CSE 40547/60547 – Computing at the Nanoscale– Spring 2011
Homework 05 – Hardware systems for non-traditional architectures
Assigned: April 11, 2011 **– Due:** April 20, 2011, 11:59 p.m. via email

Assignment:

Emerging technologies may allow for the implementation of non-traditional computer architectures that (a) offer performance advantages over a more traditional Von Neumann approach and (b) cannot be efficiently implemented with transistor-based devices. In this assignment, you are asked to consider three such approaches:

1. When discussing nanowire crossbar systems, we spent several lectures discussing how these structures may be well-suited for realizing *neuromorphic* architectures. Neuromorphic architectures were (and remain) a potential mapping for CMOL systems.
2. *CNN*-like architectures may be a good mapping for the spin wave bus devices discussed in Lecture 20.
3. Similarly, spin wave bus systems may enable "multi-bit" gates.

Below, I have specified three documents that you will need to review to complete this assignment. As before, you may not need to read every last word of each paper, but will need to go through them all. (I have also suggested a few other relevant reference papers that may be useful for you to examine when completing this assignment).

For each paper, you are asked to:

- Describe the fundamental architectural idea
- Describe why the authors believe the studied device is well-suited for that architecture
- Summarize the potential advantages of the "device—architecture" mapping
- Describe whether or not YOU believe there is a good/viable "device—architecture" mapping

As a point of reference, the document that you turn in should be ~3 pages long assuming a 12 point, Helvetica font with 1" margins. (Thus, about 1 page per paper.)

Neuromorphic

- *Paper:*
  - Cortical Models Onto CMOL and CMOS—Architectures and Performance/Price
    - Changjian Gao and Dan Hammerstrom
    - IEEE T. on Circuits and Systems I, Vol. 54, No. 11, November 2007
    - http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4383243
- *Useful references:*
  - Neuromorphic architectures for nanoelectronic circuits
    - Ozgur Turel, Jung Hoon Lee, Xiaolong Ma and Konstantin K. Likharev
    - Int. J. Circ. Theor. Appl. 2004; 32:277–302 (DOI: 10.1002/cta.282)
    - http://pavel.physics.sunysb.edu/~likharev/nano/IJCTA04.pdf

Spin Wave CNN

- *Paper:*
  - Magnetic Cellular Nonlinear Network with Spin Wave Bus for Image Processing
    - Alexander Khitun, Mingqiang Bao, and Kang L. Wang
    - Superlattices and Microstructures Volume 47, Issue 3, March 2010, Pages 464-483
    - http://dx.doi.org/10.1016/j.spmi.2009.11.004
- *Useful references:*
  - A Nano-Scale Reconfigurable Mesh with Spin Waves
    - Mary M. Eshaghian-Wilner, Alex Khitun, Shiva Navab, and Kang Wang
    - Computing Frontiers 2006
    - *http://*portal.acm.org/citation.cfm?id=1128033
  - Nano scale computational architectures with Spin Wave Bus
    - Alexander Khitun, Kang L. Wang
    - Superlattices and Microstructures 38 (2005) 184–200
    - http://linkinghub.elsevier.com/retrieve/pii/S0749603605000716

    - Spin Wave Magnetic NanoFabric: A New Approach to Spin-Based Logic Circuitry
        - Alexander Khitun, Mingqiang Bao, and Kang L. Wang
        - IEEE T. on Magnetics, Vol. 44, No. 9, September, 2008
        - http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4604771

Spin Wave Multi-bit

- *Paper:*
    - Towards Logic Functions as the Device
    - Prasad Shabadi, Alexander Khitun, Pritish Narayanan, Mingqiang Bao, Israel Koren, Kang L. Wang and C. Andras Moritz
        - IEEE International Symposium on Nanoscale Architectures
        - http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5510934
- *Useful references:*
    - Nano scale computational architectures with Spin Wave Bus
        - Alexander Khitun, Kang L. Wang
        - Superlattices and Microstructures 38 (2005) 184–200
        - http://linkinghub.elsevier.com/retrieve/pii/S0749603605000716
    - Spin Wave Magnetic NanoFabric: A New Approach to Spin-Based Logic Circuitry
        - Alexander Khitun, Mingqiang Bao, and Kang L. Wang
        - IEEE T. on Magnetics, Vol. 44, No. 9, September, 2008
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