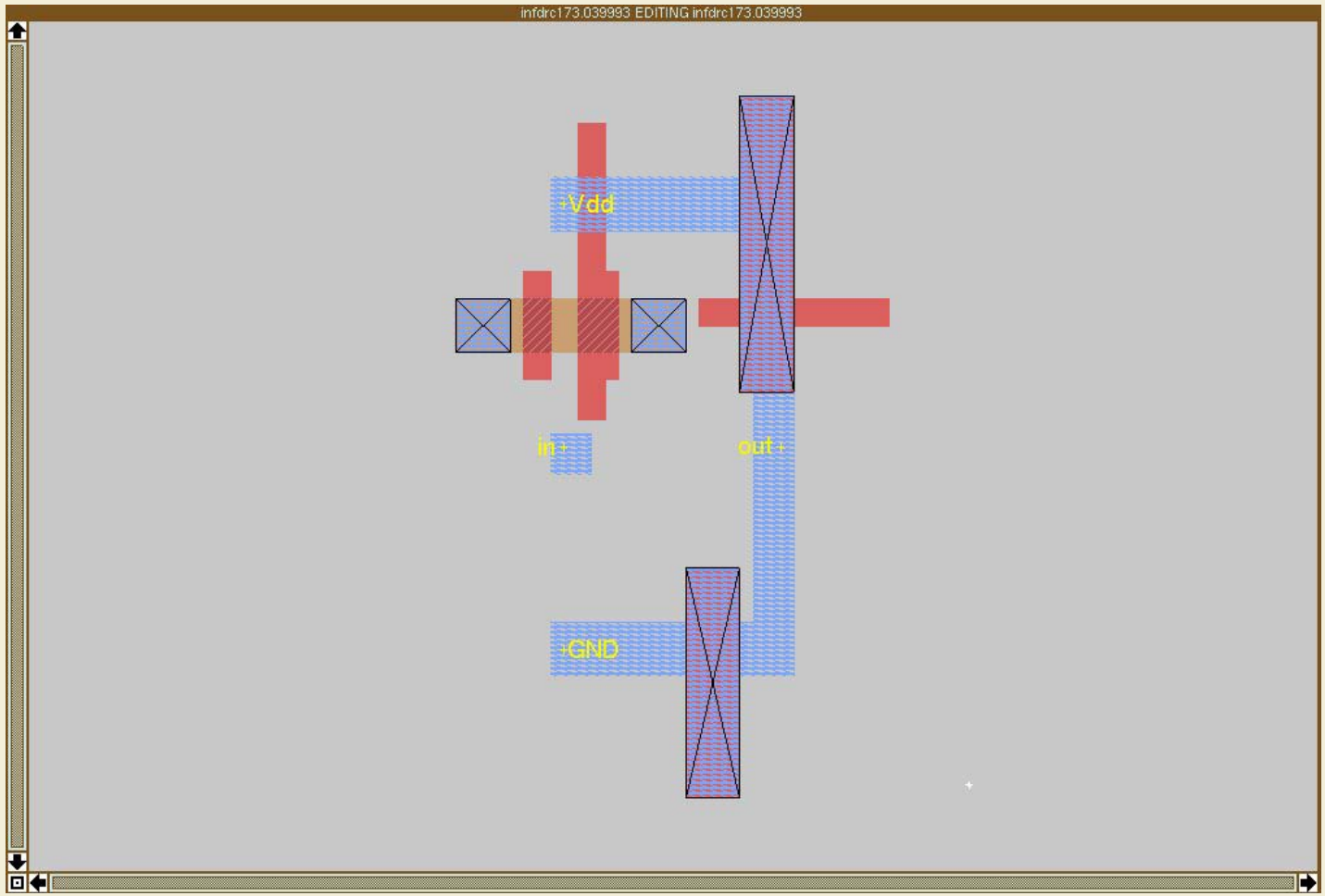
Evolving 1



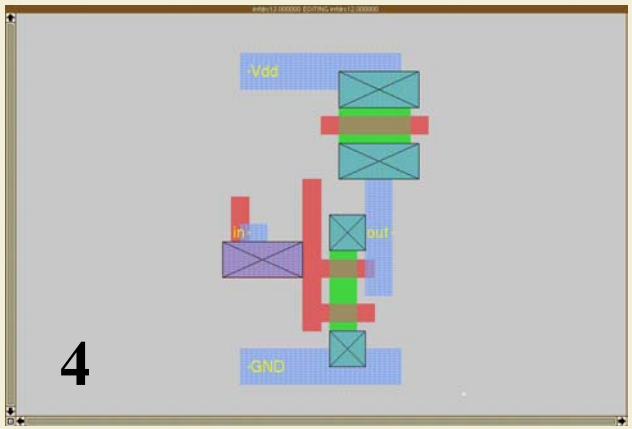
Evolving 2

