PERCS: IBM Effort in HPCS

Mootaz Elnozahy
IBM Austin Research Lab
Overview

- Team
- Design constraints
- Vision
- Technical overview
- Conclusion
The Team

• IBM
  – Austin Research
  – Watson Research
  – Server Group
  – Software Group
  – Microelectronics

• Partners
  – UIUC
  – UT
  – MIT
  – Pittsburgh
  – LANL
  – RPI
  – New Mexico
  – Cornell
  – UC Berkeley
  – Purdue
  – Wisconsin
  – U of Del
  – Vanderbilt
  – Dartmouth
Design Constraints

- Legacy investments
- Looming technology crisis
- HPC customer diversity
- Business model
  - Must do well both on commercial and scientific workloads
- Cost issues
  - Threat of commoditization
- Productivity as a main theme
IBM’s Vision

A dynamic system that adapts to application needs

The strategy

• Aggressive productivity targets
• Commercial viability
• Link into product cycle toward end of phase 2
Innovation with Commercial Viability

- **Adaptability is key**
  - Architecture gets closer to application needs, yielding better performance and broader application range

- **Backward compatibility with PowerPC**
  - Leverages existing infrastructure, training and investment
  - Exploits proven ability of the current architecture to perform well for many apps

- Leverage open source

- Modular design packaged in different configurations
Suggested PERCS Roadmap

Cell

BG/L

Power4  Power5  Power6  PowerX

PERCS

Phase 1  Phase 2  Phase 3
Technical Overview
Scope

- Application focus
  - Commercial
  - Security
  - HPC
  - Bioinformatics
  - Data streaming
  - New 2010-apps ??

- Integrated solution

Programming & user interface
System software
Architecture
Technology
Productivity Metrics

• **A theory for productivity that**
  – Reflects the importance of time-to-solution
  – Incorporates
    • Software development
    • Maintenance costs
    • Hardware costs
    • Tradeoffs among the three
  – Uses $ as a common denominator

• **Measurable system metrics:**
  – Characterize the productivity of programming environments and execution platforms
    • Experiments with programmers
  – Weighted according to application set and customer goals
Architecture Innovations

- **Adaptation**
  - Vector/stream processor morphs
  - Memory-in-processor morph (PIM-like programming model with practical hardware)
  - SMT and conventional caches for commercial apps

- **Proactive memory architecture**
  - Embedding intelligence across memory hierarchy for better performance and lower latency

- **Leverage IBM’s technology advantages**
  - Aggressive hardware design
  - New revolutionary packaging and device technologies subject to practicality & cost
Programming Model Work

- Support for newer programming languages
  - UPC, StreamIt, and domain-specific language
- Morphogenic software process
  - Bridging the gap between domain experts and programmers
- New and revised abstractions
  - Enclaves, atomic actions and asynchronous calls
- Aggressive compiler support
- Integrated development environments, visual tools & component-based software
  - Integrate best practices from commercial into HPC
Infrastructure Work

- K-42 operating system
  - Design for scalability from scratch
- High-level automated verification
  - Hardware and software
- Design for low-power, high-performance circuits
- Continuous performance monitoring and automatic tuning
- Robustness:
  - New programmer-transparent efficient checkpointing
  - Self-healing autonomic middleware
Getting It Right! PERCSim

- Feedback to hardware & software designers
  - Test-bed for quick evaluation of “what if” questions across all system levels
- Pre-hardware software development
  - Tuning and evaluation well before design freeze
- Speeds up verification and enhance methodology
- Execution-driven
  - Better represents scalable multiprocessors compared to traditional tracing (e.g. synchronization traffic)
- Power management support
Example: SPEC SDET
Summary

• An ambitious vision for adapting systems to applications
  – Solve productivity problems of HPC community
  – Explore technologies otherwise deemed too risky
  – Economic viability

• Breadth and depth of IBM’s R&D behind the effort
  – Record of innovation with reliability & delivery

• HPCS will have a strong impact on IBM and universities
  – We hope to change status quo