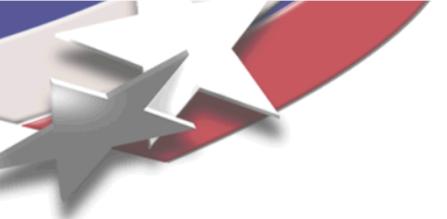


Opportunities for Neural-Inspired Ideas in High Performance Computing

Bruce Hendrickson

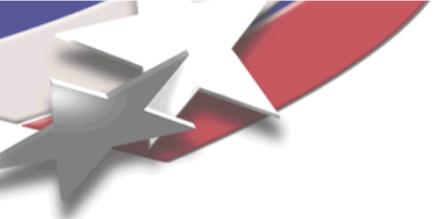
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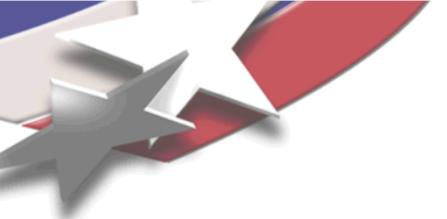
We Live in Exciting Times

- **The BRAIN Initiative**
 - Improve understanding of neural processes and capabilities
- **The National Strategic Computing Initiative**
 - Multi-agency commitment to advanced computing
 - Includes research in non-traditional computing approaches
- **The DOE-led Exascale Initiative**
 - By mid-2020's deploy systems exhibiting 10^{18} ops/second



Exascale Challenges

- From “Top 10 Exascale Research Challenges”
 - Power
 - Resilience
 - Complex memory hierarchies
 - High performance networking
- CMOS / von Neumann systems look to be unlikely to get us beyond a few exa-ops
- Can insights from neural systems provide ideas to address some of these challenges?



Possible Concepts

- **Algorithms inspired by neural systems could**
 - Manage memory hierarchies
 - Monitor machine state to enhance resilience
 - Find features in large computational data sets
- **Perhaps as a co-processor, hardware inspired by neural systems could**
 - Provide very low power computing model
 - Enable very fast, efficient matrix-vector multiplication
 - Support very fast, efficient sorting
 - Maybe enable efficient solutions to integral equations



Next Steps

- **We need better theoretical models of neural-inspired computing approaches**
 - Which neural-inspired concepts are most important and why?
 - Spike trains? Asynchrony? Co-local computing and memory? Connectivity? Approximate computing?
- **We need neuroscientists working with computer architects and algorithm designers**
 - Challenging cultural issues
 - Communities have different vocabularies, scientific objectives, frames of reference