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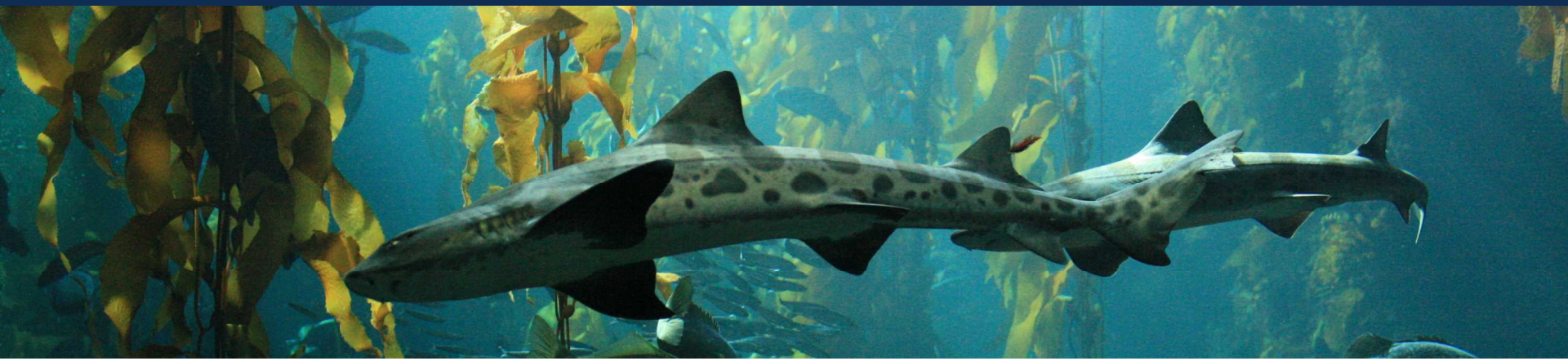

Leveraging In-Memory Key/Value Stores in HPC

Kelpie

Craig Ulmer

U.S. DEPARTMENT OF ENERGY | NNSA

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Overview: Leveraging KV Stores

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- NoSQL: Dramatic impact on *Out-of-Core* processing
  - Frameworks handle scheduling, placement, and reliability
  - Enables novice users to take advantage of parallel processing
- Good for information apps, but not Scientific Computing
  - NoSQL primary concern is disks, assumes cluster hardware
  - Can we leverage some of the concepts of NoSQL in HPC?
- Distributed In-Memory Key/Value stores are extremely useful
  - Kelpie: Experimental 2D KV for HPC built on Nessie (portable RDMA)
  - Examples: Caching, Glue, Communication, New Frameworks

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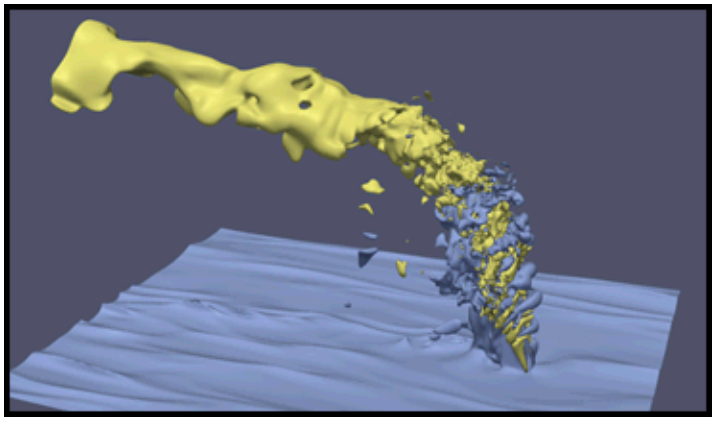
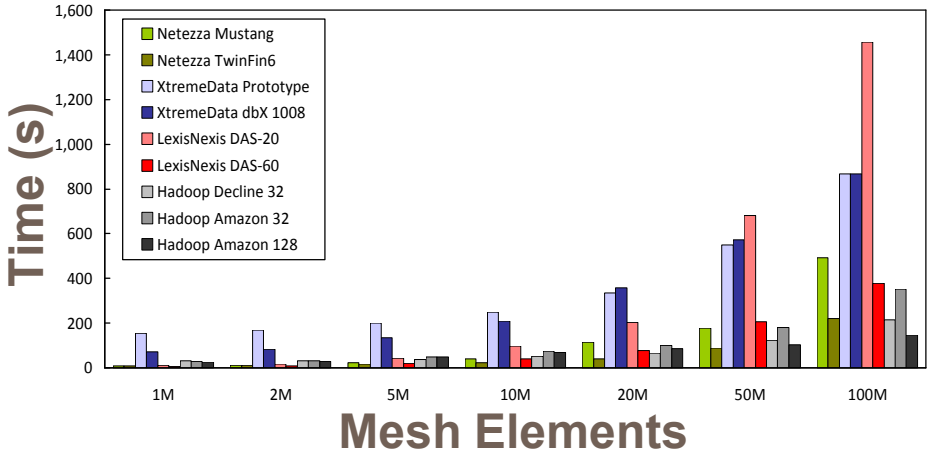
LESSONS FROM NOSQL

