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DataSpaces

BoF: Enabling Data Services for HPC

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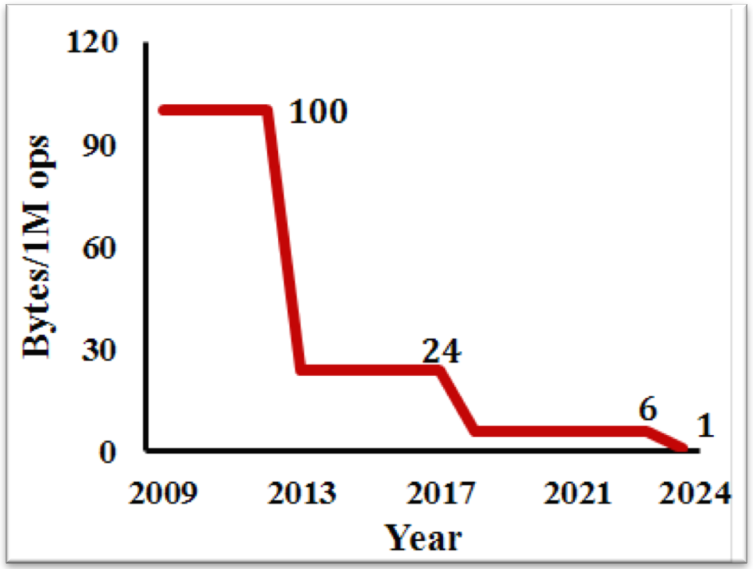
The ~~Problem~~ Opportunity

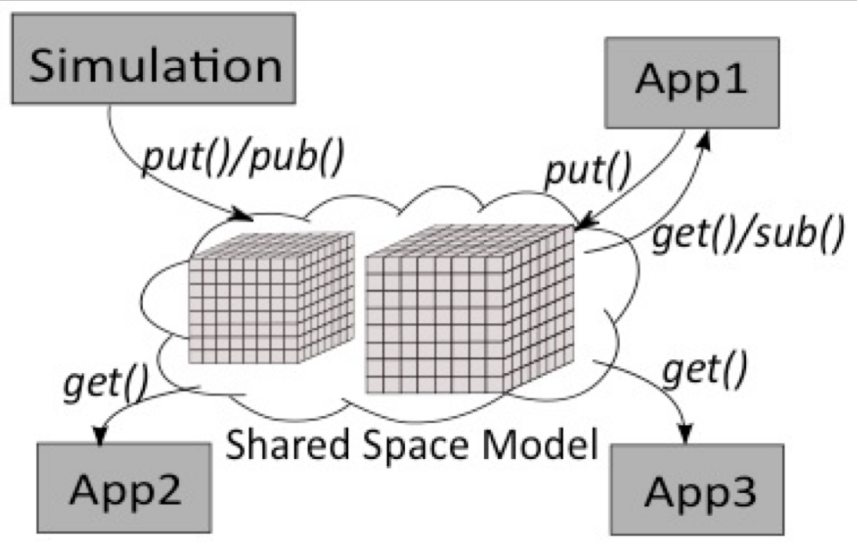
- The volume of data produced by analysis workflows is increasing faster than the storage capacity of HPC machines
  - Simulation output for Viz/Analysis
  - Data reduction is not the (whole) answer
  - Storage bottleneck threatens to stall traditional post-hoc analysis workflows
- In-situ analysis to the rescue
  - Keep simulation products in memory
  - Perform analysis concurrent with simulation
  - Live analysis gives us some capabilities we didn't have before
- Similar for multi-physics workflows
- This is HPC, and we want purpose-driven middleware that does this well



Storage capacity declines relative to processing power

DataSpaces

- In-memory data staging for coupling workflow components
  - "workflow component" can be read "process group"
  - Compare to exchanging data using files
  - Decouple coupling in time
  - Decouple coupling in space (DART communication library)
  - Low-latency, asynchronous data transfer with RDMA
- Optimized for HPC workflows
  - Assumes a shared space abstraction
  - Provides spatially-significant put/get primitives (variable x bounding box x version)
  - Indexing optimized for spatial locality of access using SFC. This permits scalability using a DHT



