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FROM FILE SYSTEMS TO SERVICES:
CHANGING THE DATA MANAGEMENT MODEL IN HPC

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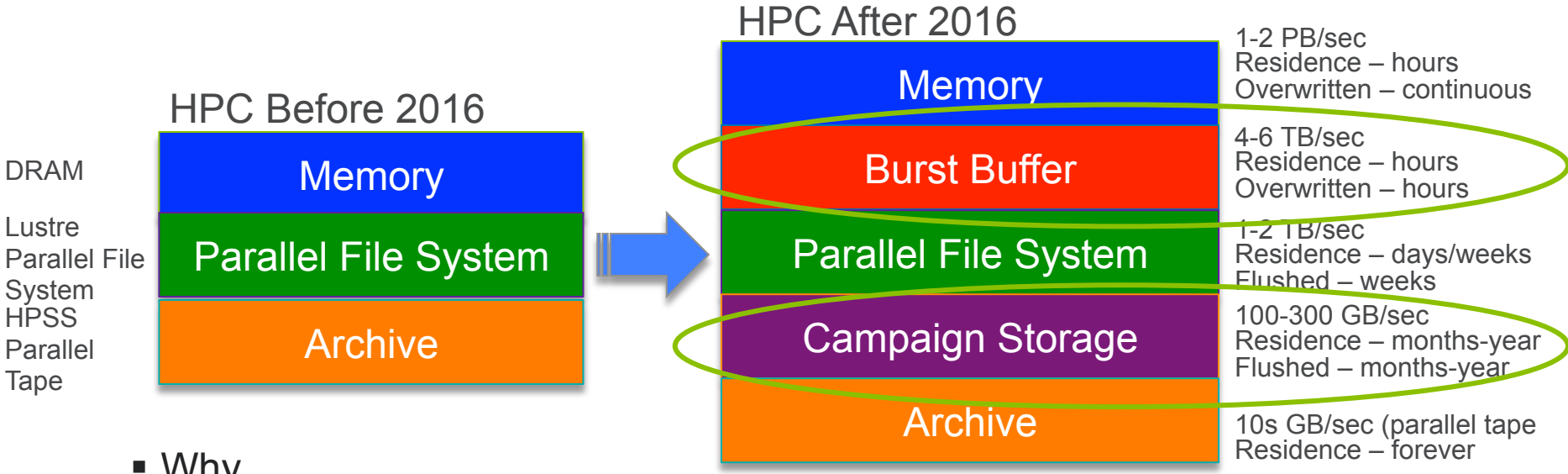
CHANGES IMPACTING HPC DATA AND STORAGE