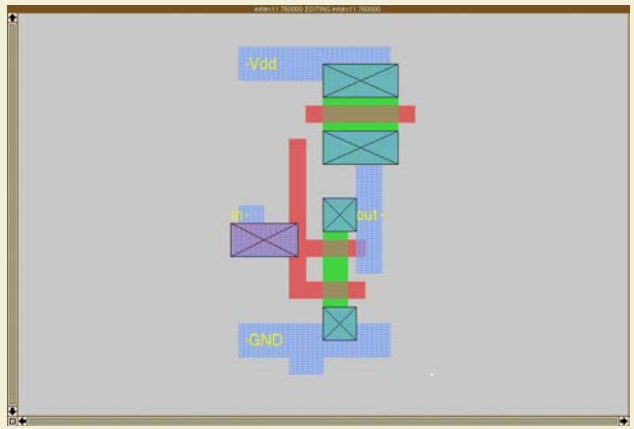


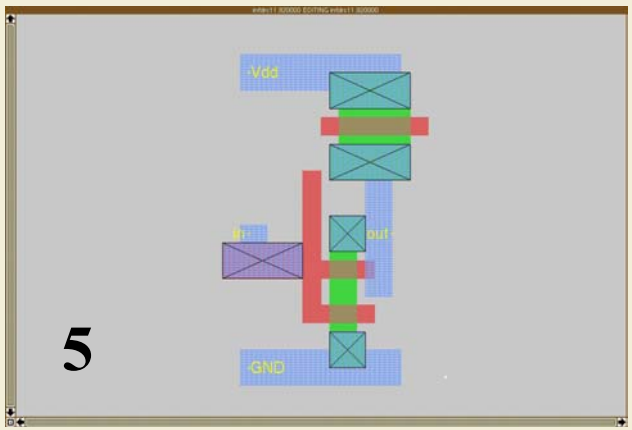
Evolving 3

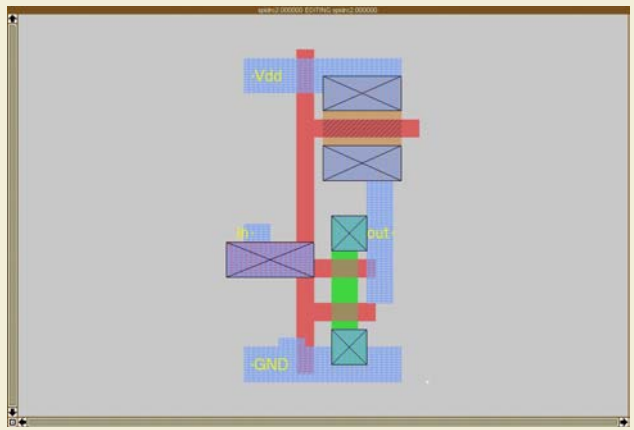


