UNITY: Unified Memory and File Space

Achievement: Developed a new high-performance computing focused data storage abstraction that places the entire memory hierarchy, including both traditionally separated memory and file-based data storage, into one storage continuum. Through the use of a novel API and a set of services centered around a smart runtime system, UNITY is able to provide a number of valuable and interesting benefits.

Significance and Impact: The unified storage space provides a scalable and resilient data environment that dynamically manages the mapping of data onto available resources based on multiple factors, including desired persistence and energy budget considerations. By eliminating the need for high-performance computing domain scientists to develop architecture-dependent optimizations for rapidly evolving data storage technologies, UNITY addresses both ease-of-use and performance.

Research Details:

- Articulated an architectural description of UNITY, a collection of services that provide data placement and movement within complex memory hierarchies based on user-provided annotations
- Developed simplified data abstraction for applications that unifies memory and storage, decouples application data layout from physical media layout, and provides explicit data versioning for consistent data sharing without global synchronization.
- The abstraction provided by UNITY increases performance portability via a smart runtime system. By eliminating requirements on HPC domain scientist to develop architecture-dependent optimizations for rapidly evolving data storage, UNITY addresses both ease-of-use and performance.

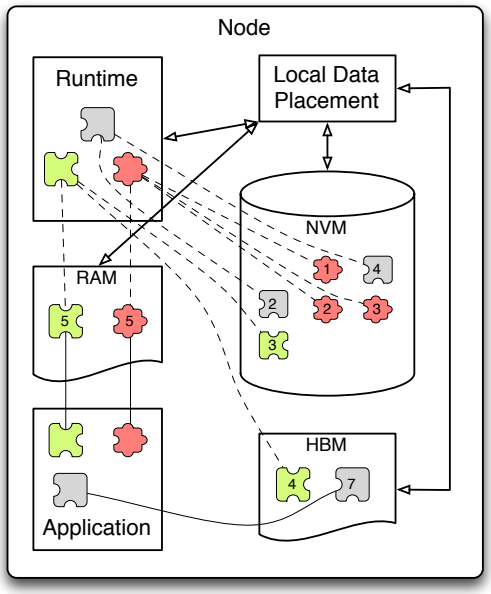

Figure 1. UNITY node architecture.

Sponsor/Facility: This work was a collaboration between ORNL, other laboratories, industry and academia. It was sponsored by the US Department of Energy (DOE) Office of Advanced Scientific Computing Research (ASCR).

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Publication: **Terry Jones,** Michael Brim, Geoffroy Vallee, Benjamin Mayer, Aaron Welch, Tonglin Li, Michael Lang, Latchesar Luchov, Douglas Otstott, Ada Gavrilovska, Greg Eisenhauer, Thaleia Doudali, Pradeep Fernando. *"UNITY: Unified Memory and File Space"*, **International Workshop on Runtime and Operating Systems for Supercomputers ROSS 2017,** Washington, D.C., USA, June 27, 2017.

Overview:
High-performance computing (HPC) practitioners have known of memory-induced performance issues at least as far back as William Wulf's 1995 paper on the "memory wall". Today, these problems remain despite two decades of computer science advances, and the situation is exacerbated by new challenges including energy budgets and deeper, more complex memory hierarchies. What was once a few distinct tiers is now a continuum of memory and storage technologies with complicated trade-offs in performance, capacity, and resilience. The consequence of more complexity to application developers is unsatisfactory. With each new technology or move to a new HPC platform, application changes are necessary to fully exploit the available capabilities. The UNITY project envisions a unified data environment where applications, tools, and system services easily and efficiently access and share data regardless of its placement within the memory and storage hierarchy. Our overall objective is to design, implement, and evaluate a new distributed runtime that unifies the traditionally distinct application views of memory- and file-based data storage into a single scalable and resilient data environment. This simplifies an application's interaction with its native data objects and hides the complexity of new emerging storage architectures. Moreover, the abstractions provided to enable automation also address traditional concerns such as ease-of-use and performance while providing the flexibility to adapt to new constraints including energy budgets and resilience.