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Modeling of Reliability for Programmable Nanowires Interconnect

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Abstract. field-programmable nanowire interconnect (FPNI) is from hybrid cmos/nano circuit family, that generalizes CMOL (cmos molcular hybrid) proposed by Likharev, that reparieren technology for a a field-programmable gate array (FPGA) architecture by lifting the configuration bit and associated components out of the semiconductor plane and replacing them in the interconnect with nonvolatile switches, which decreases both the area and power consumption of the circuit. because this architecture have terrible properties, make chalenges for reliability in this architecture. thus for reduce limitations and defect devices prposd , use from self-organization system replace boolean logic.

the key idea is used recurrent network for complex pattern recognition problems, the trade-offs between power consumption and processing speed.

this paper study on nanowire interconnected in FPNI and represent a model of simulation system, that removed scalability issues of characterization, compilation and configuration.

Keywords: FPNI, CMOL, nanowire interconnect, Recurrent networks, Self-organizing.

1. Introduction

CMOS technology for years due to some advantages such as low power consumption, high noise margins and large scale integration feature was the dominant technology, now is facing a serious challenge. Thumb permanent process of reducing the size of the CMOS technology that increase circuit density and speed are elements were now approaching its end of the road map and does not seem to be appropriate size nm 10 below, while according to ITRS forecasts that in 2020 gate length transistors must be 10nm. Modern microelectronics search for new solutions to overcome challenges is available. Now a major alternative-based nano-electronics to replace micro-electronics has been proposed: single-electron devices or Single-Electrons. Single-electron devices in which the molecules specifically designed and synthesized and used in the construction of the proposed bottom-up approach should be used. But the problem is that these devices alone afford doing things such as supply voltage or supply or interest, Do not come on. Exactly why that is now believed that the only way to achieve high performance nanoelectronics single-electron devices or molecular compound with CMOS circuits in such a manner that is Tripod weak elements in the supply of these devices use voltage addressing and etc. They are compensated is being strengthened. The result of technology, CMOS / Nano was introduced where the Nano episode does computing time and addressing CMOS parts, supplies and signal gain and recovery It is responsible.

But still the problem setting is that setting nanowires towards one another crossbar (nano-wires the way specific and automatically cross-like shape one on each other are.) Resolved, but compared to parts of CMOS technology to develop challenging and this technology toward CMOL (CMOS molecular hybrid) drives. The main advantage CMOL, simplicity, density and shape it is classified separately. CMOL technology is also due to problems including the size of nanowires, about nm4.5 nm 9 and the distance between the nanowires and the projected reach of current lithographic capabilities is According to ITRS 2030 are suffering from serious challenges and the challenges that new technology FPNI it is remembered, will fix. First a brief on this technology are discussed and then considering the fact that Boolean logic systems, many challenges including high failure rate, high variability, high obsolescence rate and etc. To

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create nano-devices, so FPNI architecture from this is the exception and should be self-organizing structure defined for it. Periodic networks can to some extent the challenges raised on their behalf, then explains that it is paid to the simulation.

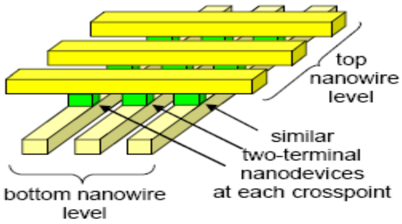

Figure 1. Nanowire crossbar.

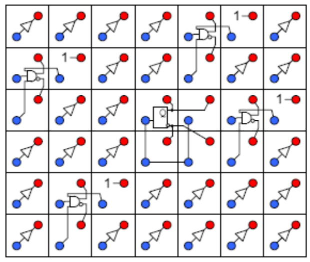

Figure 2. CMOS level in exponential cells FPNI.

2. FPNI

In the form of a nanowire crossbar structure on a CMOS chip is placed, is shown. Seen that the nanowires vertically on each other are located, with a small gap that it is a tool is shapeable Antifuse they are separated [2]. Metal pins on the bottom surface of the CMOS chip and high connections provide nanowires. Overall performance of architectural issues separately FPNI nanowires and CMOS, to connect two layers with the proper pin placement and nanowires and increase the amount of error and variability of the nanowires tells Crossbar.