MORE STORAGE/MEMORY LAYERS…

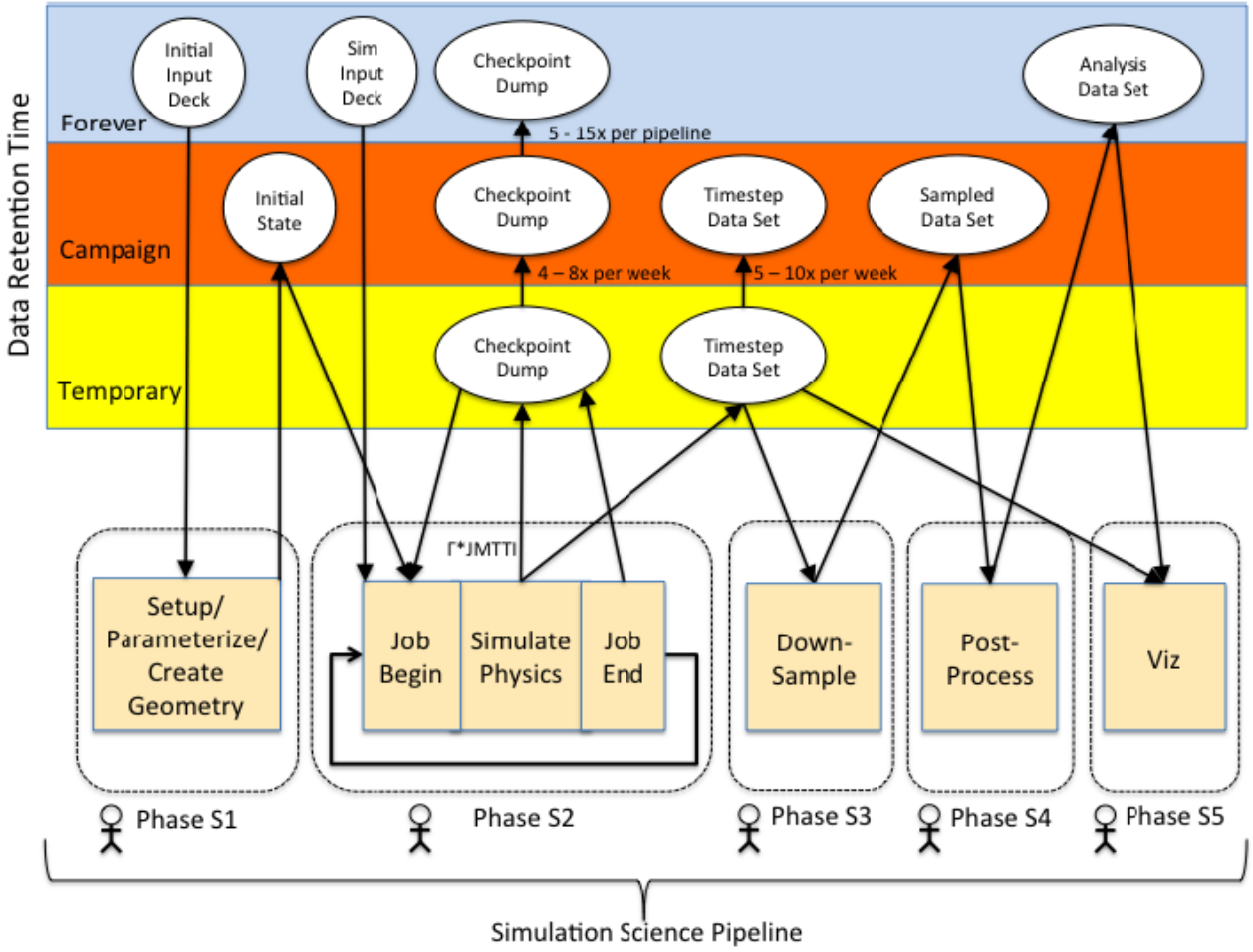


- Why
  - BB: Economics (disk bw/iops too expensive)
  - PFS: Maturity and BB capacity too small
  - Campaign: Economics (tape bw too expensive)
  - Archive: Maturity and we really do need a “forever”

Slide from Gary Grider (LANL).