Abstract DataSpaces storage model

DataSpaces Project History

- Product of Rutgers University (Center for Autonomic Computing -> RDI2)
- Originally developed to meet coupling challenges in multi-physics fusion simulation and analysis workflows
- Builds on the DART communication layer for RDMA communication
  - Originally supported Cray Portals, has been extended to DCMF, InfiniBand, OmniPath, GNI, and TCP
- A publically available standalone software product since 2012
- Has been used to accelerate applications in a wide variety of research domains (e.g. fusion, combustion, seismic, material science)
- Framework Extensions:
  - Stacker: deep-memory hierarchy s
  - ActiveSpaces: flexible code execut
  - **DataSpaces-as-a-Service (DSaaS**
  - Corec

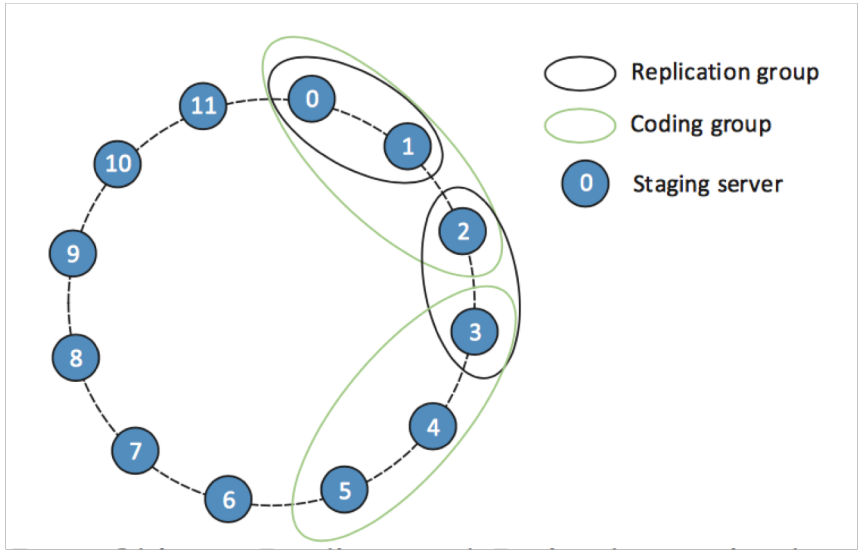
Stacker: An Autonomic Data Movement Engine for Extreme-Scale Data Staging-Based In Situ Workflows
Thursday, 4:00 C141/143/149

Deployment

- DSaaS
  - Deploy dataspaces as a persistent staging service, rather than (just) a transient communication facility
  - Allow workflow components to come and go
  - Permit more complex interactions (e.g. an analysis routine is spun-up conditionally, gets simulation output from DataSpaces, the routine completes, nodes are repurposed, etc…)
  - Wire-up is done by common configuration files and bootstrapping sockets
- Cross-job coupling
  - Fun stuff! On-demand analysis jobs, multi-scale simulation, etc.
  - Stage-in / Stage-out: save resources for jobs
  - Scheduler issues: cross-job communication credentials
  - Scheduler issues II: we'd like support to resize a job!
- Security
  - So far an impediment(!), but this is probably a bad attitude
  - We don't understand this well yet, but it's an important issue

Resiliency

- Process-level resiliency
  - Code-coupling model presents challenges and opportunities
  - Complex workflows present an opportunity to isolate failures to individual components
  - Persistent services present greater resiliency challenges:
    - Likely to see a process failure
    - Can we survive system restart?
  - CoREC (*Duan, 2018)* provides survivability features to DataSpaces using a hybrid approach: replication for hot data, error coding for cold data
  - Process group survivability is still a challenge, work on this in ULFM and CAARES
- Data resiliency as a feature
  - Deal with data corruption
  - Localize failures: prevent data corruption from propagating to other workflow components



CoREC hybrid process resiliency scheme

Duan, Shaohua, et al. "Scalable Data Resilience for In-memory Data Staging." 2018 IEEE International Parallel and Distributed Processing Symposium (IPDPS). IEEE, 2018.