Quantum Dots Cellular Automata: Fault Tolerant Logic Gates and Wires

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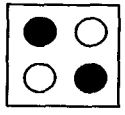
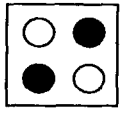
Basics of QCA



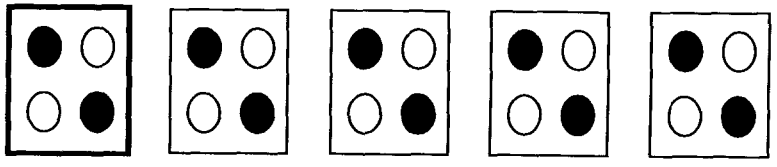
Polarization P = -1, Encoding Binary 0



Polarization P = +1, Encoding Binary 1

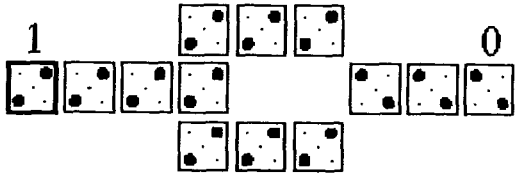
Quantum Cellular Automata (QCA) Molecule and Binary Information Representation in QCA

Input



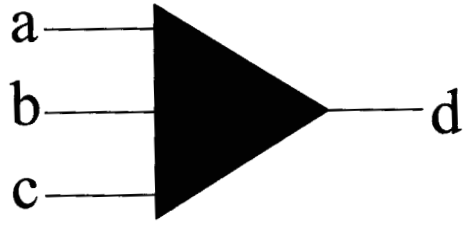
Output

A QCA Binary Wire

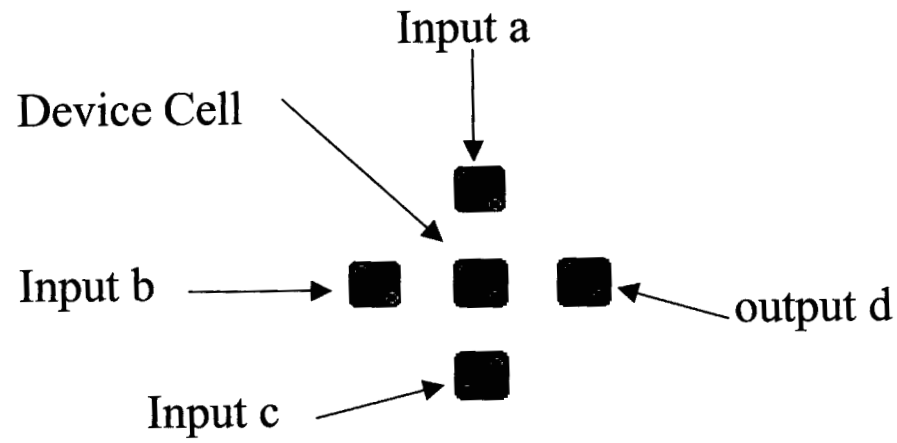


Inverter Chain (NOT Gate)

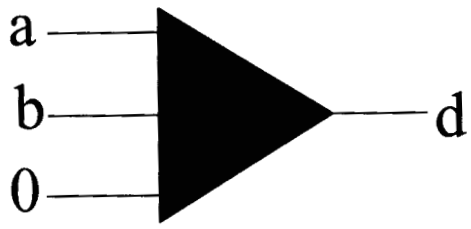
Basics of QCA: Majority Gate



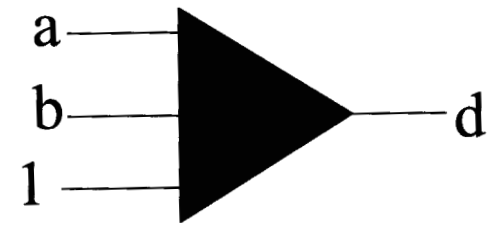
a) Schematic of Majority Gate



b) QCA Implementation of Majority Gate



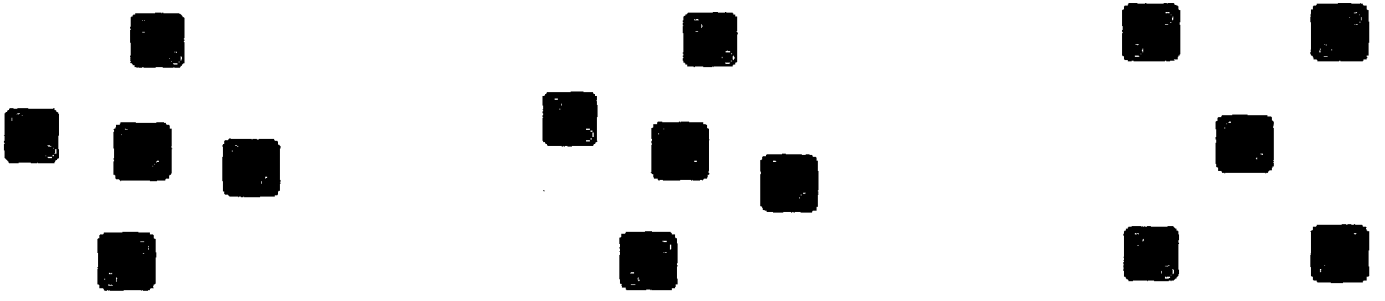
c) A QCA-based *OR Gate* by fixing one of the Majority Gate inputs to logical value 0



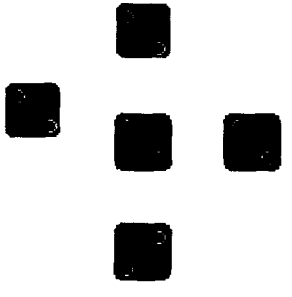
d) A QCA-based *AND Gate* by fixing one of majority Gate the inputs to the logical value 1

Majority Gate: an intrinsically suitable logic gate for implementation with QCA

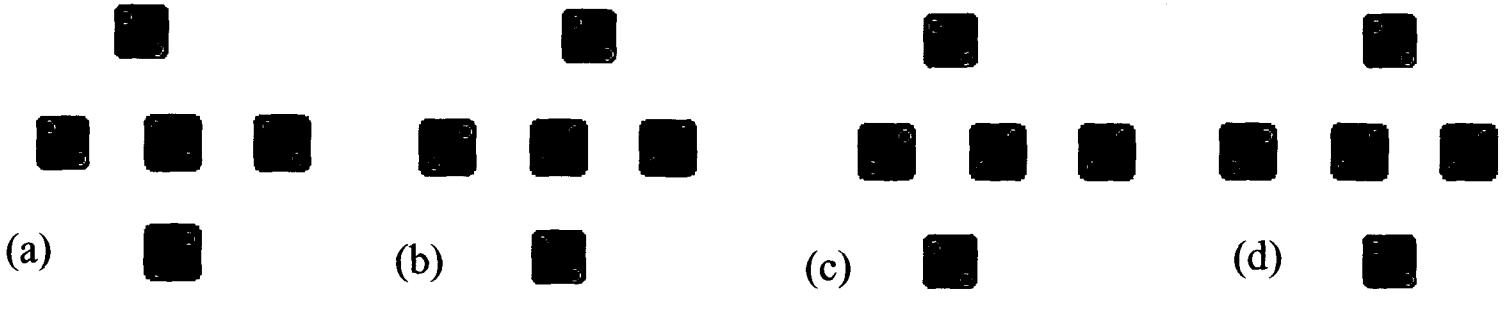
Fault Tolerant Majority Gates



Three functioning Majority Gates with imprecise but symmetric assembly.
Input and output cells are equally rotated (with different rotations) around the device cell.

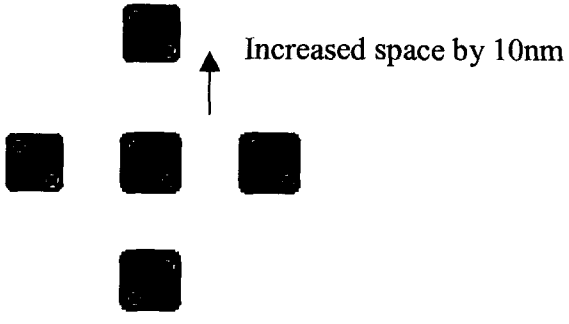


A functioning Majority Gates with imprecise and unsymmetric assembly.
One of the input cells is displaced with respect to the device cell.