SIMULATION WORKFLOW

APEX Workflows, LANL, NERSC, SNL,
SAND2015-10342 O, LA-UR-15-29113



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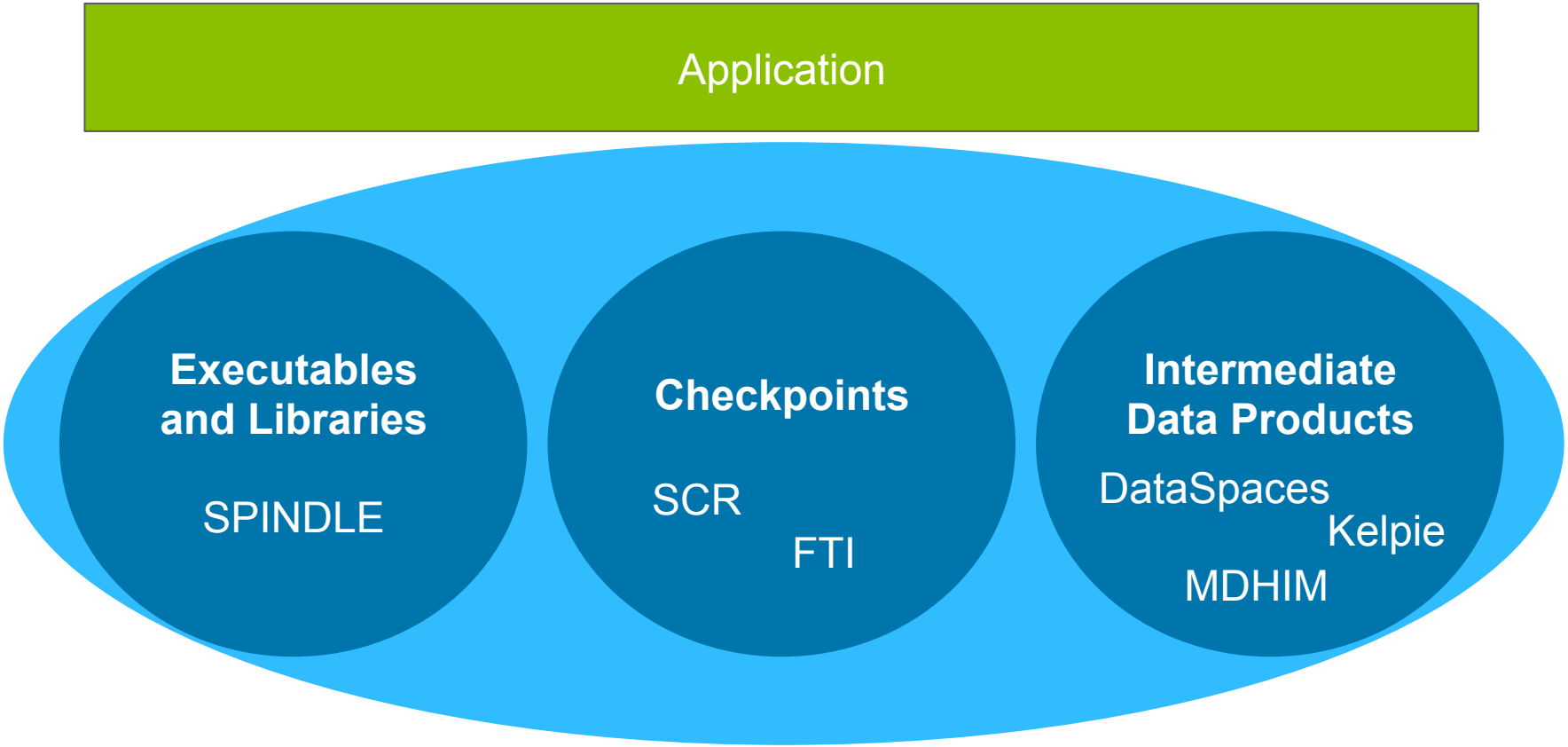
SPECIALIZATION OF DATA SERVICES



	Provisioning	Comm.	Local Storage	Fault Mgmt. and Group Membership	Security
Rusty → **ADLB** *Data store and pub/sub.*	MPI ranks	MPI	RAM	N/A	N/A
DataSpaces ← Manish *Data store and pub/sub.*	Indep. job	Dart	RAM (SSD)	Under devel.	N/A
DataWarp *Burst Buffer mgmt.*	Admin./ sched.	DVS/ lnet	XFS, SSD	Ext. monitor	Kernel, lnet
FTI ← Franck *Checkpoint/restart mgmt.*	MPI ranks	MPI	RAM, SSD	N/A	N/A
Kelpie *Dist. in-mem. key/val store*	MPI ranks	Nessie	RAM (Object)	N/A	Obfusc. IDs
SPINDLE *Exec. and library mgmt.*	Launch MON	TCP	RAMdisk	N/A	Shared secret

