# *Software Working Group*

Chairman's Note: This document was prepared by the "software and applications" working group and was received by the entire workshop in plenary session without modification.

# *Findings*

- What we've learned over the last 15 years
  - Successes
  - Challenges that have emerged in the last 15 years
- Current concerns and needs for the next 5-10 years
- Impact of new hardware technologies

# *Five improvements in the last 15 years?*

- Experience with systems and some applications at large-scale
- Independent software vendors now support distributed memory programming paradigms, narrowing programming models
- Commercial interest in exploiting multicore architectures
- Opportunity to use our community experience with extreme concurrency on mesh-based applications (more generally, apps with geometric-based decompositions)
- Adoption of software components in some legacy applications has provided a route for the evolution of codes in terms of algorithms, software, and even languages

# *Five priority challenges – emphasizing what has changed in the last 15 years?*

- Fault tolerance for hardware unreliability
- Growth and change of the memory wall problem (latency and bandwidth)
- Greater demand for application concurrency (to exist and to be exposed)
- Fragility of the software stack
- Relationship between commodity and HPC hardware and software

# *Five present concerns*

- Independent software vendors are not thinking at the necessary scales
- Few participants from academia have access to the state of the art HPC systems
- Exhaustion of precision at new application scales
- (Validation and) Verification problem is becoming unavoidable and intractable
- Legacy and new code present some different issues (and may need different solutions)

# *Impact of New Hardware Technologies*

- Modifications/extensions to current approaches (languages, libraries, etc.) probably sufficient
  - Software doesn't care whether digital logic uses CMOS or nanotubes
  - Completely different approaches should also be considered and supported as high risk, high payoff

# *Recommendations*

- Reflect three major hardware directions:
  - Commodity architectures following Moore's Law to at least 2020
  - Specialty/Custom Architectures
  - Discontinuities (e.g., Quantum computer)
- 17% per year improvement (by some metric, on some classes of apps), sustained, would have great impact
  - Exponential improvement is one way to create a qualitative difference from evolutionary, quantitative improvements
  - A software roadmap could help
    - Realistic targets should be drawn from application needs
    - Metrics must be chosen carefully to ensure solutions address classes of applications, not model problems or individual apps

# *Software for Commodity*

- Software needs to address issues of
  - Memory Wall
  - Concurrency
  - Interoperation with other tools
  - Performance comprehension
  - Faults and errors

# *Software for Specialty Architectures*

- In addition to commodity issues,
  - Algorithms and performance comprehension for unique features in specialty architectures (e.g., techniques for streams, vectors, threads, parcels, …)
  - System software to lower the overall cost
- Concerns about hardware
  - Scalar performance (and other Amdahl law effects)
  - More software/hardware co-design
- Adoption path for legacy software and legacy software developers
  - What are the minimal extensions to MPI, C, and Fortran to exploit unique features?
    - Analogue is vector or multithread extensions to Fortran, not a new language

# *Discontinuities*

- Software that supports coprocessors
  - E.g., quantum co-processor attached to conventional system
  - Also applies to hybrid systems (Commodity + FPGA, PIM, …)
- Custom languages (such as ones for quantum computers)

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