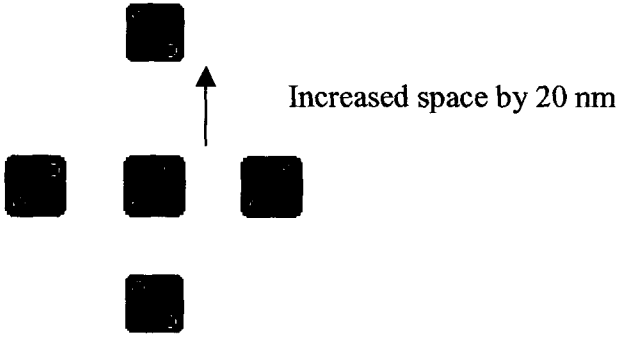


Non-functioning designs for Majority Gate with imprecise assembly.
One or both vertical input cells are displaced with respect to the device cell.

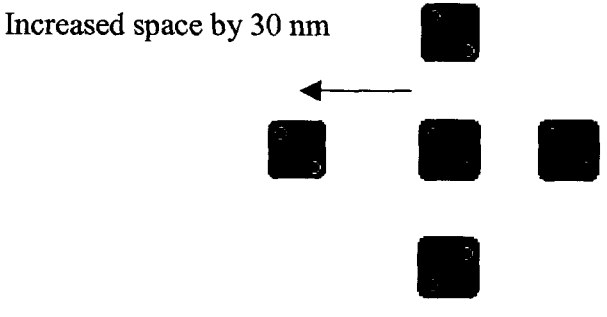
Fault Tolerant Majority Gates

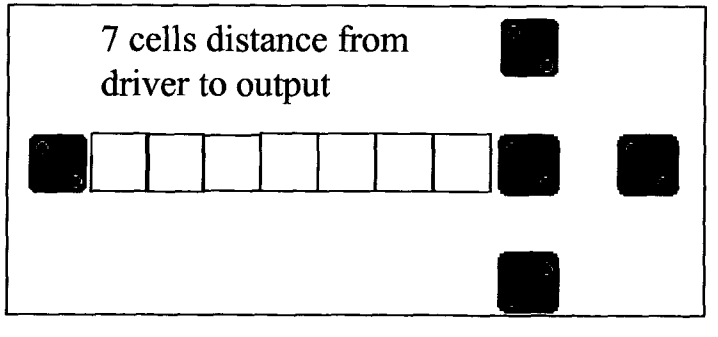


A functioning Majority Gate with imprecise assembly. The top vertical input cell is displaced by 10 nm with respect to the device cell.



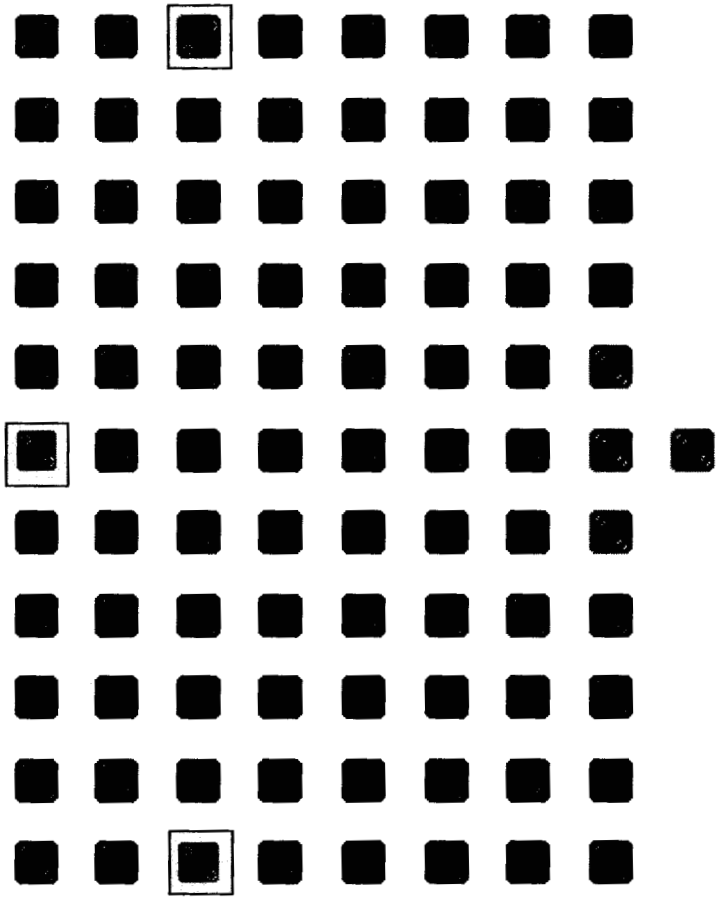
A non-functioning design for Majority Gate with imprecise assembly. The top vertical input cell is displaced by 20 nm with respect to the device cell.



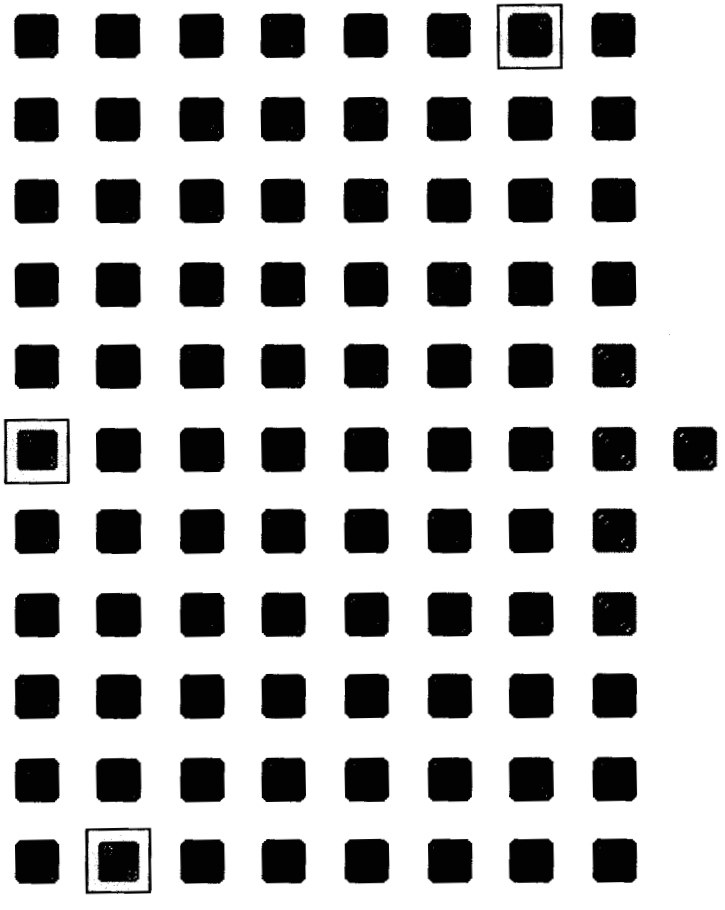


Two functioning Majority Gates with imprecise assembly. The horizontal input cell can be displaced with respect to the device cell by up to 70 nm.

Block Majority Gate



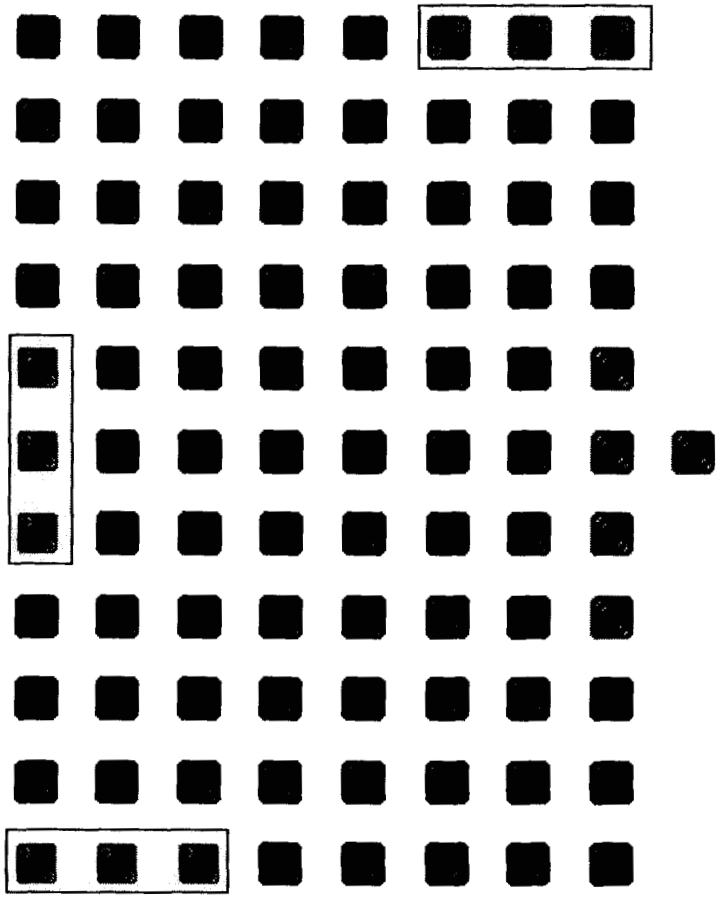
A QCA array Majority Gate with precise assembly and precise inputs alignment.