COMPOSING DATA SERVICES

OUR GOAL

Enable composition of data services for DOE science and systems

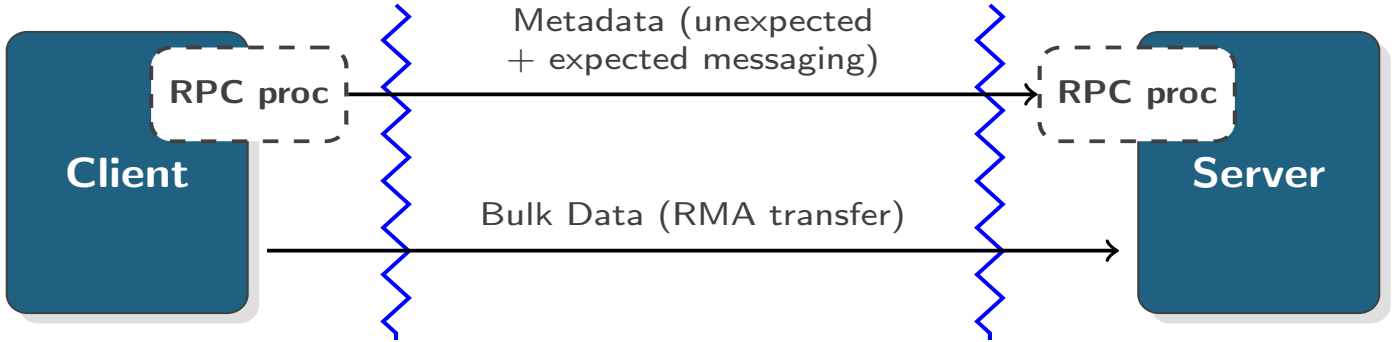
- Application-driven
  - Identify and match to science needs
  - Traditional data roles (e.g., checkpoint, data migration)
  - New roles (e.g., equation of state/opacity databases)
- Develop/adapt building blocks
  - **Communication**
  - **Concurrency**
  - Local Storage
  - Resilience
  - Authentication/Authorization

COMMUNICATION: MERCURY

https://mercury-hpc.github.io/

Mercury is an RPC system for use in the development of high performance system services. Development is driven by the HDF Group with Argonne participation.

- Portable across systems and network technologies
- Efficient bulk data movement to complement control messages
- Builds on lessons learned from IOFSL, Nessie, lnet, and others



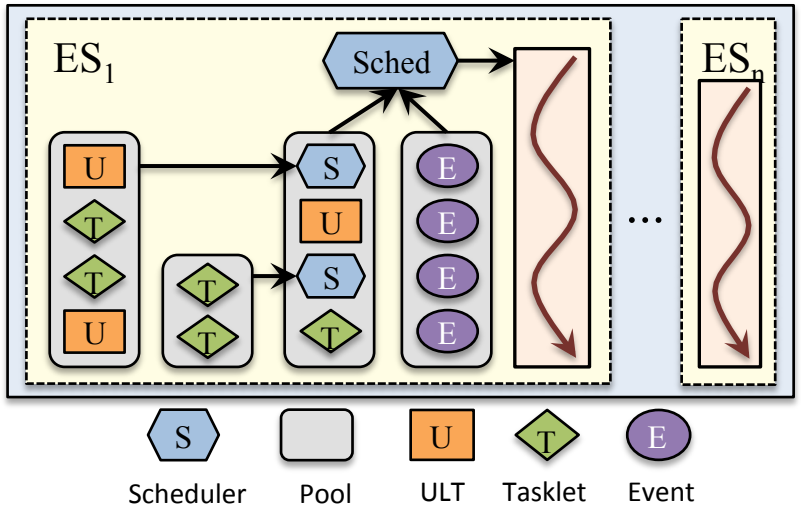
CONCURRENCY: ARGOBOTS

https://collab.cels.anl.gov/display/argobots/

Argobots is a lightweight threading/tasking framework.

- Features relevant to I/O services:
  - Flexible mapping of work to hardware resources
  - Ability to delegate service work with fine granularity across those resources
  - Modular scheduling
- We developed asynchronous bindings to:
  - Mercury
  - LevelDB
  - POSIX I/O
- Working with Argobots team to identify needed functionality (e.g., idling)

