MULTI-OBJECTIVE GEOMETERIC OPTIMIZATION FOR HETEROGENEOUS ARCHITECTURES

Project Description

ARL has developed a method for performing multi-objective geometric optimization in the context of optimally positioning blue force Soldiers to reduce the risk posed by ballistic threats while maximizing the observability of surveillance targets identified by mission requirements. A 3D ray-tracing algorithm is used for evaluating ballistic threat probability and surveillance observability distributions. Markov Chain Monte Carlo optimization is employed for identifying optimum Soldier positioning within a high-dimensional search space. Leveraging ARL experience in developing high-performance algorithms for heterogeneous architectures, a scalable, task-parallel implementation of the method was developed that offloads all computation to distributed heterogeneous processors. Target systems are tactical HPC networks characterized by dynamic topologies, low reliability, and highly constrained computational resources with distributed heterogeneous processors. The goal of the project is the demonstration of our methods for computationally intensive processing using tactical HPC networks.

Relevance of Work to DOD

Tactical networks are dynamic, heterogeneous, unreliable, and highly constrained. The effective use of such systems requires research and development of suitable parallel programming methods and algorithms. Multi-objective geometric optimization for blue force positioning using full 3D representation of environment ensures the safest placement of personnel and greatest ability to acquire information regarding red force position and movement. The goal of this research is to develop computational methods to provide Soldiers with all that can be known, faster than the enemy, in an environment with constrained computational resources.

Computational Approach

Our approach is to use a full 3D ray-tracing method for evaluating ballistic threat probability and surveillance observability distributions. Markov Chain Monte Carlo optimization is used for identifying optimum Soldier positioning within a high-dimensional search space. We have developed parallel programming methods and algorithms for implementations suitable for tactical HPC networks.
We employ a generalized C++ simulation engine that provides high-level extensibility and portability without sacrificing low-level performance. The parallel programming model provides transparent resource allocation and

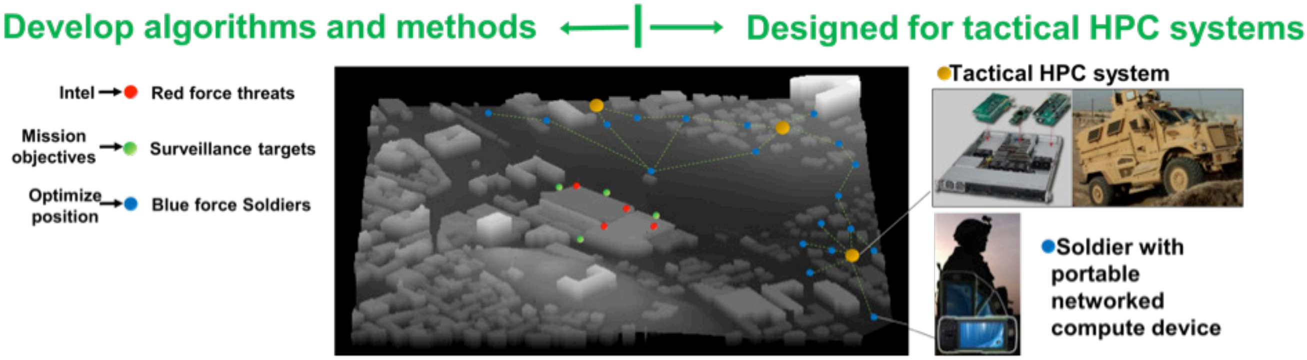

Figure 1: (above)
Developing methods and algorithms for optimum positioning of blue force Soldiers to maximize mission objectives while reducing the risk of ballistic threats. The approach is designed to target tactical HPC networks with dynamic topology, low reliability, and highly constrained heterogeneous resources.

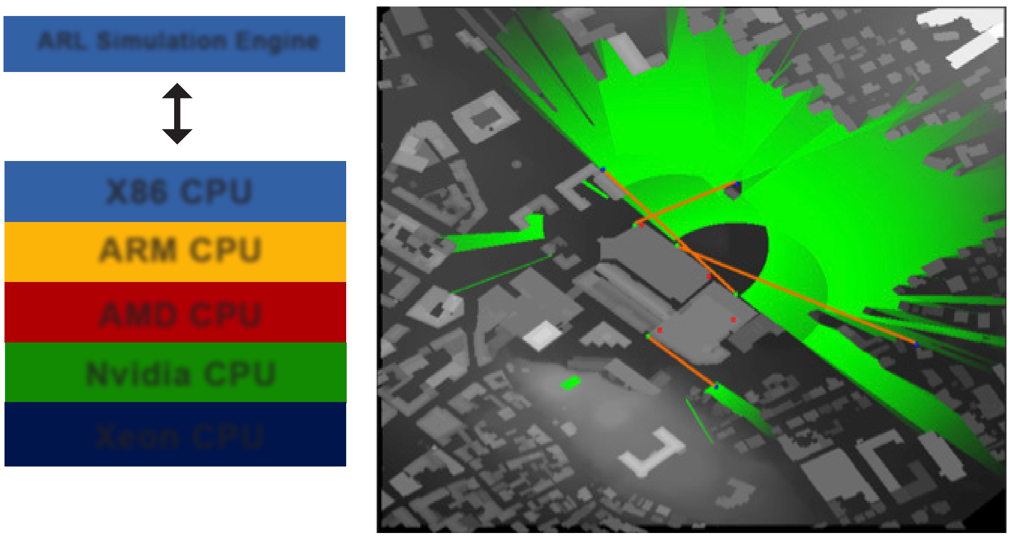

Figure 2: (left)
Optimized positioning of blue force Soldiers for surveillance of multiple targets and subject to multiple ballistic threats.

enables load-balancing across available resources without requiring explicit multi-device accounting. The method has been demonstrated on diverse platforms including x86 and ARM CPUs, AMD and Nvidia GPUs, and Intel Xeon Phi accelerators. Recent work includes collaboration with Stanford University to explore the application of Partially Observable Markov Decision Process (POMDP) for dynamic scenarios.

Results

We have developed a multi-objective geometric optimization method for optimum positioning Soldiers subject to ballistic threats. We have also developed software algorithms for implementation in a portable simulation engine suitable for tactical HPC networks.

Our work closes the gap between available data and the computational capability for extracting situational awareness in near real time.

Future

For the future, we plan to develop dynamic scheduling algorithms within the existing simulation engine. Scaling tests using large HPC systems with GPU and MIC accelerators at ARL will be performed. Functional tests will also be performed using an emulated tactical HPC network. We will collaborate with Stanford University to explore the application of partially observable Markov decision processes for the extension to dynamic scenarios

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