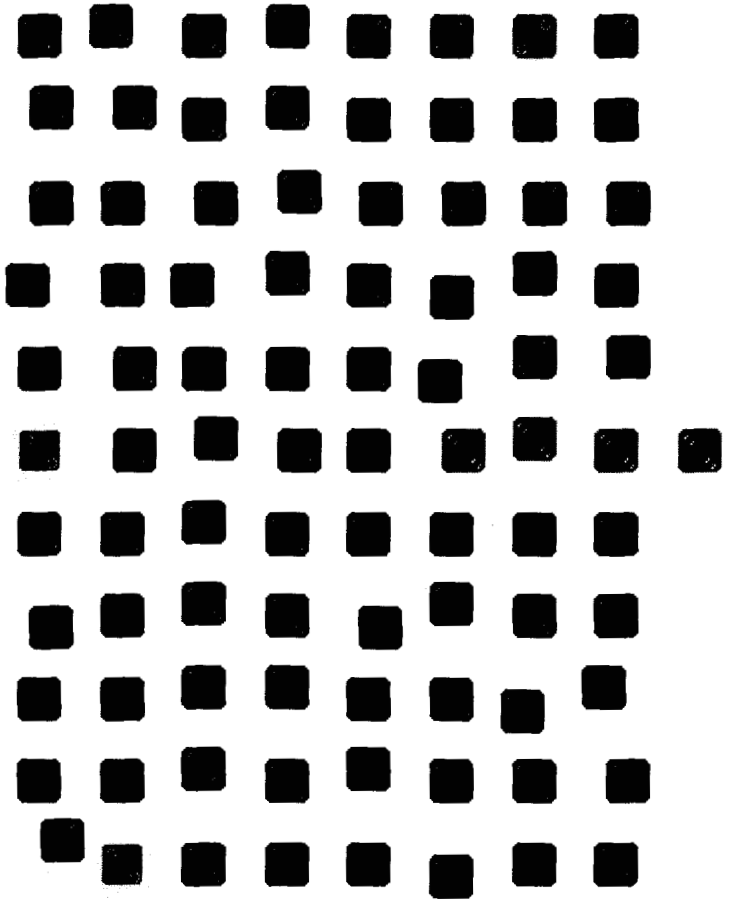
A QCA array Majority Gate with precise assembly and imprecise inputs alignment.

Red square indicates input cells and blue square indicate output cells

Block Majority Gate



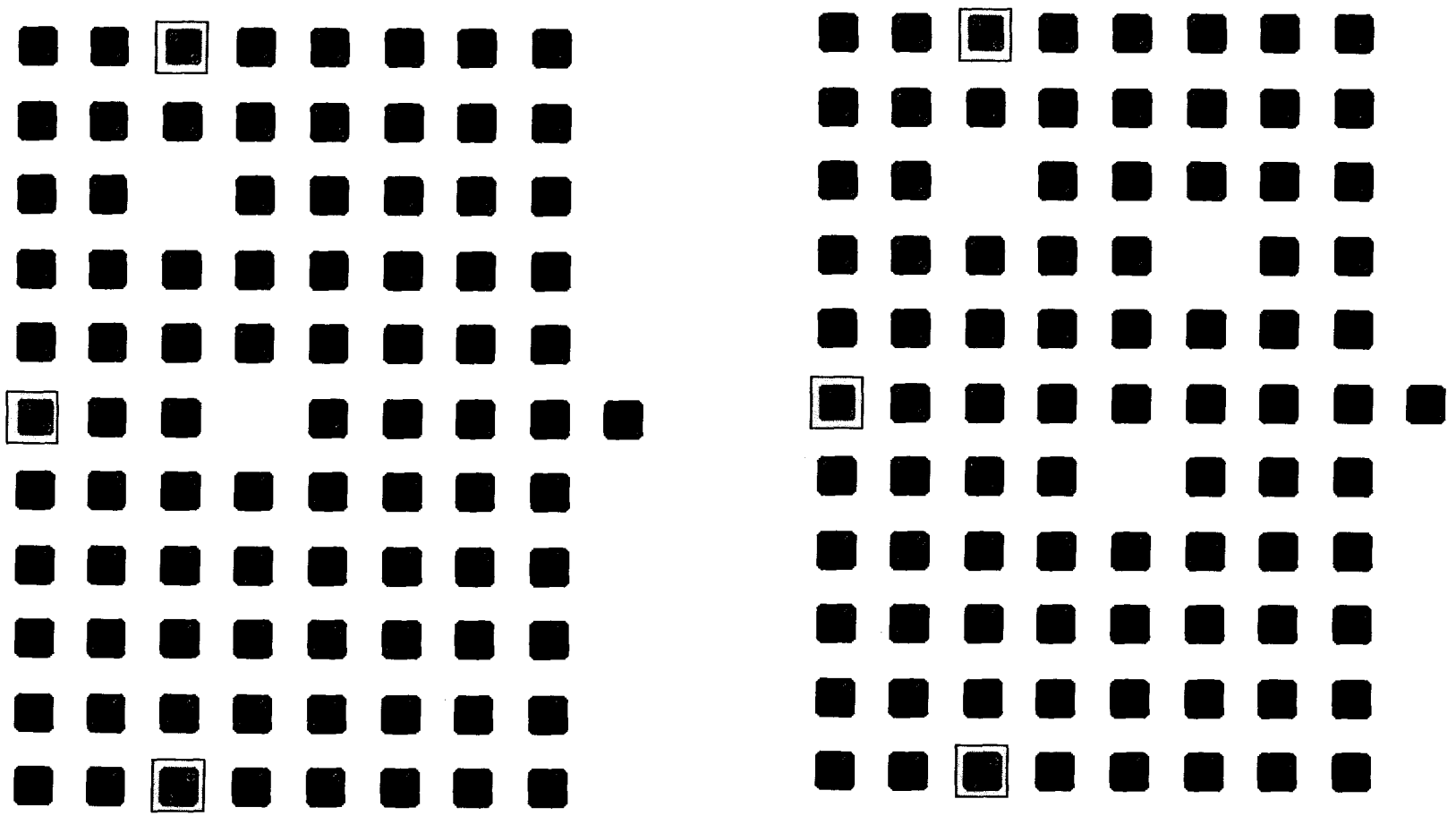
A QC a array Majority Gate with precise assembly and multiple cell and misaligned inputs.



A QCA array Majority Gate with imprecise assembly and misaligned inputs.