FPNI nanowires as the address is diagonal (with a little spin to the length), which due to the nano-wires connecting pins are better [3]. CMOS level regular square cells are divided, that a cell input pin for reading a signal from the nanowires and an output pin to stimulate a signal from the gate is connected to the nanowires. Primary input and output on a pair of cells that are acts as an input signal and an output signal is applied. An input signal to the output flow cell arrays as it brings real and reversed on two output pins are applied. The output signals through a nanowire towards the two input pins directed from there to be sent outside the chip.

Overall FPNI chip that includes the same cells Logic gates, buffers and flip-flop is composed, that cells surrounding it I / O is surrounded by a structure similar to logic blocks can be formed CLB (Configurable Logic Block) is used in the FPGA [4].

3. Recurrent networks

Recurrent network dynamic system that can cycle through a graph is presented. An edge graph for transferring data between two nodes is used. Generally edges receive transfer data from the transmitter and receiver to augment the doing. Nonlinear become a node on a graph of data received from the edges is doing and to adjust its internal state reacts to the information and sends its edge (despite being directed edges in both directions of information sends) and the edges if conditions change due to being compatible with the network can send data. In a network-compatible periodic feedback interactions between nodes, edges and intermediate inputs to the outside world emerges. If the components are treated well, the system can be almost as a set of differential equations to model continuous. Because the component as well Ghyrzaty behaves like the system can compute the interest on the interest component is made of random or accidental. Compatible network implementation on a periodic hardware problem and the resulting behavior of edges and nodes are scattered, the need to calculate its dynamic edge in complex systems as a single process or state variables, which took able to implement two important features:

(1) proliferation. Edges should be able to take a lot of input data and produce it with an output of some factors to compare. This factor is called a weight scale and actually has a function for the edge condition.

(2) Compatibility. Edge condition, then its weight must be in a correct way to respond to the behavior of nodes that are connected to it change. An equation that describes the situation will evolve a comprehensive law called the edge. Various laws have been proposed for the edges and most famous. One of their first Hebbian rule in which the description of nodes that fire together wire together, and are to be paid. In other words, when two nodes are connected by an active, at times the same weight attached to its edges to

strengthen the relationship increases. But a law is not perfect, because it increases the weight of the edge if a way to reduce it has not expressed. Perhaps the first rule for the full weight (w) an edge of two nodes ni and nj can connect to the Law "gated steepest descent" (gate cost reduction) that was invented in 1950 by Grossbery was:

$$\frac{dw}{dt} = S_j(-\frac{1}{\tau_s}w + kS_i) \quad (1)$$

In this equation, w, represents the edge weight, S_j is a function of the status of internal nodes, n_j drive by the edges is, Si is an activity for the source node, n_i drive to the edge, K is a learning rate constant τs Time is rapidly weakening. Functions to the left of the equation is defined for the network designer (although the stability limits for these functions may be created.) Right side of this equation use a term Hebbian,

$$kS_jS_i \quad (2)$$

The edge weight in response to communication activity increases, and a weakening term non-Hebbian,

$$(-1/\tau s)\ wSi \quad (3)$$

The weight depending on the operation was reduced. Activity functions in practice may Sj and Si single-bit output to produce and reproduce a logical AND is reduced but nevertheless nonlinear operations would continue at the edge. Faster timeframe for having the nodes, according to a simple model in the input node to collect and convert to plug these together using a complex conversion functions (such as rational function 1 / (1-ex)) low-pass filters are the result. If the y nodes of a domestic situation we can consider the following equation to model:

$$\frac{dy}{dt} = -\frac{1}{\tau_r}y + sigmoid(\sum inputs) \quad (4)$$

A useful structure for the stable periodic networks of connections and on-center off-surround in Figure 3 is displayed, is. Yj nodes in a network are arranged in two dimensions, so each node to its nearest edge of the neighborhood is connected. Center nearest neighbors is called (with a smaller oval in the upper layer is indicated in Figure 3), by the edge nodes receive stimulatory activity increases, will drive.

