DOE-COE Breakouts

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May 23, 2016
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This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.
Managing the Memory Hierarchy
Breakout Session 1

Douglas Doerfler (LBL), et al,
DOE Center of Excellence Performance Portability
Meeting
April 18-21, 2016
Breakout Charge Questions

• What are the practical limitations of using current programming models for managing the memory hierarchy
  – Do you plan to integrate multi-level memory support into your code?
  – What are your memory capacity requirements in the 2020 timeframe?
  – Can you live with 16, 32, 64 GB per node? Per NUMA domain?
  – How much effort are you willing to do to support multi-level memory?

• Languages, directives, attributes, other?
  – Are you willing to use a “non-standard” memory management programing model?
  – Do you need memory management interoperability of C, C++ and Fortran in a common code?
  – Would you like to see a type attribute for variables to declare fast memory storage?

• What is the proper balance between user control and runtime control for memory placement and management?
  – Did Ian’s presentation cover all of the possibilities here?
Setting the Stage

- Assumptions, boundary conditions for the discussion
  - On package memory (MCDRAM, HBM)
  - Off package, bulk capacity, memory (DDR)
  - Byte addressable non-volatile memory (future NV technologies)
- Quick survey: Are you actively integrating multi-level memory (MLM) into your code?
  - About $\frac{1}{4}$ of application developers said yes
  - About $\frac{1}{4}$ said will be in the near future
  - About $\frac{1}{2}$ were not developers
- Are we really sure we need MLM concepts in next-generation machines?
  - No clear indication we can avoid MLM in future machines
  - Skeptical that on-package memory only can satisfy adequate Byte/FLOP balance ratios
Practical Limitations of using Current Programming Models

• What’s wrong with memkind?
  – Assumes that were data resides is static, but real codes go through multiple phases so you want to dynamically change data attributes
  – Memkind solution is completely developer managed
  – Not sure why one would want a library-based solution
  – But still want a way for developers to manage this at a low level

• What developers really want is to be able to describe the attributes of data and have introspection of the node to help manage data placement
  – Some combination of the compiler and a “runtime” to manage the data

• Also need a higher level, higher productivity solution
  – CHAI style?
  – UVM?
  – OpenMP?
• There is a desire and a need for variable type attribute extensions to specify “memory characteristics”
  – Attributes (vs declarations) allow type characteristics to propagate through the system
  – Some disagreement that a declarative statement is sufficient, but there was some argument that the extra semantics would help in using a data structure with this information
• This is a language issue and is just as applicable to Fortran as C/C++
  – However, changes in type system in languages will take time to get through the language committee
• Some discussion that the attribute should not be “fast”, but instead “doesn’t need to fast”.
  – May also want to capture other attributes such as latency
• Action: Cray has agreed to explore the attribute feature
  – Group can send suggestions to Luis De Rose (ldr@cray.com)
Would appreciate not just a programming model but also a tool to tell us what data structures would benefit most from fast memory

- This is my hotspot for memory accesses
- Is this a latency bound access, or BW bound
- This still may have the limitation that the results will change with input deck and phase changes in the code

Action: Recommendation the the CoE have tutorials for tools available today

- Cray does have some capability in this area based on L2 misses, release sometime this year
- Nvidia’s nvprof can already see memory migrations (UVM)
Languages, directives, attributes, other?

• How do get C/C++ and Fortran to use the same mechanisms for data attributes
• Much of the previous discussion covered this topic area
• This propagates down to the libraries too
• We need cross standard standards!
Proper balance between User control and Runtime control for memory management

• Statement: “Doing memory management by hand is hard, we did that on RoadRunner for the SPEs ...”
• Statement: “Would like to see a hierarchy of approaches from use it as a cache right through to low-level programmer driven
• Again, much of this topic was discussed in prior topics
• Continued to make the case runtime control
• Impacts MPI, O/s, libraries, I/O buffers, etc
• Analogy with binding processes and threads to cores is similar
  – Except we really don’t want to bind due to dynamic nature of an application
• A brief discussion regarding the ability of the O/S to be part of the memory management
  – Certainly could, but should it be? -> NO