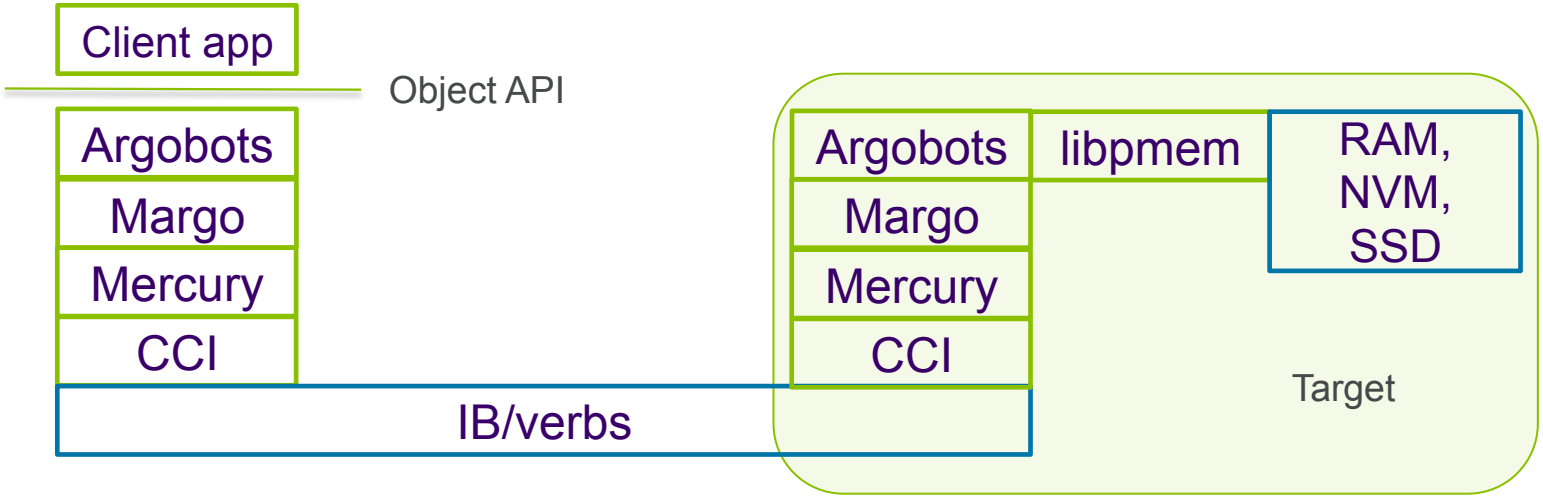
Argobots Execution Model



THREE EXAMPLE SERVICES

1. REMOTELY ACCESSIBLE OBJECTS

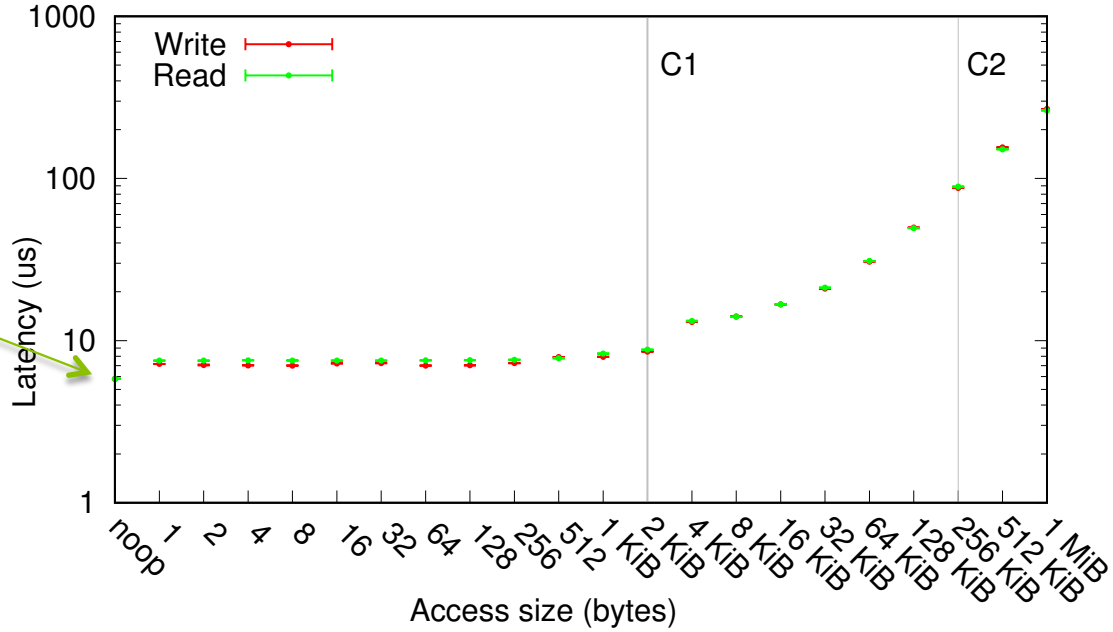
- API for remotely creating, reading, writing, destroying fixed-size objects/extents
- libpmem (http://pmem.io/nvml/libpmemobj/) for management of data on device



