CCMT

Scalable Network Simulations

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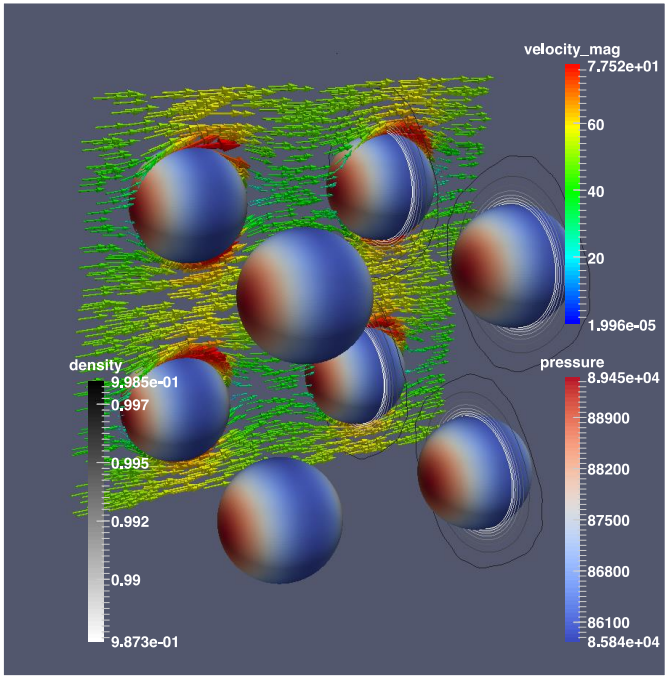
CCMT Center Goals

- To radically advance the field of CMT*
- To advance predictive simulation science on current and near-future computing platforms with uncertainty budget as backbone
- To advance a co-design strategy that combines exascale emulation, exascale algorithms, exascale CS
- To educate students and postdocs in exascale simulation science

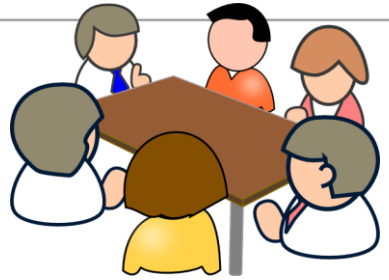
CMT-Nek simulations



* Compressible Multiphase Turbulence

Slide courtesy T.L. Jackson, Technical Manager, CCMT

Early conversations in our meetings



- Developing scalable software
  - What programming model do we use?
  - What is the measurable benefit of switching from MPI-only application to MPI+X?
  - Will we have to develop and optimize key kernels for each platform?
  - What affect will the future memory technologies have on our application? How can we better decompose the app to maximize the benefit from next-gen memories?

- Optimizing app for high performance and low energy consumption
  - We don't have the devices for experimentation, we don't have the time to do cycle-accurate simulations, do we have analytical performance and energy models?

What we need is a tool that allows fast, scalable, reasonably accurate multi-objective simulation of architectures that are not available yet!

… and preferably we do not need to write a lot of code before doing this exploration.

Co-Design Using Behavioral Emulation

Application Design-space Exploration

Architecture Design-space Exploration

Notional systems exploration

Code & Algorithmic Design-Space Exploration

CMT-bone

Future-gen Systems & Notional Architectures

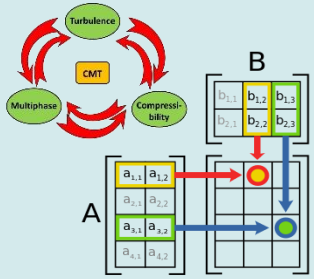
Systems & Architectures

system *(macro-scale)*

node *(meso-scale)*

device *(micro-scale)*

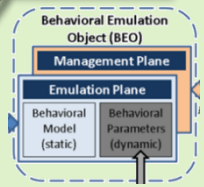
Key CMT-bone kernels & comm patterns



Application BEOs* *AppBEOs*

```
init (device);
mem_init (A);
mem_init (B);
broadcast (A,comm_grp);
scatter (B,B*,comm_grp);
compute
(dot_product,A,B*);
```

Architecture BEOs* *ArchBEOs*



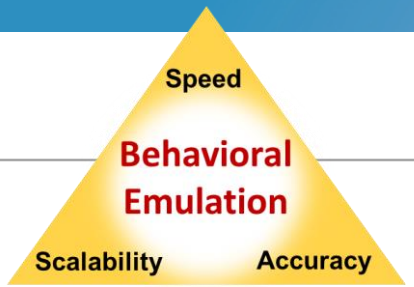
Simulation Emulation Platform

Behavioral simulation (SW) or emulation (HW) experimentation

Testbed benchmarking & experimentation

* BEO – Behavioral Emulation Object

Behavioral Emulation



- Multi-scale, coarse-grained, component-based simulation methodology
  - We have a functional PDES which allows exploration *using plug-and play models*
  - A key concern is to allow *model calibration from any source* – testbeds, detailed simulations, analytical models etc.
  - One advantage of working in a multi-disciplinary center is the focus on verification and validation of simulations – *device-level simulation results on my poster*

- Developing a highly-scalable simulator is a big-task, probably not the best thing to spend our time doing
  - Can we leverage existing simulators but use our approach to modeling?
  - Reduce development and support effort, and possibly leverage existing models developed by other users of the tool

Scalable Network Simulation using SST *

We are looking at SST* for supporting scalable network simulation

1. Develop abstract end-point models **'motifs'** for the various communication routines used in CMT-Nek
   - Identified routines: Nearest-neighbor communication using pairwise exchange, all-to-all using crystal routing, allreduce, bcast etc.

2. Of course we need to validate the simulation results:
   - Full application is too complex and cumbersome to do targeted study, so we developed a mini-app **'CMTBone'** for in-house use

3. Understand the sensitivity of simulations to the various model parameters
   - Our hope is to reduce the number of component models, parameters, and events being simulated
   - It has to be good enough to provide a first-order approximation of performance which can enable application developers to do some early design space exploration

* Structural Simulation Toolkit