Kavli Institute at Cornell – National Nanotechnology Infrastructure Network

Symposium on Computing Challenges

October 12-14, 2008, Cornell University, Ithaca, NY

If one could make devices at 10 nm length scale, one would be able to fit nearly *a trillion* devices in a 2.5 x 2.5 cm^2 area. The devices will likely exhibit large time-dependent variability in operating characteristics and even intermittent failures. With limits to heat extraction, less than a thousandth of the available devices could have simultaneous switching activity if they were transistor-like. The traditional approach of incrementally improving each design generation fails as an approach under these constraints. What would be the properties and design principles for an optimized trillion device system?

The computation model under these constraints must exploit the available computational resources efficiently. This requires a synergistic design approach that involves devices, architecture, software, and algorithms. Some of the relevant questions that one may ask and areas for discussion include:

a. What does mathematics have to say about representations and computation time?
b. Is the answer necessarily in parallelization? Are there natural approaches to parallelization of problems?
c. Will such an approach lead to a homogeneous or heterogeneous model?
d. What are the issues in complexity at the intersection of mathematics and physics and biology?
e. How does one decompose large problems for mapping into hardware and software?
f. Will there be domain-specific languages? What are the algorithmic implications?
g. How does software remain aware and handle dynamic changes in hardware?
h. How does compilation handle hardware that changes due to variability and defects? How do you design for a probabilistic hardware environment?
i. Is there a need to revisit non-Turing models for computing?
j. What is the role of analog as another path to abstraction?
k. What is the tradeoff between fixed function and programmability?
l. Are the answers specific to the computation problem being solved?
m. Are there alternative models like Quantum computing?

The workshop brings together people with hardware, software, neurosciences, physics, and mathematics perspectives to educate each other and to have a collective discussion that may lead to identification of the key problems and the possible approaches to solutions.

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