Exploring The Use of Sub-Threshold Transistors Using Genetic Algorithms

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Genetic Algorithms

• A population of n binary strings is randomly created; these binary strings are also called chromosomes, individuals, or genotypes.

• Each individual is evaluated with respect to a particular specification, which is usually the function to be optimized; a scalar value, called fitness, is then assigned to each genotype.

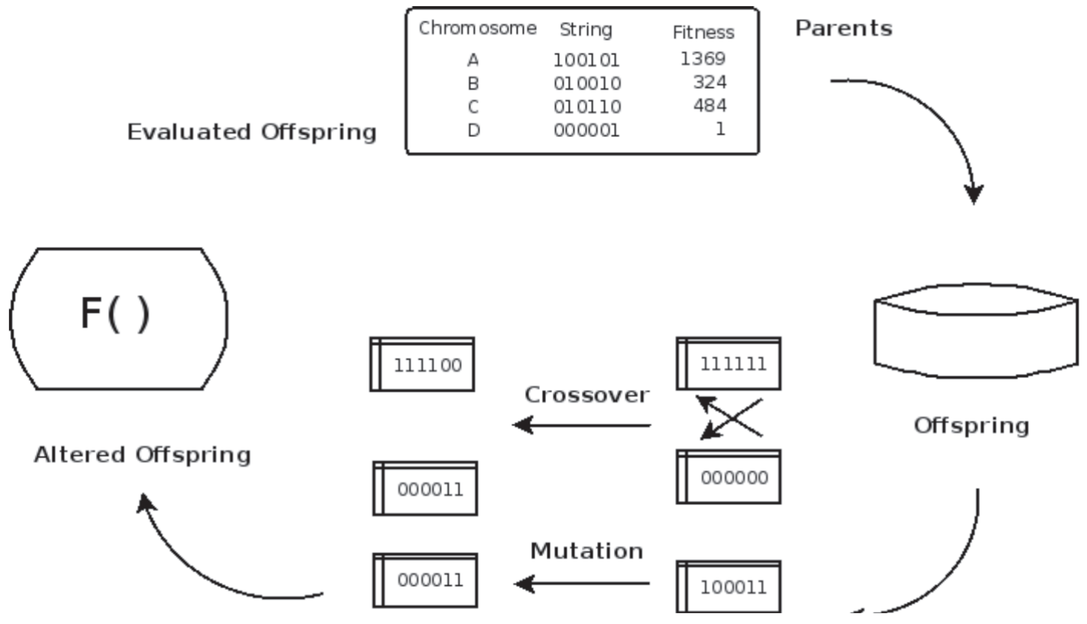
• Based on this scalar value, the population undergoes the process of selection; a set of n individuals is probabilistically chosen, in such way that a higher fitness confers higher chances of selection to an individual. Therefore, even though probabilistic, the selection process is biased towards fitter individuals.

• After selection, pairs of individuals are randomly chosen from the selected pool, and with a particular probability, undergo the recombination process, also called crossover. The crossover operator, similar to the case of evolutionary strategies, splices the contents of each pair of individuals, creating two offspring mixing the genetic contents present in their parents' strings. In case the two parents do not undergo the crossover operation, they are copied unchanged to the new pool.

• The mutation operator is applied to the new pool of individuals procuced after the application of crossover. Mutation is applied typically with a very low rate to all the bit positions that constitute the chromosome. If successful, it flips the value of the particular bit; otherwise, the bit is left unchanged.

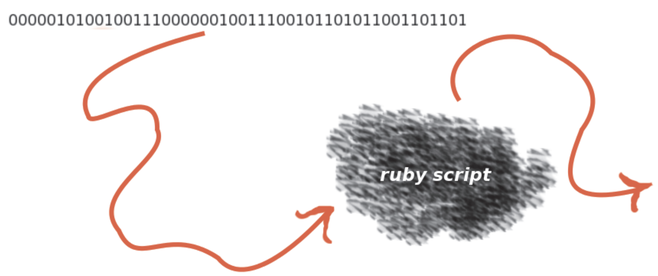
• After mutation, a new generation of individuals is produced. This new generation goes through the process described above, from evaluation to the mutation step.

This cycle repeats until a stop criterion is met, such as a maximum number of generations is reached or a desired solution is found.



Implementation

- A circuit definition file is parsed into a binary string representing the existing net-list.
- The binary string is then run through the genetic algorithm to create the next genome.
- The current binary string is then written to a new circuit definition file to be processed by Ultrasim.




```
.lib "tsmc18dN" NMOS
.lib "tsmc18dP" PMOS
.usim_opt mos_method=s postl=1

* gnd! is always 0
.global 0 vdd! gnd!
* set the supply voltage
VCC vdd! gnd! dc 1.8

M1 (net6 a gnd! gnd!) tsmc18dN w=270.0n l=180.0n
M0 (z b net6 gnd!) tsmc18dN w=270.0n l=180.0n
M3 (z b vdd! vdd!) tsmc18dP w=270.0n l=180.0n
M2 (z a vdd! vdd!) tsmc18dP w=270.0n l=180.0n

* put an output load on the circuit
C0 z gnd! 100f


* define the input stimulii for the above circuit
VINA a gnd! PULSE(0 1.8 0 5n 5n 10n 50n)
```

Transistors

• There are two distinct types of transistors, termed N-type and P-type. These are classified by the type of substrate that the transistor is built on.

• Transistors' minimum required operating voltage is currently 0.5v-0.8v depending on manufacturing and reliability guidelines.

• Input voltages below these values provide unreliable outputs. Transisitors operating below 0.5v have produced analog-like outputs.

• It is unknown what sort of circuits could be developed to take advantage of this analog-like behavior.

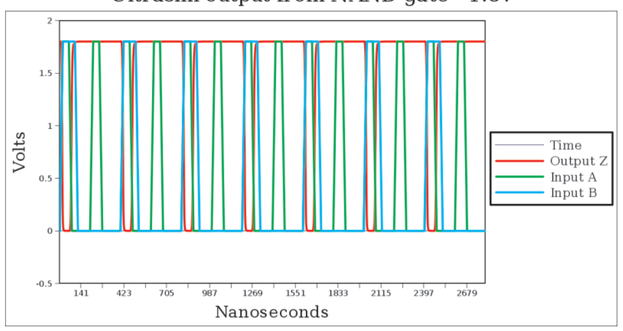
Simulation

• The use of simulation in circuit design is well established.

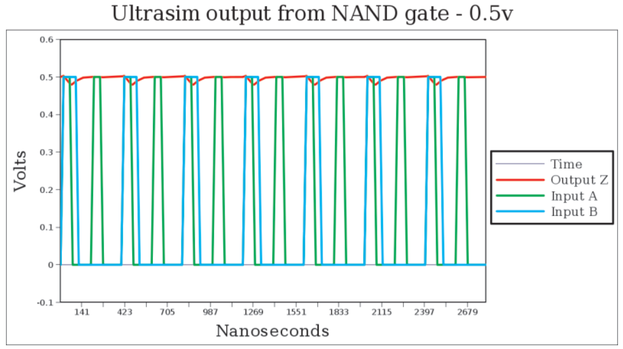
• Using simulation it is possible to test circuits for proper behavior before taking the costly step of manufacture.

• When exploring new techniques, simulation allows multiple variables to assessed in a reasonable manner.

Ultrasim output from NAND gate - 1.8v



Ultrasim output from NAND gate - 0.5v



Acknowledgements

Funding Provided by National Science Foundation

Baskin School of Engineering

Richard Hughey, PhD

Matthew Guthaus, PhD

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