Neighbors a little more distance is called the surround (the larger ellipse in Figure 3), surrounded by the edge nodes of activity reduces the intake, will drive. Edge weight for each connection with (wjj ') is identified. Also, items related to the source node to sink and the index j with j 's is shown. For the other nodes in the center and surround are not always constant weight is zero. Each node in the set of edges of the layers (Figure 3 is shown with xi.) Or located around the edges. The edge weight wij is marked with the behavior of this network is discussed by the law can be described with the following equation:

$$\begin{aligned} \frac{dy_j}{dt} &= -\frac{1}{\tau_r}y_j + sig\ \mathrm{mod}(\sum_i w_{ij} + \sum_{j'} w_{jj'}y_{j'}) \\ \frac{dw_{ij}}{dt} &= S(y_j)(-\frac{1}{\tau_s}w_{ij} + kS(x_i)) \\ \frac{dw_{ij'}}{dt} &= S(y_{j'})(-\frac{1}{\tau_s}w_{jj'} + kS(y_i)) \end{aligned} \quad (5)$$

These structures can be as in Figure 3 is proposed to be consecutive arrangement. This type of network structure and dynamics of working more widely Grossberg (1976 and 1980) for having stability by Wilson (1999), Carpenter and Grossberg (1991) and Kosko (1990 and 1991) is discussed and described [9] and [10].

4. Simulation

4.1. Application

Network for sensitivity to defects, instrument variability, noise and the like in this article to emulate a classic problem in self-organizing systems Payments: Self-organizing a three-dimensional array of filters sensitive to edges that have different orientations are . For such an array can be the first stage image matching system as a design character recognition system used. To nurture the idea of an image can be very sensitive using gray shadows and edges and by determining the size of orientation angles around the edge of each section to deal with image. This is an application of stimulation by itself, but when the first implementation was done in 1973 Malsberg this fundamental issue was Self-organizing systems (the same writing program "Hello-World" in a new programming language) and so this post a simple solution for testing provides. (1999 Miller, 1998 Olson and Grossberg, 1999 Farks and Miikkulainen) [13].

4.2. Network Structure

Simulated network nodes of one layer, with limits of recursive center-surround is formed by a pair Rayh that converts the input image pixel is interpreted in a row is the spike will drive (Figure 4).

Separate arrays for the resolution shown in Figure 4 have been implemented in a realistically rendered photocell, transducer arrays and arrays will be placement of nodes. 16∗All array sizes are 16 (computational fully dynamic simulation is expensive, so the network can process larger and need more tolerance.) Rayh photocell to provide shade of gray images for converting arrays to be used. Each pixel in the array a value in the range of 1 - (white) to 1 (black) is. Rayh become clear that provide two (on-array) and arrays off (off-array) are called, in low pass filters are used. Each cell of the two weighted average of the plurality An array pixels in the smaller circle in the neighborhood center-surround array of photo cells that are located just below to calculate. Neighborhood center has three radial value and neighborhood radius 6 are surround. Average calculated for each cell on (on) the following:

(6) Average cell off (off) the negative mean value obtained for clear cell (on) is. When the clear cells in a black area around the center are seen by White, Spike is often stronger and off cells around the center by the black and white are much stronger response. Set a square knot, center-surround structure is periodic. Each node entries from the edge 7 7 squares by neighboring cells in the array off and that these cells are∗ located just below, will receive. The two sets of edges to total nodes are called acceptor field. Nodes as well as its neighbors to 4∗3 stimulates square and within the neighborhood of 4 ∗the neighborhood 3 square stimulation is prevented. Since the side of stimulation to prevent inputs result in only half the input side is stimulated, the net result of stimulation of eight near neighbors and neighbors to prevent the ring surrounded by them.

