Parallel Prefix Adder in QCA technology

Kim Aragon Escobar
Renato Perez Ribas
Instituto de Informática
Universidade Federal do Rio Grande do Sul

April 27, 2013

Why quantum-dot automata

- Transistor physical limitation;
- High speed circuits;
- Natural pipelined;
- The information is propagated using the eletric field.

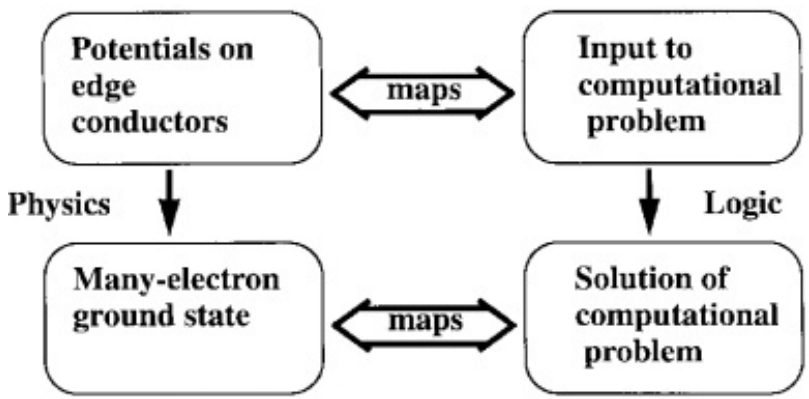


Figure: QCA Cell

Basics

- Each cell has 4 dots and 2 eletrons;
- Based in three devices: Wire, Majority Gate and Inverter.

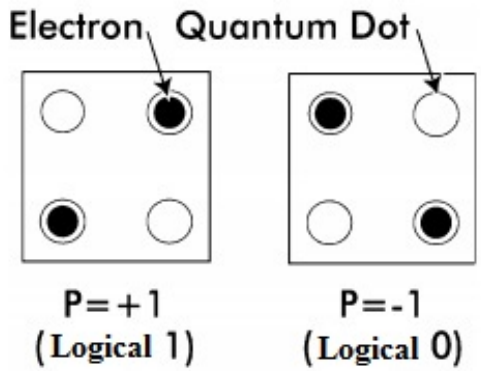
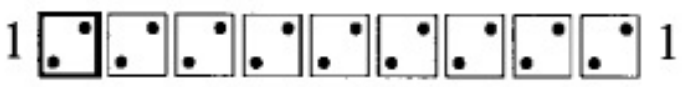
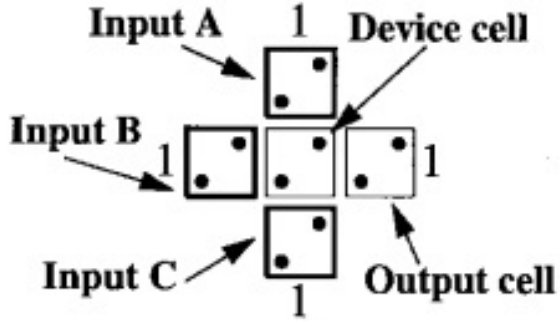


Figure: Technologic mapping

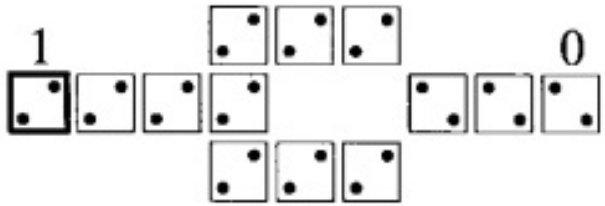
Devices



(a) Wire



(b) Majority Gate



(c) Inverter

Figure: QCA Main Devices

PPA Algorithm

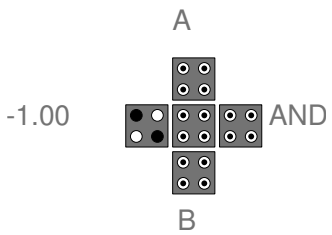
1. Calculate P_i and G_i: $P_i = a_i \oplus b_i$ and $G_i = a_i \cdot b_i$
2. Calculate the group generation and the group propagation using the following expressions: $G_{i+1,i} = G_{i+1} + P_{i+1} \cdot G_i$ and $P_{i+1,i} = P_{i+1} \cdot P_i$
3. Calculate the Couts for each bit: $Cout_{i-1} = G_{i,0} + P_{i,0} \cdot C_{in}$
4. Calculate the sum for each bit $S_i = P_i \oplus Cout_{i-1}$

