Open Campus Collaborative Opportunities

Computational Sciences Campaign

Dr. Raju Namburu
U.S. Army Research Laboratory
Basic and applied research in computational sciences exploiting advanced computing architectures to maintain the superiority of Army materiel systems and enable land power dominance.

Army Needs:
• Unburden the Soldier
• Lighter, more effective protection
• Improved Lethality and Effects
• Information Dominance
• Operate in contested and congested environments
• Logistics and expeditionary Maneuver

Solving the hard problems . . .
ARL People and Expertise

Strategic Collaboration Areas

- Data Intensive Sciences
  - Model Order Reduction
  - Large-scale data analytics
  - Real-time simulations/emulations
- Tactical HPC
  - Tactical Cloudlet
  - Heterogeneous Computing
- Extreme scale computing – Algorithms
  - Interdisciplinary sciences
  - Multi-scale
  - V&V and Uncertainty quantification

Plus topics covered in 21 posters ...

People and Expertise

- Computational Chemistry and materials
- Computer Scientists
- Computational Neuroscientists
- Computational Electronics and Networks
- Computational Electromagnetics
- Computational Fluid Dynamics
- Computational Structural Dynamics
- Computational Signal and Image Processing
- Scientific Visualization
- Computational Mathematics
- Computer Engineers

- Supercomputing Software Challenge Award
- First Place: Software Design Contest, ACM-IEEE, 2014

ARL developed software is widely used by DoD HPC User community, Academia, Govt. labs, and Industry

The power of supercomputing in the hands of the Warfighter
ARL Computational Sciences Facilities

100,000 + cores
3.7 Petaflops

Supporting Facilities
- DoD – ARL DSRC
- Army HPC Research Center
- Visualization facility
- Advanced Computing Lab
- Mobile Network Modeling Institute
- Multi-scale Material Modeling Enterprise
- Multi-scale Reactive Modeling Institute
- Blast Protection for Personnel and Platforms Institute
- Dynamic Optical Networking test bed
- Software Defined Networking test bed
- DoD HPC program outreach and PETTT program

World Class ARL Supercomputing Research Center
Open Campus
Supercomputing Resource

PARALLEL COMPUTER
• Cores 7,168 - 2.8 GHz Intel
• Memory 21 TB
• Storage 350 TB

Access
Computer Name  JVA
Network  TBD

Leverage ARL and OC expertise
• ARL Computational Sciences Research
• ARL Supercomputing Research
• DoD HPCMP Outreach
• ARL in-house Scientific Software

ARL Open Campus Collaborator: $0.25 per cpu-hr (each cpu has 8 cores)

To access the ARL Open Campus System, email outreach@arl.hpc.mil
Open Campus
Supercomputing Resource

Scalable Scientific Software (partial list)

- C
- C++
- Fortran
- Gamess
- GNU Compiler Suite
- GNU Utilities
- Intel Compiler Suite
- Java
- Jove
- Octave
- OpenMP
- OpenMPI
- Overflow
- Tcl/Tk
- Perl
- Python
- Vi/Vim
- PARAVIEW
- VISIT
- TECPLOT
- TOTALVIEW
- MATHLAB
- LAMMPS
- GRIDGEN
- GRIDPRO
- FFTW Libraries
- CSE
- HMS
- Ensight
- AERO
- ParaMetis
- ICE
- ARES
- ParQC
- Compose
- SPOOCFEM
- FFTW Libraries
- AEH3D
- MLPG
- HealMesh
- CIA
- MINDS
- CLUTO
- FDTD3D
- WARF3D
Open Campus
Supercomputing Resource
DoD HPC PETT Classes (over last two years – partial list)

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Strategic Research Areas

Tactical High Performance Computing (HPC)
- Tactical HPC
- Heterogeneous computing architectures

Very Large-scale Data Analytics for the Army
- Large-scale data analytics
- Real-time data access and analytics

Computational Predictive Design for Interdisciplinary Sciences
- Tyranny of scales
- Interdisciplinary / Complexity of Army systems
- Uncertainty quantification
Vision
Mobile HPC to the tactical edge optimized for battle command applications using emerging heterogeneous computing systems

Impact and Relevance:
- Unburden the Soldier
- Increase logistical efficiency and unit self-sufficiency

Key Research Challenges:
- Complex heterogeneous computing optimization
- HPC in small form-factor
- New approaches for performance portability
Tactical High-Performance Computing
ARL People and Expertise

Technical Areas
• Develop models that can accurately couple computational performance with power
• Develop scalable algorithms to optimize power for computing
• Explore scalable and distributed algorithms for heterogeneous computing architectures
• Scalable algorithms for battle command applications
• Explore advanced computing architectures - neuro-synaptic, qbits, etc.

Collaborative Opportunities
• Novel methodologies to express and capture parallelism in software
• Algorithms for emerging hardware designs (qbits, neuro-synaptic) to allow for faster Army-relevant applications
• New methods to allow for power optimization across a diverse spectrum of processors

Expertise
• Computer Science
• Battle-command applications
• Computational Mathematics
• Computational Electromagnetics
**UNCLASSIFIED**

**Tactical High-performance Computing**

**ARL Infrastructure and Facilities**

- **ARL Advanced Computing research facilities include:**
  - Emerging ARM-RISC based systems
    - Monolithic
    - Heterogeneous (power vs. performance)
  - Calxeda servers
  - FPGAs
  - Neuro-synaptic hardware
  - Large-scale heterogeneous GPU cluster
    - 5,000 cores
    - 600 GPUs
  - ARL Supercomputing facilities