Red square indicates input cells and blue square indicate output cells

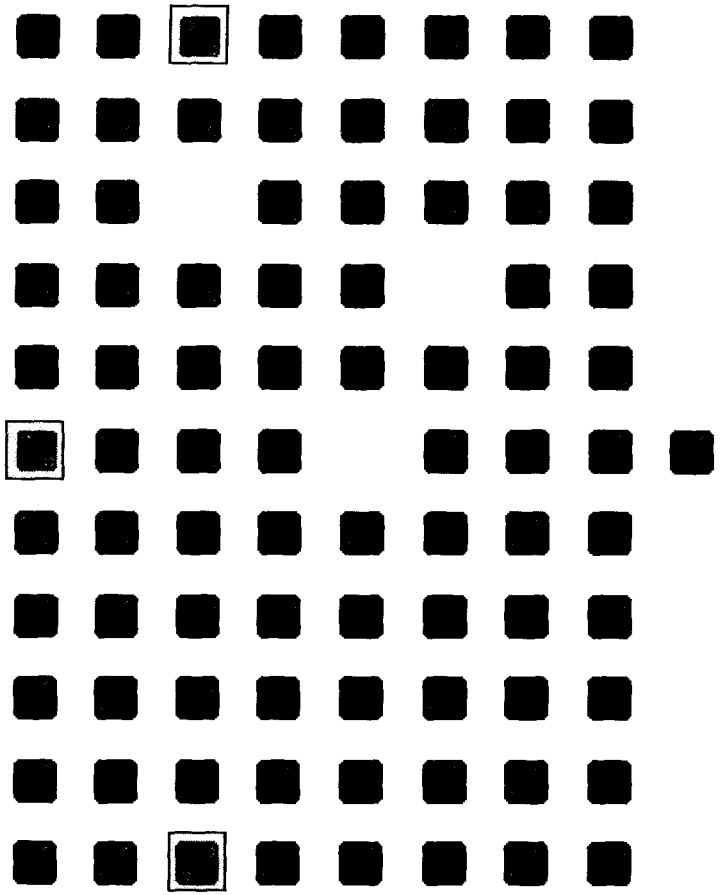
Block Majority Gate



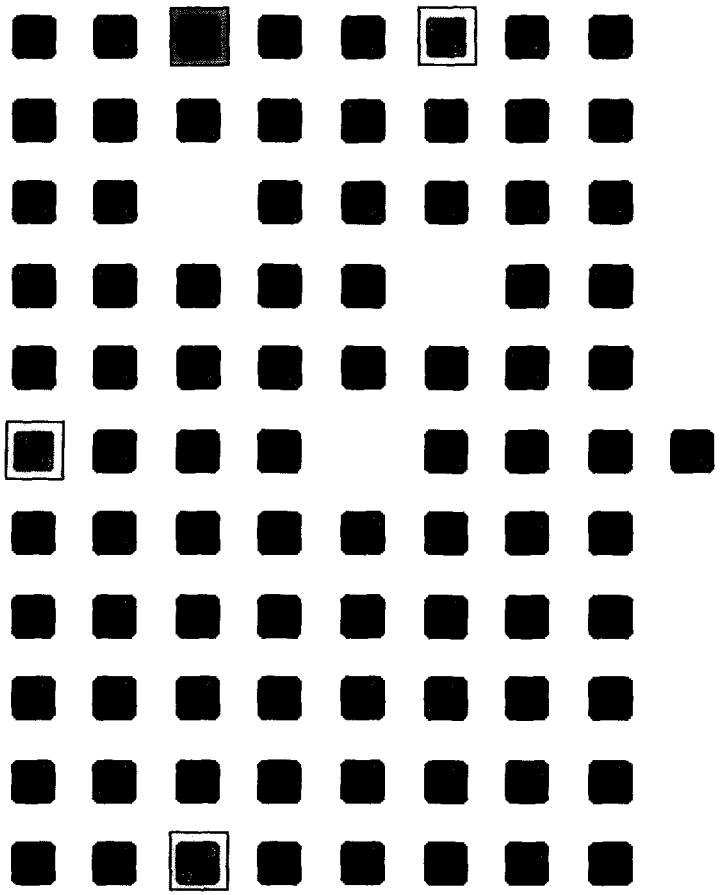
Two QCA array Majority Gates with regular assembly but with randomly missing cells.

Red square indicates input cells and blue square indicate output cells

Block Majority Gate

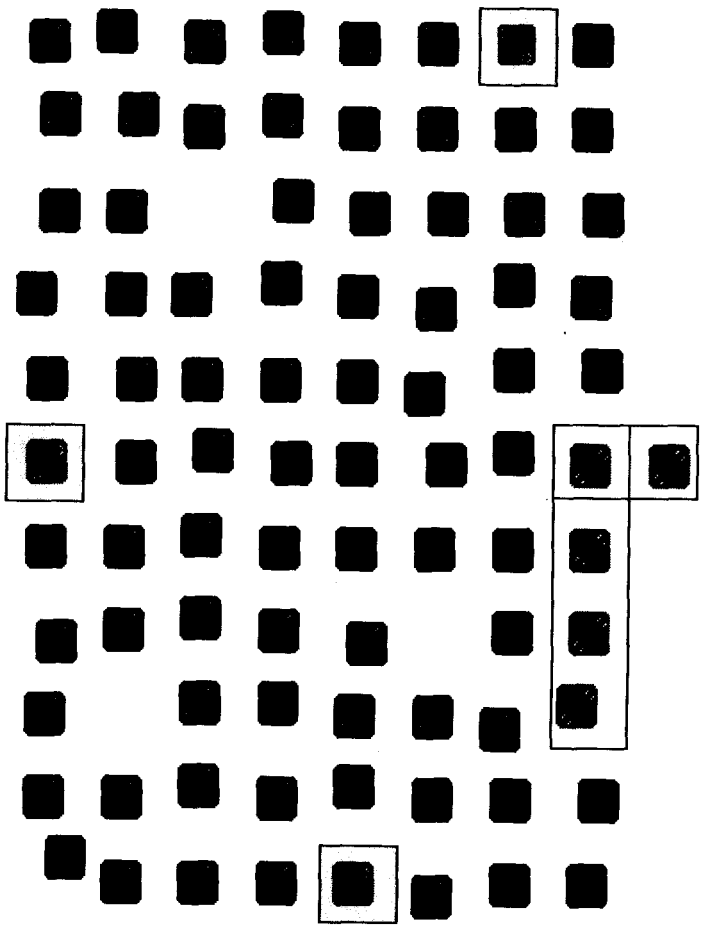


A QCA defective array which does not function as a Majority Gate.



The same QCA defective array can function as a Majority Gate by changing one input position.

