Opportunities for Neural-Inspired Ideas in High Performance Computing

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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