P. Carns et al. “Enabling NVM for Data-Intensive Scientific Services.” INFLOW 2016, November 2016.

1. REMOTELY ACCESSIBLE OBJECTS: HOW MUCH LATENCY IN THE STACK?

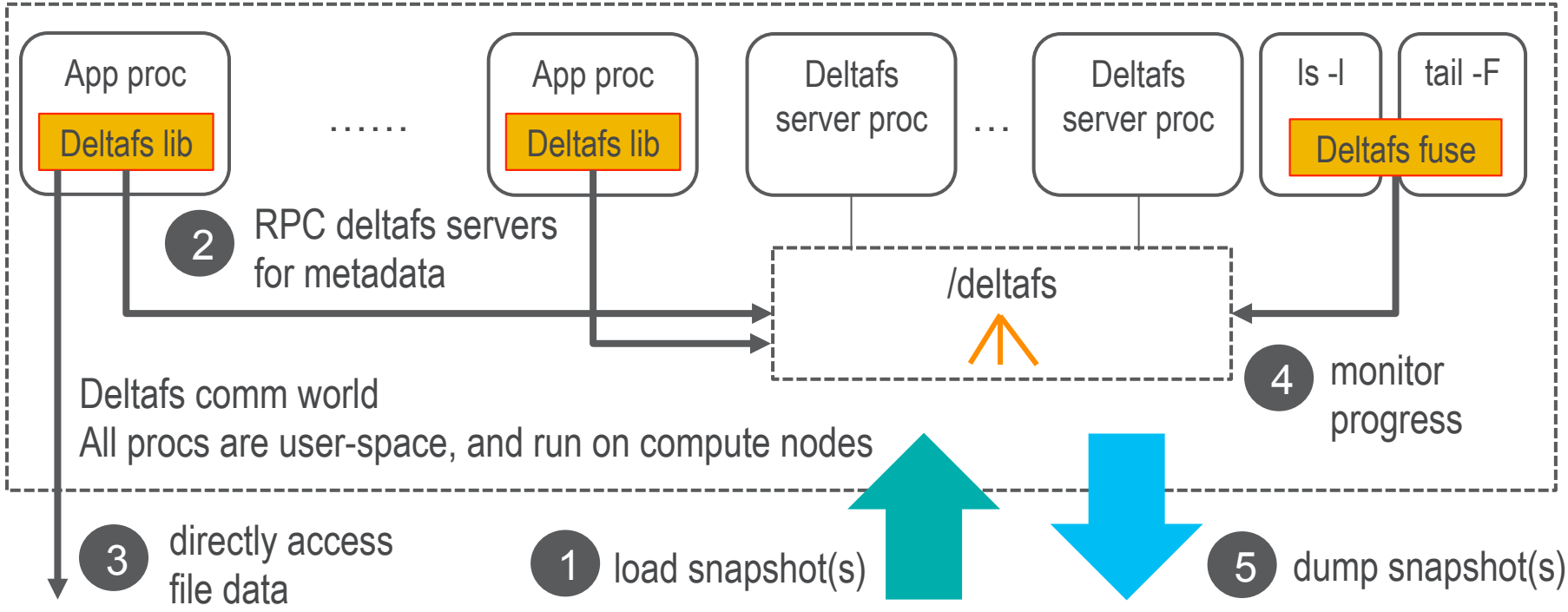
5.8 usec NOOP



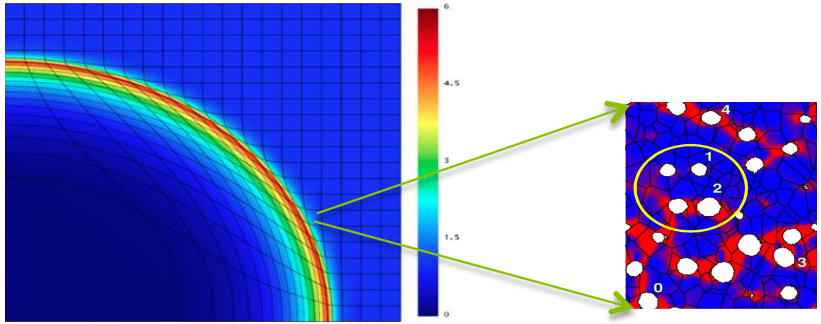
FDR IB, RAM disk, 2.6 usec round-trip (MPI) latency measured separately

2. TRANSIENT FILE SYSTEM VIEWS: DELTAFS

Supporting legacy POSIX I/O in a scalable way.

