Intuitive Visualizations for Analyzing Exascale Workloads

Performance analysis of parallel scientific codes is becoming increasingly difficult due to the rapidly growing complexity of applications and architectures. Existing tools fall short in providing intuitive views to reveal the root causes of performance problems. We have developed a new paradigm of projecting and visualizing performance data obtained from one domain onto other domains for faster, more intuitive analysis of applications. We gather performance data in three domains: hardware, application, and communication. For each domain, we define projections that allow the data to be visualized in the other domains. Using these methodologies and visualization techniques, we demonstrate the careful unscrambling of otherwise tangled measurements caused by adaptive systems. By attributing performance anomalies directly to their causes, we are able to visualize performance measurements in the domain most intuitive to the user, which are not necessarily those in which the measurements are collected.

The HAC model

The Hardware domain represents the compute nodes and physical interconnect that form the parallel machine. The Application domain is the physical or other simulation space being modeled by the application. The Communication domain is the virtual process topology for a parallel application. Performance data is typically collected in one of these domains. The HAC model projects data into domains where it is most intuitive to analyze.

Projections on the application domain

Floating point operations (middle) and L1 cache misses (bottom) mapped to the application domain (top) for multiple time steps of Miranda running on 256 cores of an Infiniband cluster.

Projections on the hardware domain

Communication is becoming the dominant performance bottleneck as we scale to a large number of cores. It becomes important to analyze communication in terms of contention on specific links (hot-spots) and distribution of network traffic on the links in various directions.

Projections on the communication domain

Times spent in the three load balancing sub-phases of SAMRAI plotted against the MPI ranks. Phase 1, i.e., load distribution appears to lead to longer wait times in other phases. This MPI rank view does not reveal the cause of the performance problem.