Hybrid Architectures for Evolutionary Computing Methods:

Automated Transfer of Evolutionary Computation Successes to the Evolvable Hardware Domain

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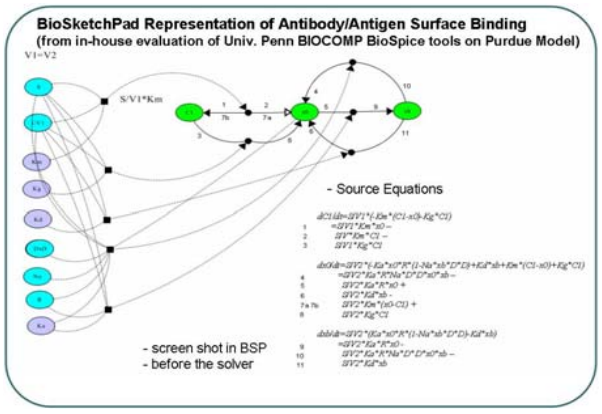
Hybrid Architectures for EC Methods – Key Ideas:

Compare the performance of Evolutionary Computing methods (e.g. Genetic Algorithms) and classical algorithms for solving hard optimization problems, as a function of porting to hybrid software/hardware platforms to gain extreme speed-ups.

Hybrid Architectures for EC Methods – Bio-model Fitter Application:

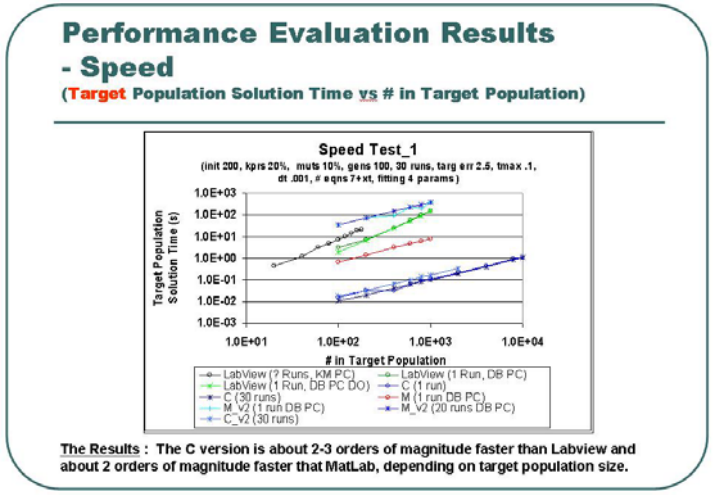
- Parameterized nonlinear differential equation model of species concentrations in an antigen/antibody binding reaction
- Relevant to our DARPA bio-programs; goal is improved tools for discovering and tuning bio-process models, optimizing systems that use them, and transitioning tools to BioSpice user community



Accomplishments to Date

Development Spiral 1 – "PC Software":

- Developed real-valued software implementations using three environments (Labview, C, Matlab using GAOT) and two versions of the bio-model
- Effectiveness and efficiency of various implementations compared experimentally
- As expected, implementation environment has a major impact on efficiency



Current Research

Development Spiral 2 – "Cluster":

MPI-based island model port of C implementation on heterogeneous HPC

Development Spiral 3 – "FPGAs":

Step 1 – HW fitness evaluation
Step 3 – HW EA

- High-level description following the random-function framework of Merkle and Lamont (7th ICGA)
- Representation, operators, and fitness instantiated to match implementations from "PC software" spiral
- Other instantiations exploiting additional domain specific knowledge and memetic techniques

Development Spiral 4 – "Hybrid cluster":

Heterogeneous HPC implementation updated as each FPGA step is completed

Future Directions

Near-term: (application domains)

planning – scheduling – ATR - network & distributed database design and operation – course of action composition - hyperspectral imaging analysis - antenna design – information superiority – topics in computing and sensing with biology

Long-term: (theoretical developments)

- Multi-objective optimization
- Automated transfer of EC successes from software implementations to evolvable hardware implementations

Advanced Computing Architectures Branch:

- High Performance Computer Distributed Center with heterogeneous FPGA per node HPC
- DOD Leader For In-House Expertise in HPC Parallel Applications and Concepts
- Agent for programs with direct applications (DARPA / SimBioSys)

IF Team Members: D. Burns, C. Thiem, T. Renz, Z. Pryk, L. Merkle, K. Day

Collaborators:

Multiple branches within AFRL/IF, GA Interest Group, AFIT, GECCO Workshop, Wright State, DARPA BioComp & SimBioSys PI's, NCSU, Rose-Hulman, Purdue, VT

Military and Security Applications of Evolutionary Computation Workshop (MSAEC-2004)