Evolving 4-7

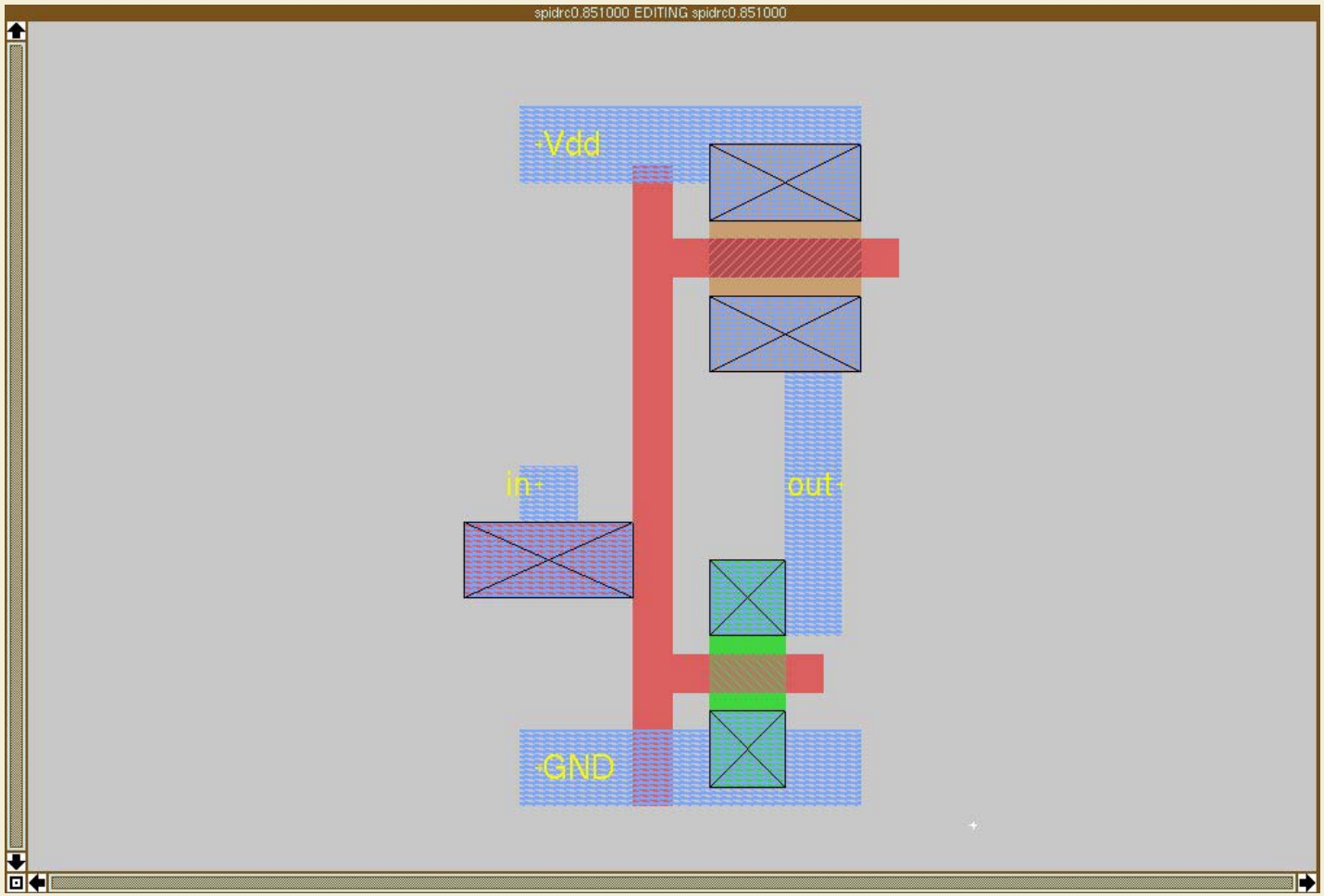




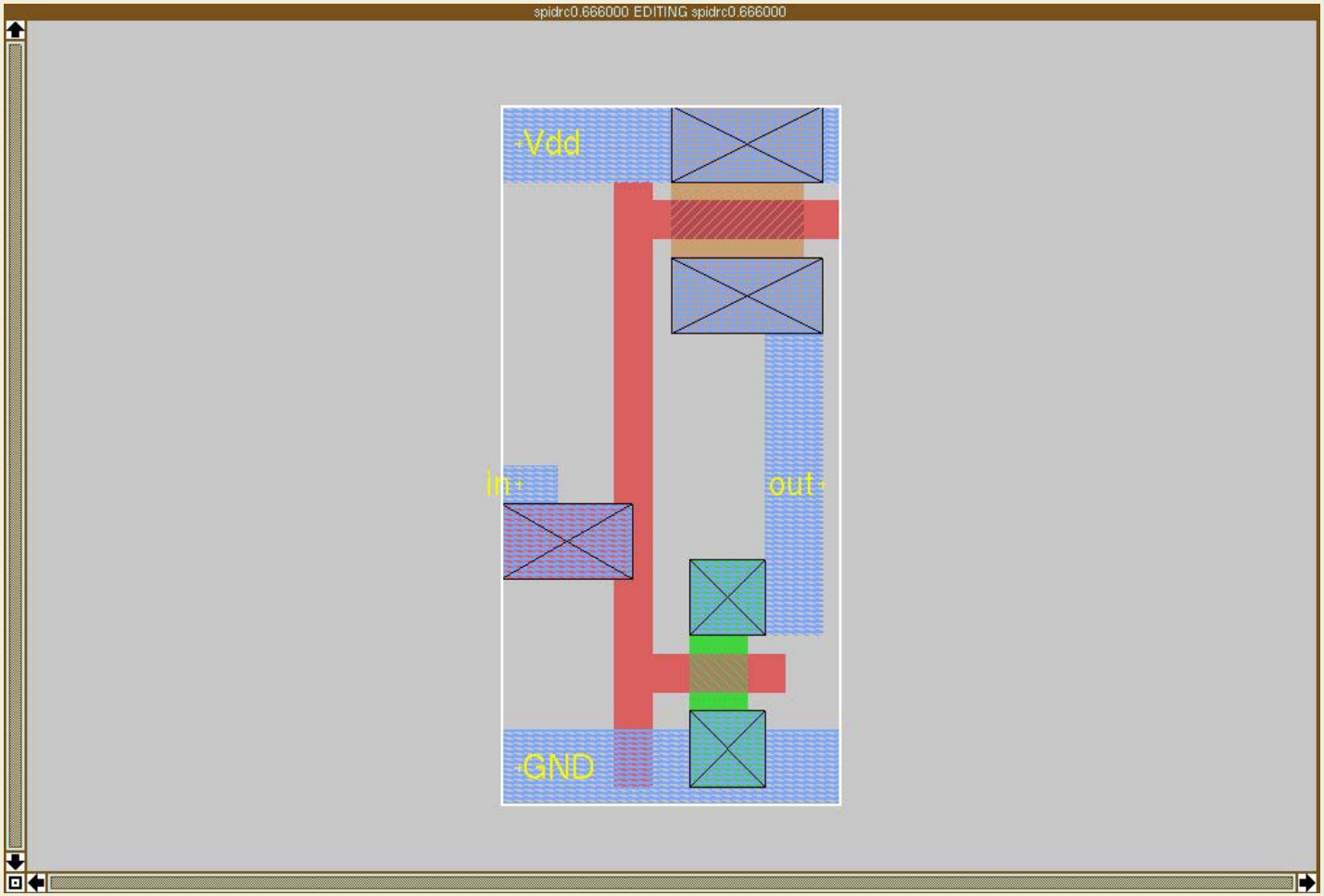




Evolving 8: Aha! Inverter



Evolving – Success 1



Limitations

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