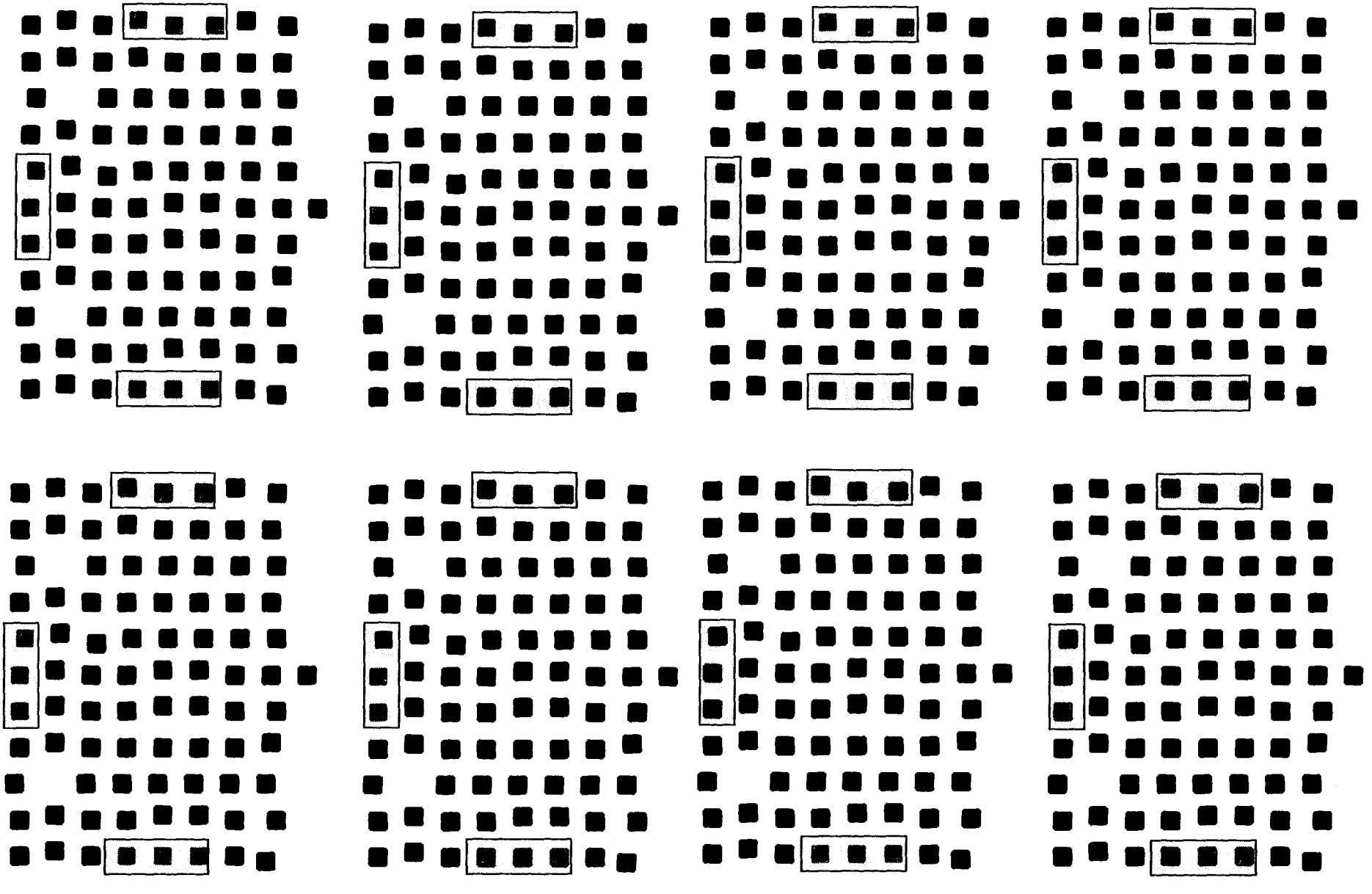
Block Majority Gate



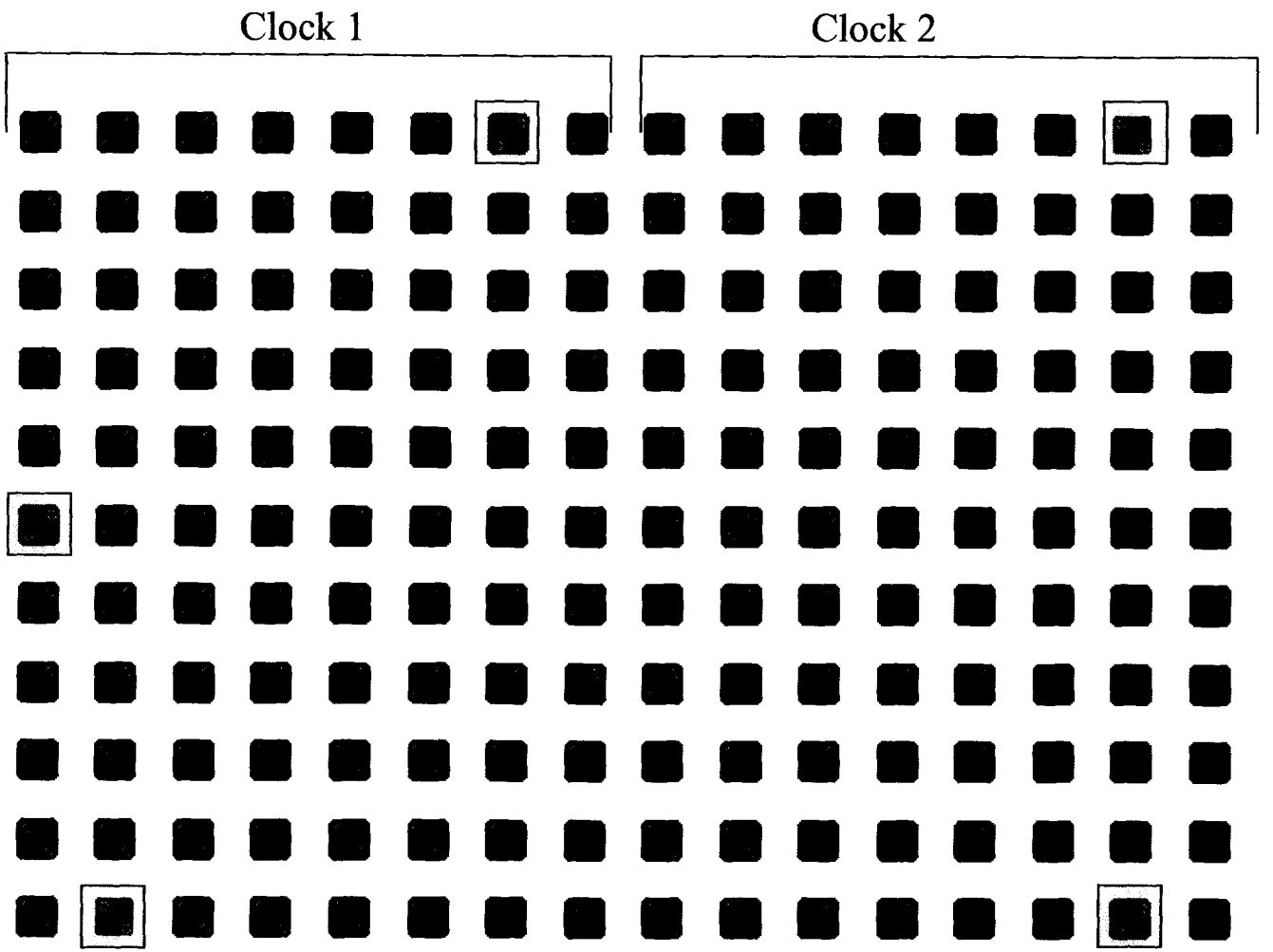
An irregular and defective QCA array which functions as a Majority Gate.

Block Majority Gate

A block fault tolerant Majority Gate with multiple input cells: All combination of inputs