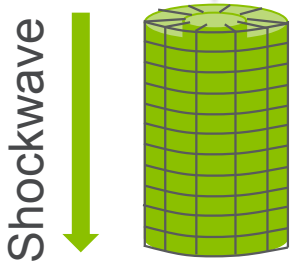


3. CONTINUUM MODEL COUPLED WITH VISCOPLASTICITY MODEL



Lulesh continuum model:
- Lagrangian hydro dynamics
- Unstructured mesh

Viscoplasticity model [1]:
- FFT based PDE solver
- Structured sub-mesh

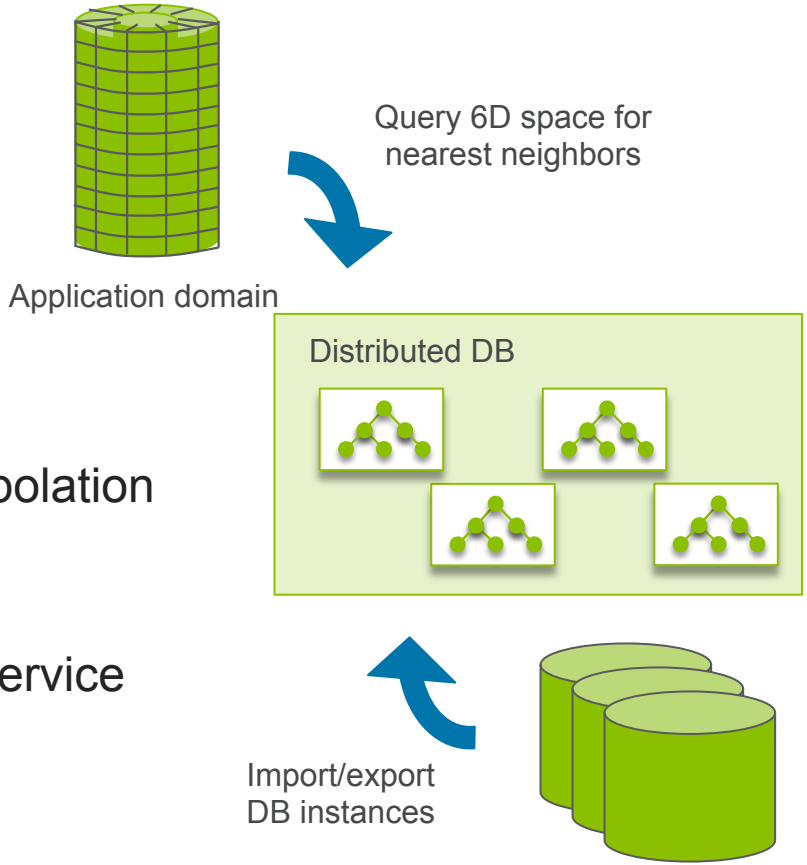


- Future applications are exploring the use of multi-scale modeling
- As an example: Loosely coupling continuum scale models with more realistic constitutive/response properties
  - e.g., Lulesh from ExMatEx
- Fine scale model results can be cached and new values interpolated from similar prior model calculations

R. Lebensohn et al, Modeling void growth in polycrystalline materials, Acta Materialia, http://dx.doi.org/10.1016/j.actamat.2013.08.004.

3. FINE SCALE MODEL DATABASE

- Goals
  - Minimize fine scale model executions
  - Minimize query/response time
  - Load balance DB distribution
- Approach
  - Start with a key/value store
  - Distributed approx. nearest-neighbor query
  - Data distributed to co-locate values for interpolation
  - Import/export to persistent store
- Status
  - Mercury-based, centralized in-memory DB service
  - Investigating distributed, incremental nearest-neighbor indexing



FINAL THOUGHTS

- Stage is set for distributed services in HPC
  - Richer resource management
  - Increasing emphasis on workflows
  - Convergence of data intensive and computational science

- If we're going to "get rid of POSIX", we need alternative(s)

- Real opportunity to make life easier for applications
  - And have fun doing it!

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