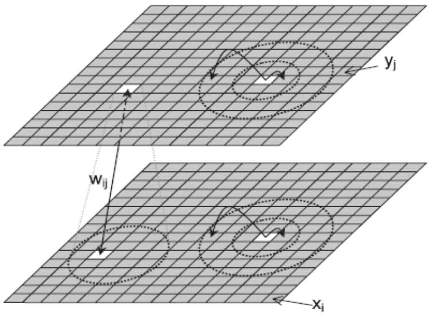

Figure 3. Recurrent two-layer network compatible.

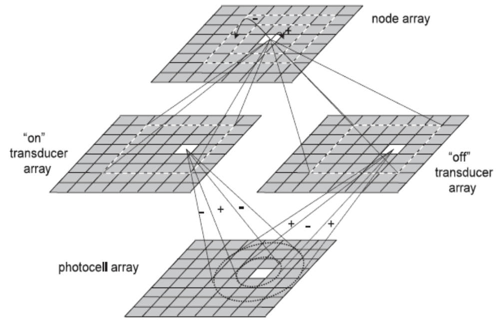

Figure 4. Simulated Network.

4.3. Methods

The edge network is to being overweight and the maximum integral node is zero initialized. 16 random input images with allot pixel values∗16 randomly distributed on a given Gvsyn the complexity and Core Image 18exp (-d2)-18exp (-d2/152) is smoothing (in terms of random fields of approximately Gvsyn Bartsch and Hemmen (2001)), where the distance d measured in units of pixels. 5000000 clocked network for each cycle and a new random image in 9 seconds offers. To evaluate the ability to network to find the edge to plan a series of 24 half-black/half-white has been, for the edge images (θI), with direction θ, unevenly across (π2 and 0) distributed have. Pixels (θIij), in each picture as white (1 -) or black (a) is or if they interrupt each other edge directions, the proper placement is inside them. This talk of an accurate response to the node, but no image is approximately normally used(for example, Olson and Grossberg 1998) [13].

To check the quality of disclosures in the presence of edge defects and tool variability, the ability to choose topics that often measure the performance of the filter position is used, is used. Follows the Swindale (1998) components were calculated:

$$a = \sum_k R(\theta_k)\cos\theta_k$$
$$b = \sum_k R(\theta_k)\sin\theta_k \quad (7)$$

The best direction (φ) for a node can be calculated as follows:

$$\varphi = \arctan(b / a) \text{ if } a > 0,$$
$$\text{or } \varphi = \pi \arctan(b / a) \text{ if } a < 0, \quad (8)$$

And the ability to choose (Si), for node n_i

$$Si = (1 / 24)(a^2 + b^2)^{1/2} \quad (9)$$

Network feature selection using feature selection for the average for all nodes in the network is obtained:

$$S_{network} = \frac{1}{nodes} \sum_i S_i \quad (10)$$

4.4. Simulations discussion

Network defined in the previous section of 256 nodes and 31,488 edges have been formed. Since the implementation of network-based spike according differential equations approximation (5) is, the network can be treated by a simple integral Exposure to 31,477 differential equations, for example the fourth order Runge-Kutta integration stuck as the stairs are consistent and compatible (1992). In practice the equations are fixed because it is hard and fast target system nodes and edges to which at different times and in many cases reacts. Integral conventional systems such as Runge-Kutta fixed on the need to take small steps to obtain acceptable accuracy and precision, that are fully publicly. Lists such as the direct integral method for semi-implicit extrapolation (1992) can be faster than the smaller systems, but when you need multiple inverse Jacobin matrix does not work as well. So a simple way, similar to the method by Gear and Kevrekidis (2002) have described, is used. This idea of integration steps alternating nodes and edges will quickly be. When nodes integrated modes edges is kept constant, spike stored by a new incoming (update) and integrating them to be done. Integration at the edges of the status of the nodes is kept constant and the edge condition by a Euler approximation of Equation (5) are new. This method of implementing a simple and fast simulation, which has followed a small fee.

5. Conclusion

Structure presented in this paper intends to propose an overall picture beyond what the strategy is the main aim of this paper presents a simple scheme to structure Self-organizing strong network that can be cheaply produced in addition to the process by the semiconductor and become integrated with pulse-based communication, the designer for more compromise between speed and power consumption helps.

6. References

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