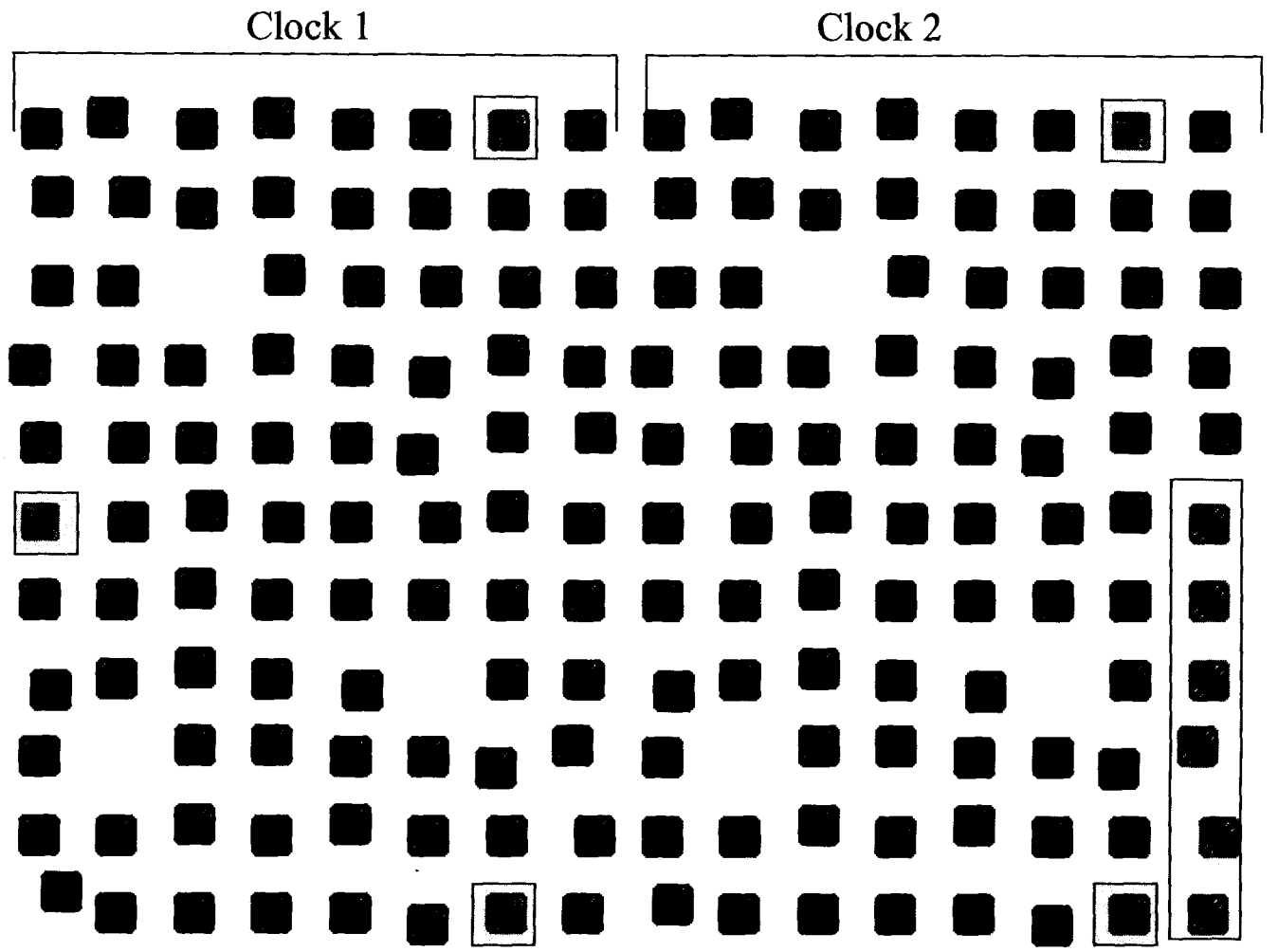


Toward Fault Tolerant Circuits: Cascading Fault Tolerant Block Majority Gate



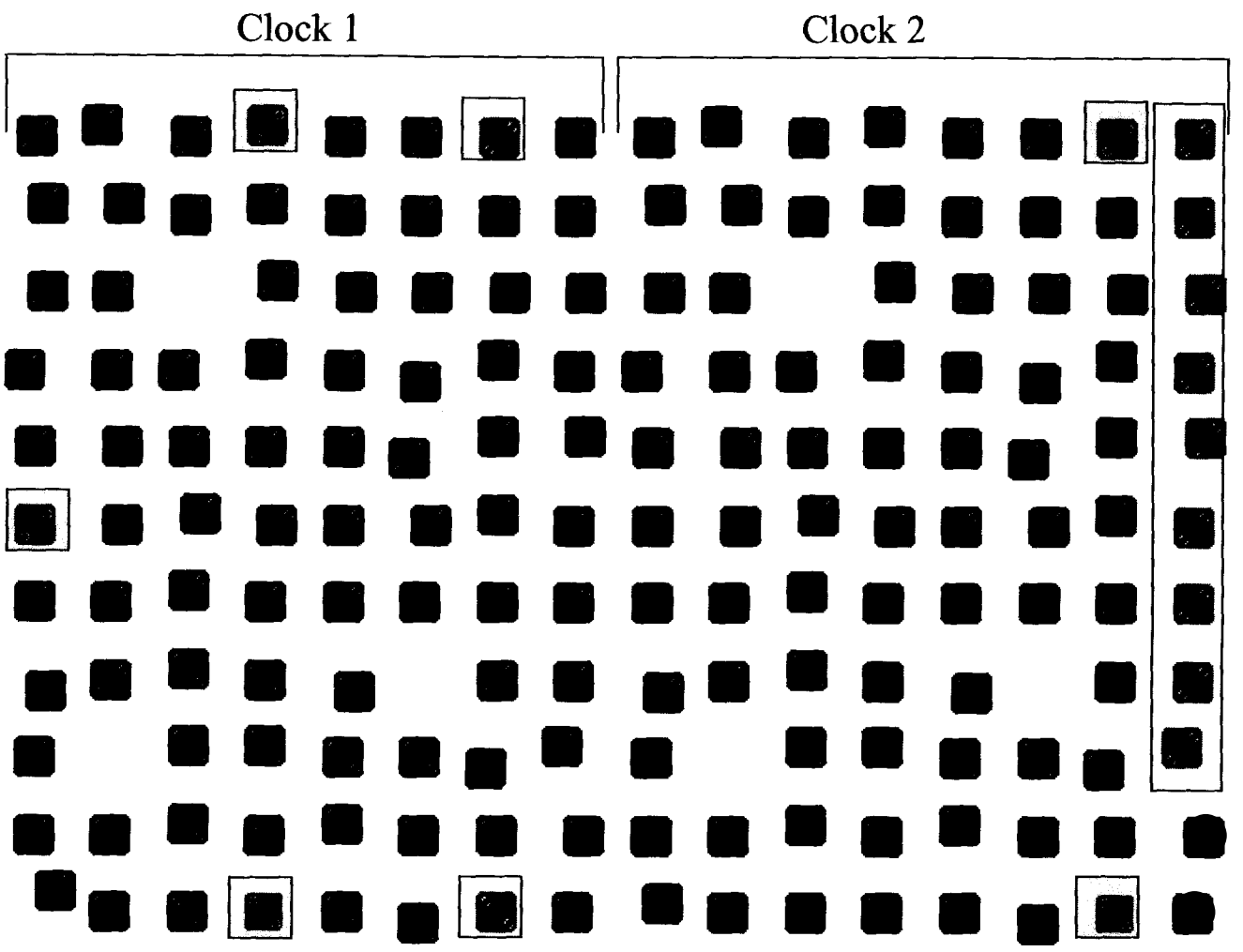
A simple circuit composed of two cascaded regular block Majority Gates.

Toward Fault Tolerant Circuits: Cascading Fault Tolerant Block Majority Gate

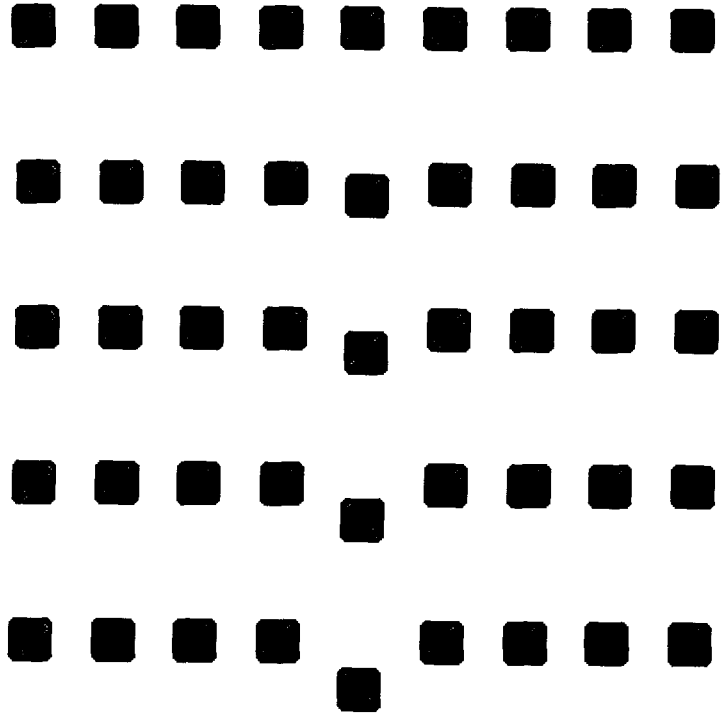


A simple circuit composed of two cascaded irregular and defective block Majority Gates.

