Quantum Dots Cellular Automata: Fault Tolerant Logic Gates and Wires

Amir Fijany and Benny N. Toomarian

Jet Propulsion Laboratory
California Institute of Technology
**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*

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

Red square indicates input cells and blue square indicate output cells.
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
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

WORKS

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WORKS

WORKS

WORKS

WORKS
Study of Block Fault Tolerant QCA Lines

works

does NOT work

does NOT work

does NOT work