- **ODROID big.LITTLE processor configuration for high performance and low power**

- **Epiphany 64-core processor technology**

- **IBM TrueNorth architecture for neuro-synaptic computing**
Tactical Cloudlet

Vision
Mobile High Performance Computing capacity and novel Soldier capabilities for increased effectiveness at the tactical edge

Impact and Relevance:
• Effective Soldier-based processing
• Optimized bandwidth allocation and lower overall requirements

Key Research Challenges
• Models for coupling computation and ad hoc networks
• Processor provisioning
• Resiliency
• Novel application/capabilities for Soldiers

Provisioning assets and placing HPC nodes in the field connected by mobile ad hoc networks

New capabilities (such as tactical red/blue force dynamic analysis and placement) are possible with tactical HPC
Tactical Cloudlet

ARL People and Expertise

Technical Areas

- Models for coupling computation and communication
- Processor provisioning
- Novel application/capabilities for Soldiers

Expertise

- Computer Science
- Interdisciplinary optimization
- Computational Mathematics
- Computational network sciences

S&T areas of collaboration opportunities

- Novel resilient distributed computing methodologies with ad hoc networks
- Algorithms for emerging hardware – power, performance and portability
- Adaptive programming models to Soldier’s requirements
Tactical Cloudlet
ARL Infrastructure and Facilities

• ARL Tactical High Performance Emulation Environment
  - Model assessment
  - Leverages and expands the Extensible Mobile ad hoc Network Emulation (EMANE) system at ARL
  - Both virtual (emulated) and real devices are included

• Advanced Computing Laboratory

Heterogeneous Emulation system

Cloudlet optimized distributed processing incorporating HPC

Planning and optimization for asset provisioning and process migration
Computational Predictive Design for Interdisciplinary Sciences

Vision
Scalable predictive modeling capabilities for complex interdisciplinary Army materiel Systems

Impact and Relevance:
• Predictive methods to accelerate design to manufacturing to rapid fielding
• Scientifically challenging multi-scale application
  • Innovative materials
  • electronic warfare
  • Army weather effects

Key Research Challenges:
• Scalable algorithms and methods
• Scale bridging methodologies to connect models of varying scales
• Development of approaches to address uncertainty quantification in mathematical models

Rapid fielding = Lives Saved
Computational Predictive Design for Interdisciplinary Sciences

Technical Areas
• Uncertainty quantification and verification & validation
• Robust approaches to validate forecast model accuracy
• Model order reduction methods
• Formulated methodology for creation, scheduling and control of nested parallel applications for scale-bridging in multi-scale models
• Developed proof-of-concept algorithm for multiple materials in meso-scale dislocation simulation
• Army-scale weather prediction model maturation

Collaboration Opportunities
• Computational algorithms for next generation multi-scale materials
• Quantified forecast uncertainty metrics
• Robust approaches to validate forecast model accuracy
• Hierarchical Scale-bridging Framework
• Interdisciplinary computing for weapon-target interaction
• Scalable algorithms for cyber protection and operation
Computational Predictive Design for Interdisciplinary Sciences

ARL Infrastructure and Facilities

- ARL DoD Supercomputing Resource Center
- Army HPC Research Center
- Scalable computing environment infrastructure
- Advanced weather data collection arrays
- Advanced Computing Laboratory
- Visualization Facility

Scalable, expandable weather models

Precise, high-resolution atmospheric observations

Xeon Phi + GPU Cluster

AMD + GPU Cluster
Large-scale data analytics

Vision
To perform large-scale data analytics for simulation, experimentation, observational, and theatre data to enhance understanding and improve the Army materiel systems.

Impact and Relevance
• Surprise/Tactical Intelligence Mission Command - improve small unit communication to enable ability to execute mission command on the move
• Gain insight to large data in time to have impact on new theoretical and system development

Key Research Challenges
• Developing scalable algorithms and methodologies for decomposition of data for parallel execution.
• Discovery of new scalable data access for dynamic analysis
• Optimal implementation on new and emerging High Performance Computing architectures and platforms
Large-scale data analytics
ARL People and Expertise

Technical Areas
• Large Scale Visual Data Analytics and Information Visualization
• Parallel Data Analytics
• Data Mining and Correlation Discovery
• Development of Algorithms for Extreme Scale Simulations

Expertise
• Computer Science
• Interdisciplinary Sciences
• Computational Mathematics
• Scientific and Information Visualization

Collaboration opportunities
• Dynamic Graph Analysis for Enormous Datasets
• Geospatial and Information Visualization
• Extreme Scale Computational Frameworks
• Scalable Data Mining Algorithms
• Visual Data Analytics for Large Data Streams Processing of Enormous Datasets
Large-scale data analytics
ARL Infrastructure and Facilities

**Excalibur**
- Has over 101,000 processors, a theoretical peak speed of 3.7 PetaFLOPS, and
- **120 TB of Flash Storage**.

**HPCMP (DHPI-ATEC)**
- 66 node cluster
- Over 1000 processor cores
- 200 TB storage
- 10TB SSD storage
- OS: Red HAT Enterprise LINUX 6.5

**FOB**
- 64 node heterogeneous cluster
- 48 - X86 co-processor nodes
- 16 - NVIDIA K20 GPGPUs
- OS: Red HAT Enterprise LINUX 6.5

**Solid State Disk Subsystems**
- Faster I/O than Traditional Disks
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DEMOS

- High Performance Computing facility
- Tactical Cloudlet
- High-fidelity Predictive Simulations
- Software Defined Networking (SDN)
- High Fidelity Live Virtual Data Intensive Simulations
Question?