Toward Fault Tolerant Circuits: Cascading Fault Tolerant Block Majority Gate



Fault Tolerant QCA Lines



K:\Aquinas\Line Tolerance

Study of Fault Tolerant QCA Lines

Randomly Placed cells

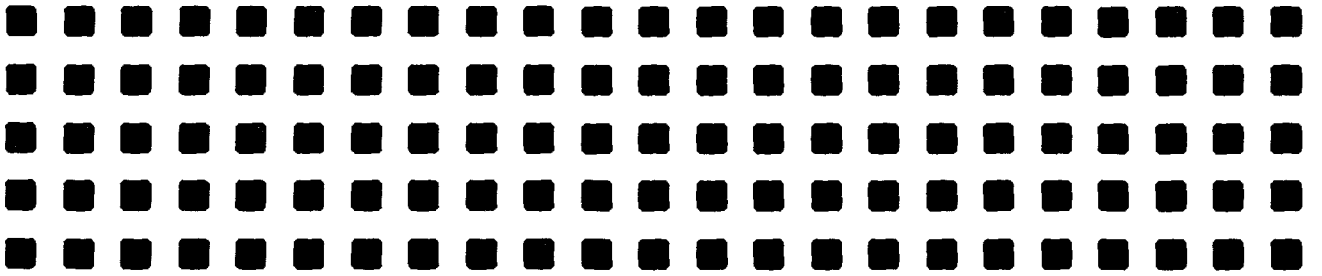
WORKS

DOES NOT WORK

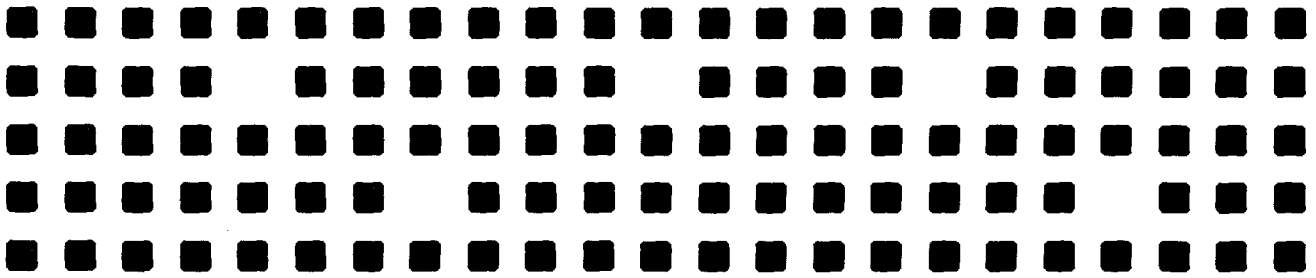
WORKS

Study of Block Fault Tolerant QCA Lines

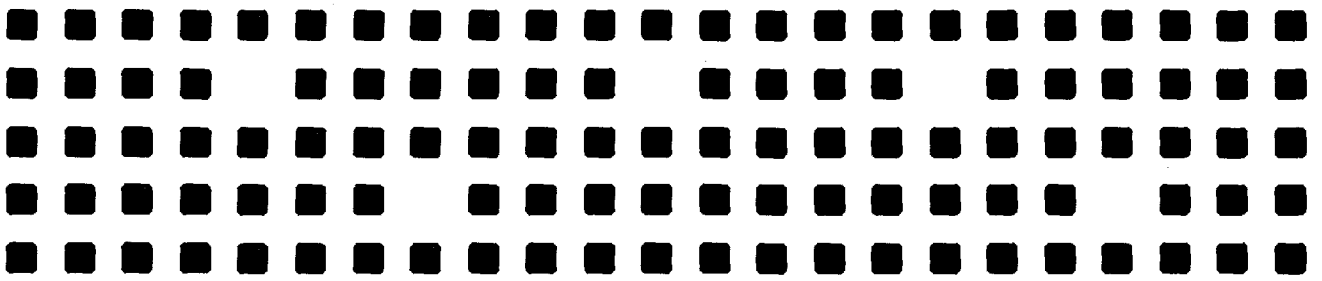
WORKS



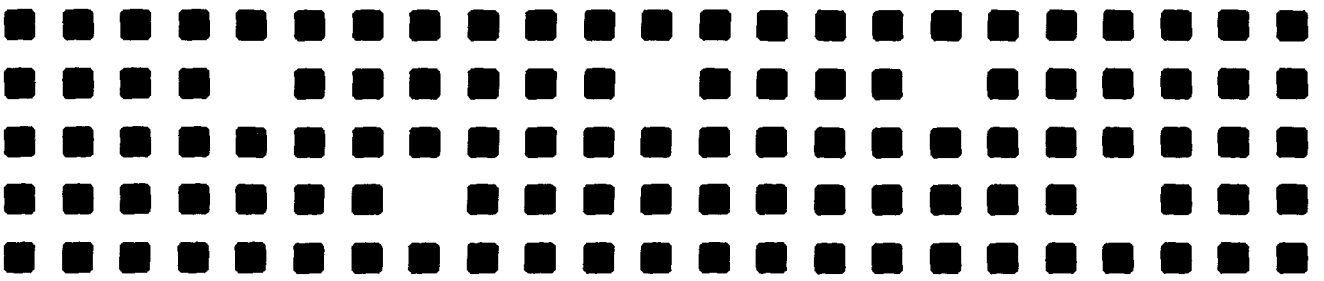
WORKS



WORKS

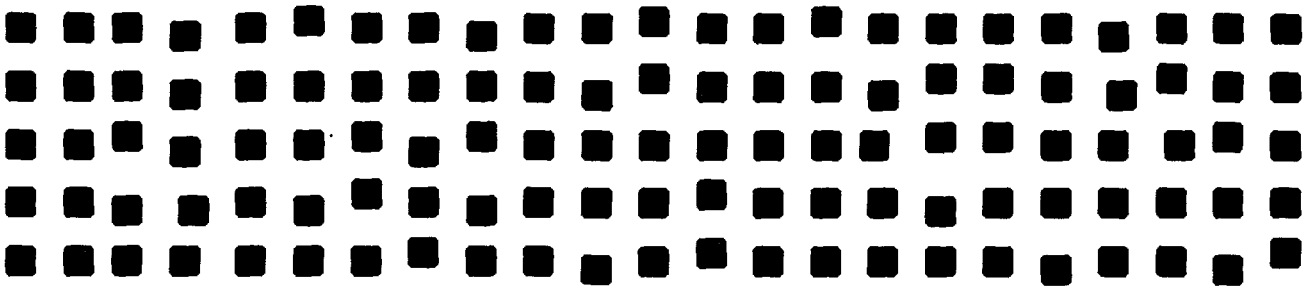


WORKS

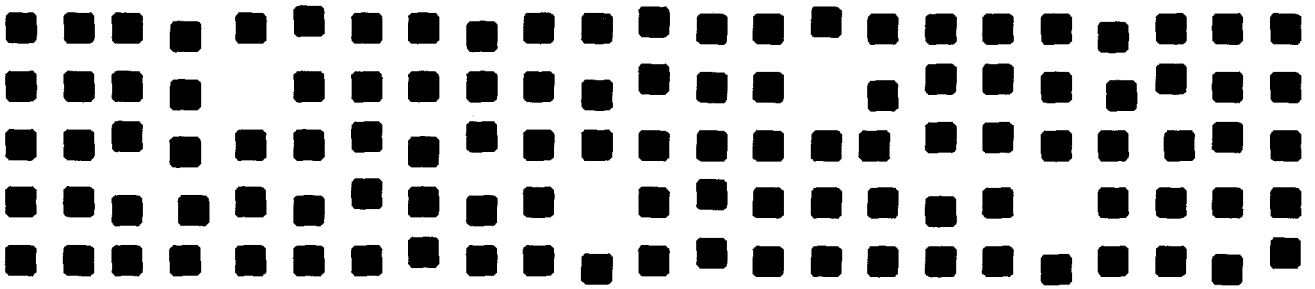


Study of Block Fault Tolerant QCA Lines

WORKS



WORKS



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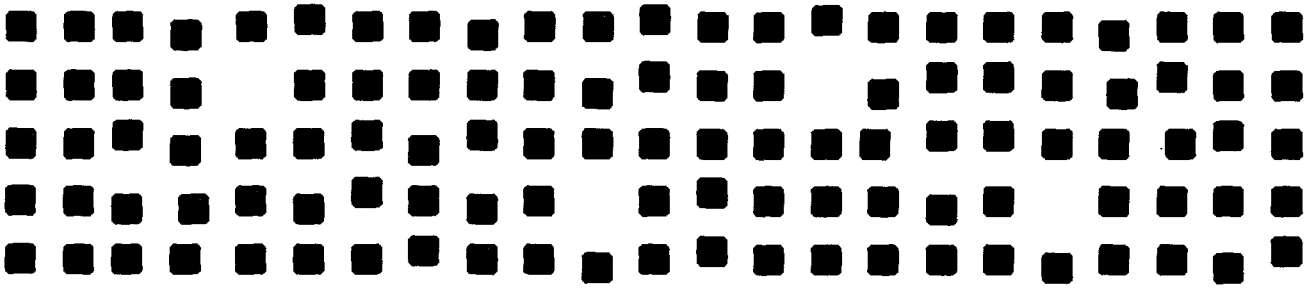

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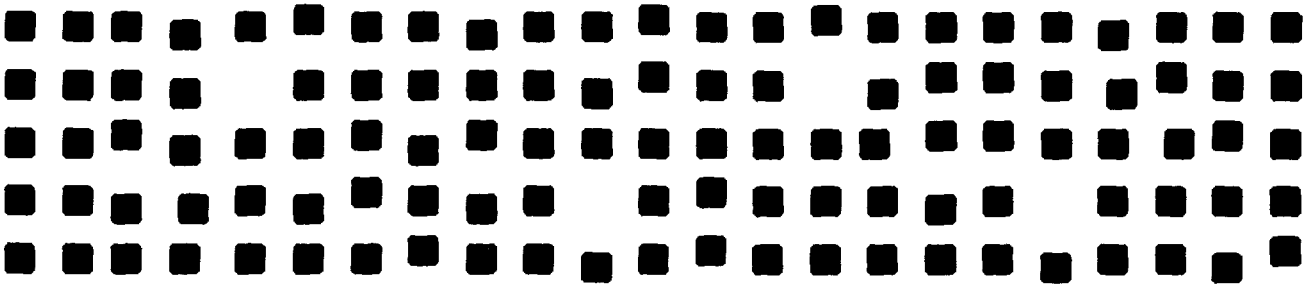
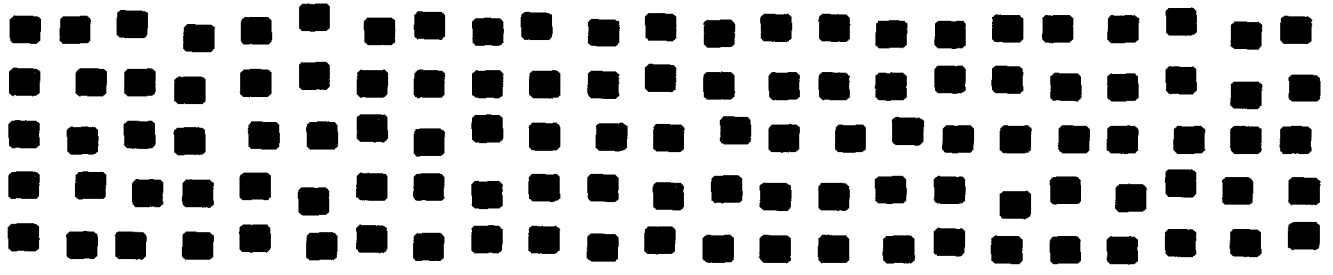