Majority Equations

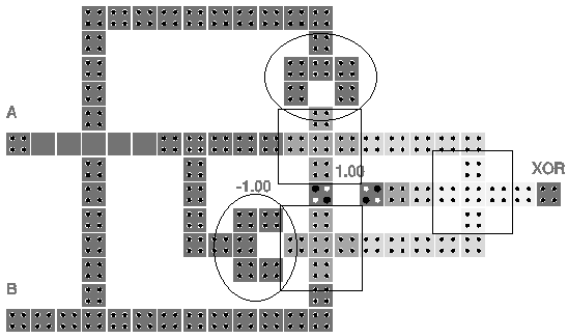
Principal Translations

- $OR = a + b \Rightarrow M(a, b, 1)$
- $(G_1, P_{i+1,i})$ $AND = a \cdot b \Rightarrow M(a, b, 0)$;
- (P_i, S_i) $XOR = a \oplus b = a \cdot (\ b) + (\ a) \cdot b \Rightarrow$ $M(M(a,\ b, 0), M(\ a, b, 0), 1)$;
- $(Cout_{i-1}, G_{i+1,i})$ $F = a + b \cdot c \Rightarrow M(A, M(B, C, 0), 1)$.

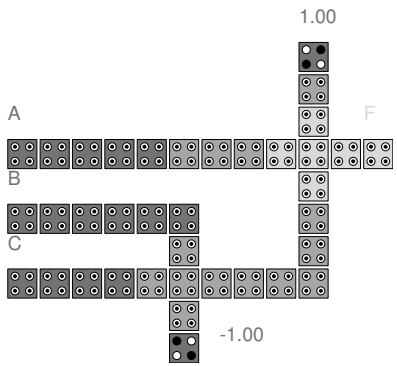
Circuits



(a) AND



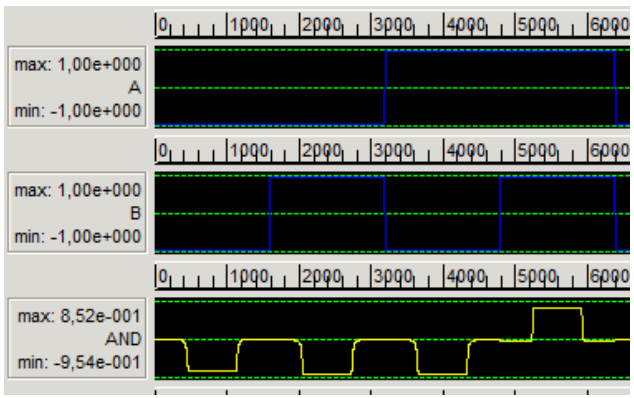
(b) XOR



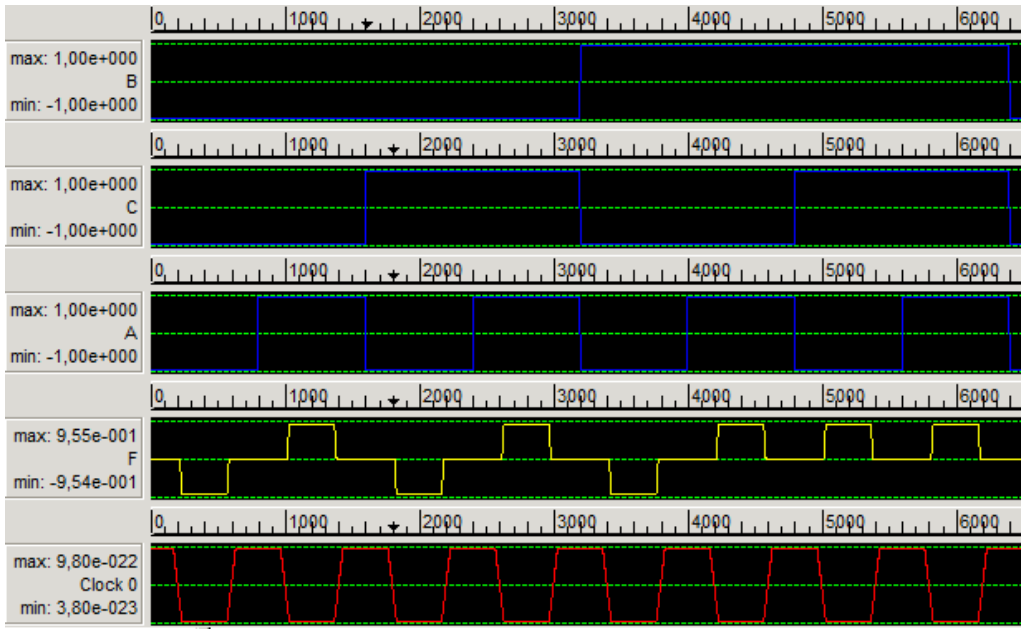
(c) F

Figure: Circuits

Wave Form



(a) AND



(b) XOR

Figure: Wave Forms

Conclusions

- This paper presents ...
  - Majority Equations to each PPA cell;
  - Implementation of each PPA cell using QCA Technology.
- Future works ...
  - Full implementations of PPA with 4 bits;
  - Develop a strategy to assembly and route all cells of a more complex circuit;
  - Comparison with adders in literature.

.

Acknowledgments

Research partially supported by Brazilian funding agencies CNPq and FAPERGS, under grant 11/2053-9 (Pronem).