Study of Block Fault Tolerant QCA Lines

WORKS



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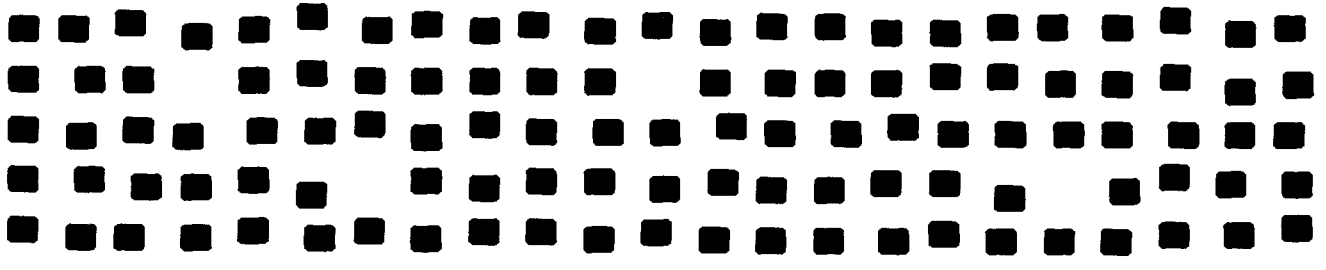

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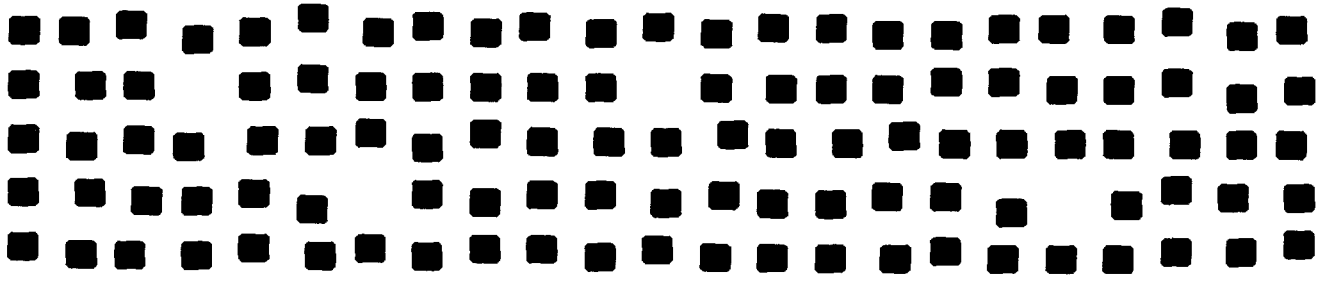

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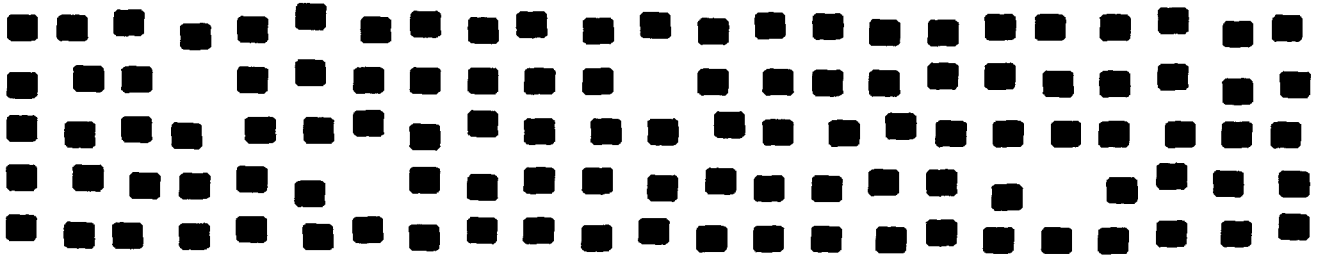
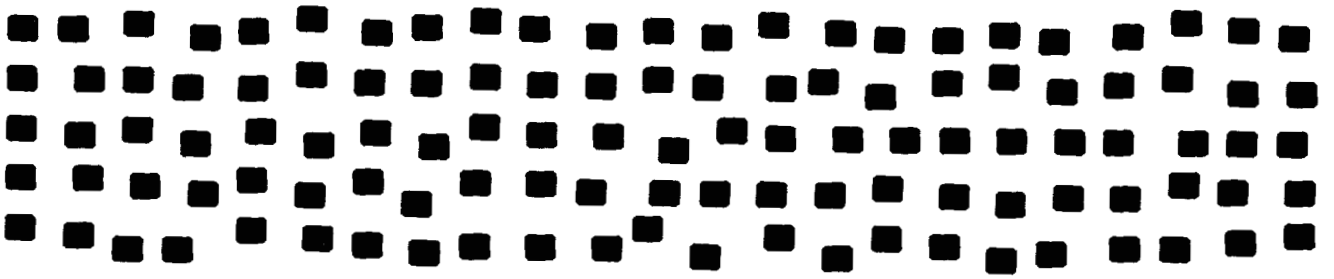
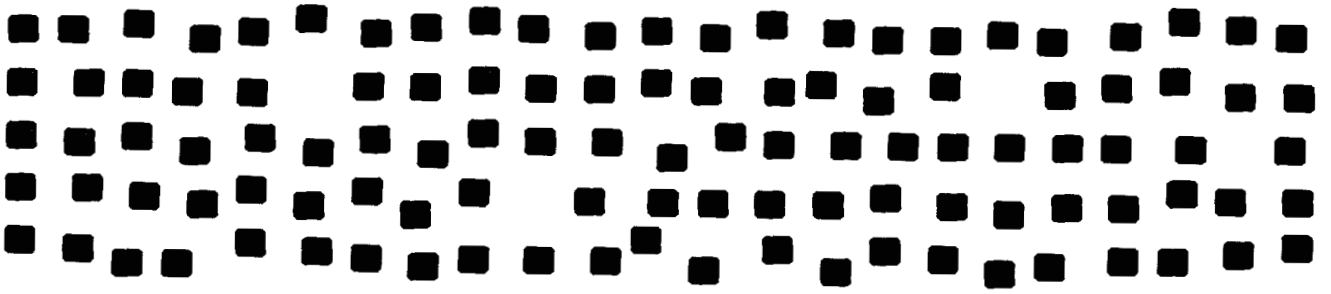


Study of Block Fault Tolerant QCA Lines

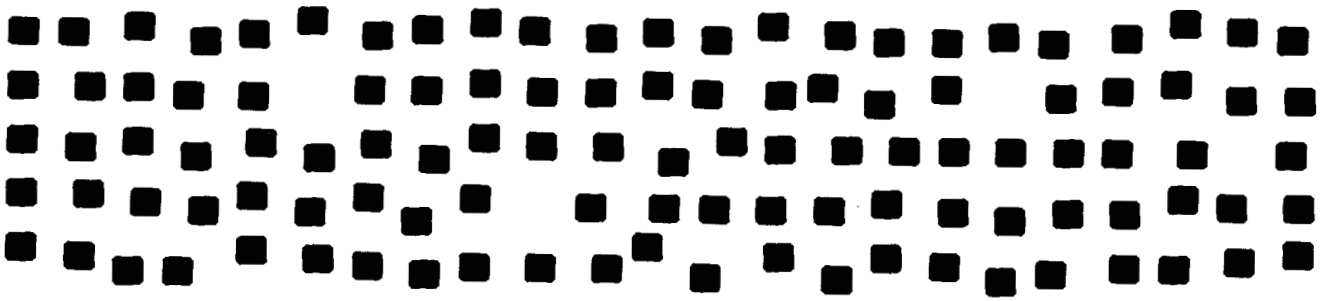
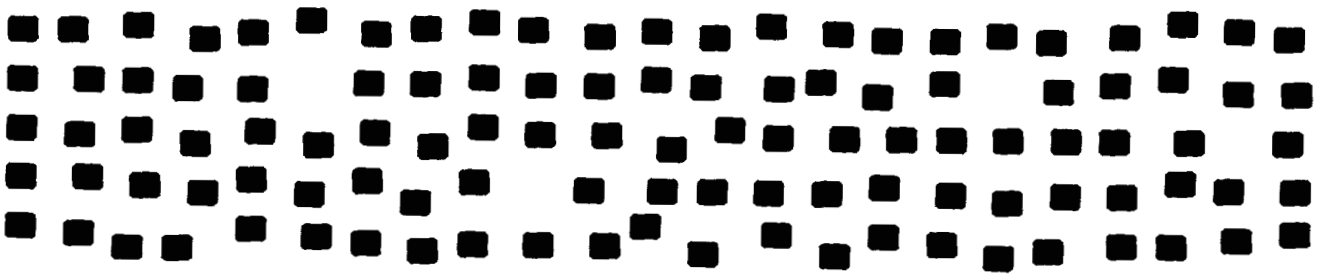
works



does NOT work



does NOT work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