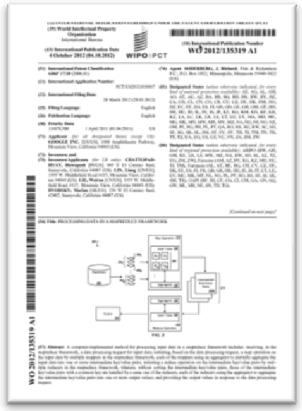
How did we get here?

- Sandia started investigating NoSQL frameworks in 2008
  - Can we leverage for post-processing on clusters?
  - Make it easier to build one-off analysis
- Ported analysis kernels to different frameworks/stores
  - Hadoop, Pig, Accumulo, Cassandra, MongoDB, SectorSphere…
  - LexisNexis DAS, InfoSphere, XtremeData, Netezza
- Hadoop Map/Reduce most practical





MapReduce Recap



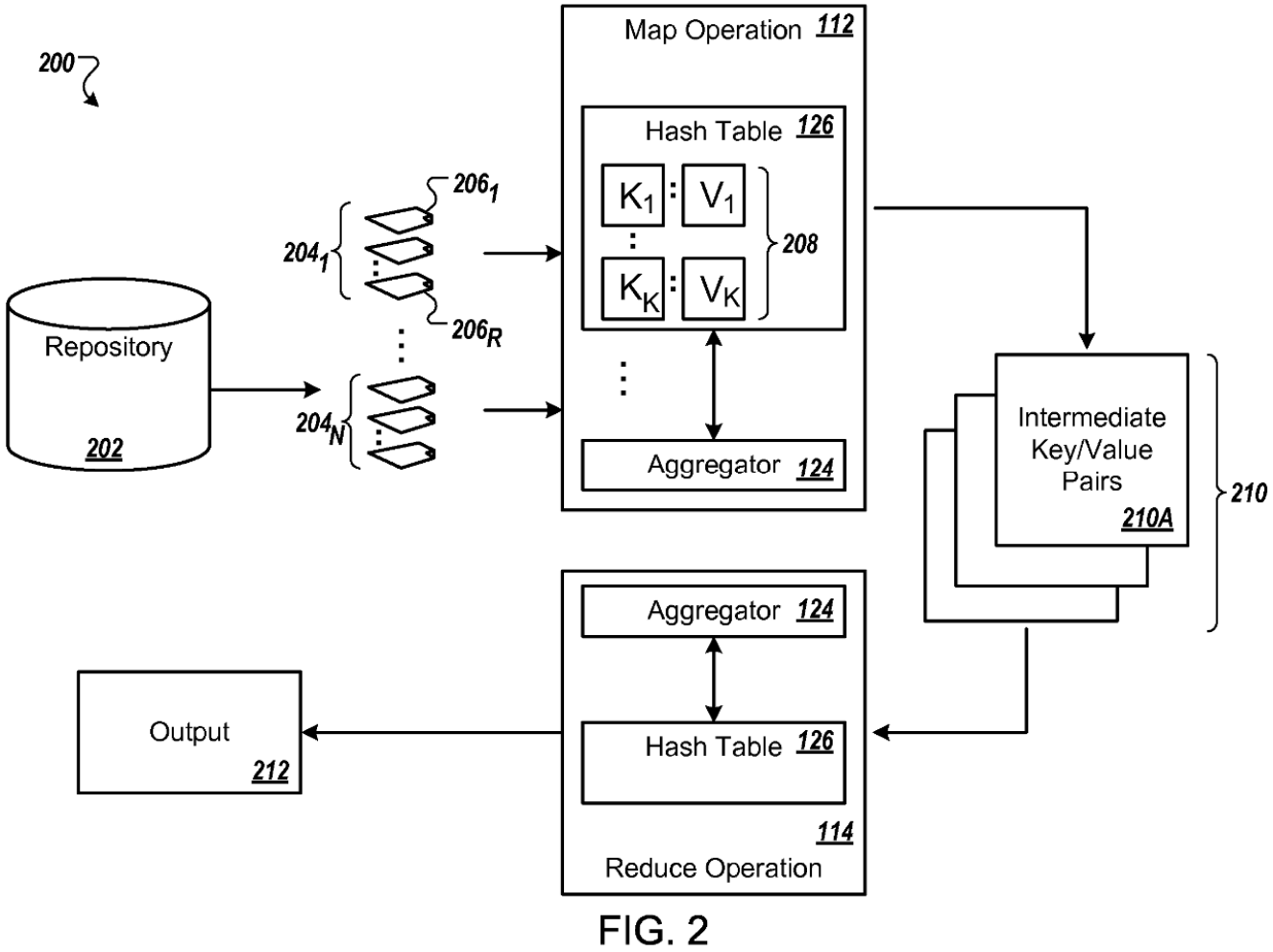


FIG. 2

Good Points of MapReduce

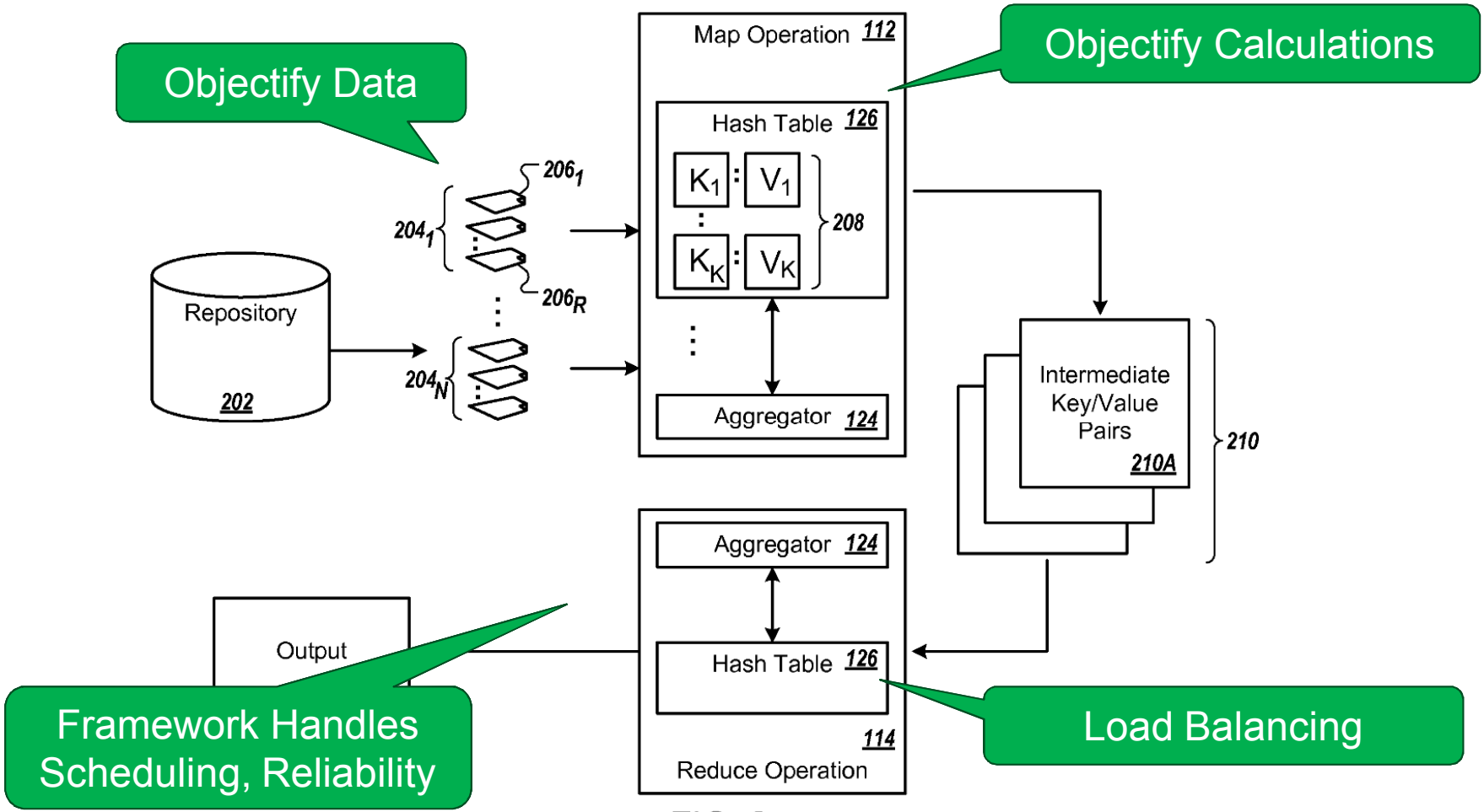


FIG. 2

Bad Points of MapReduce

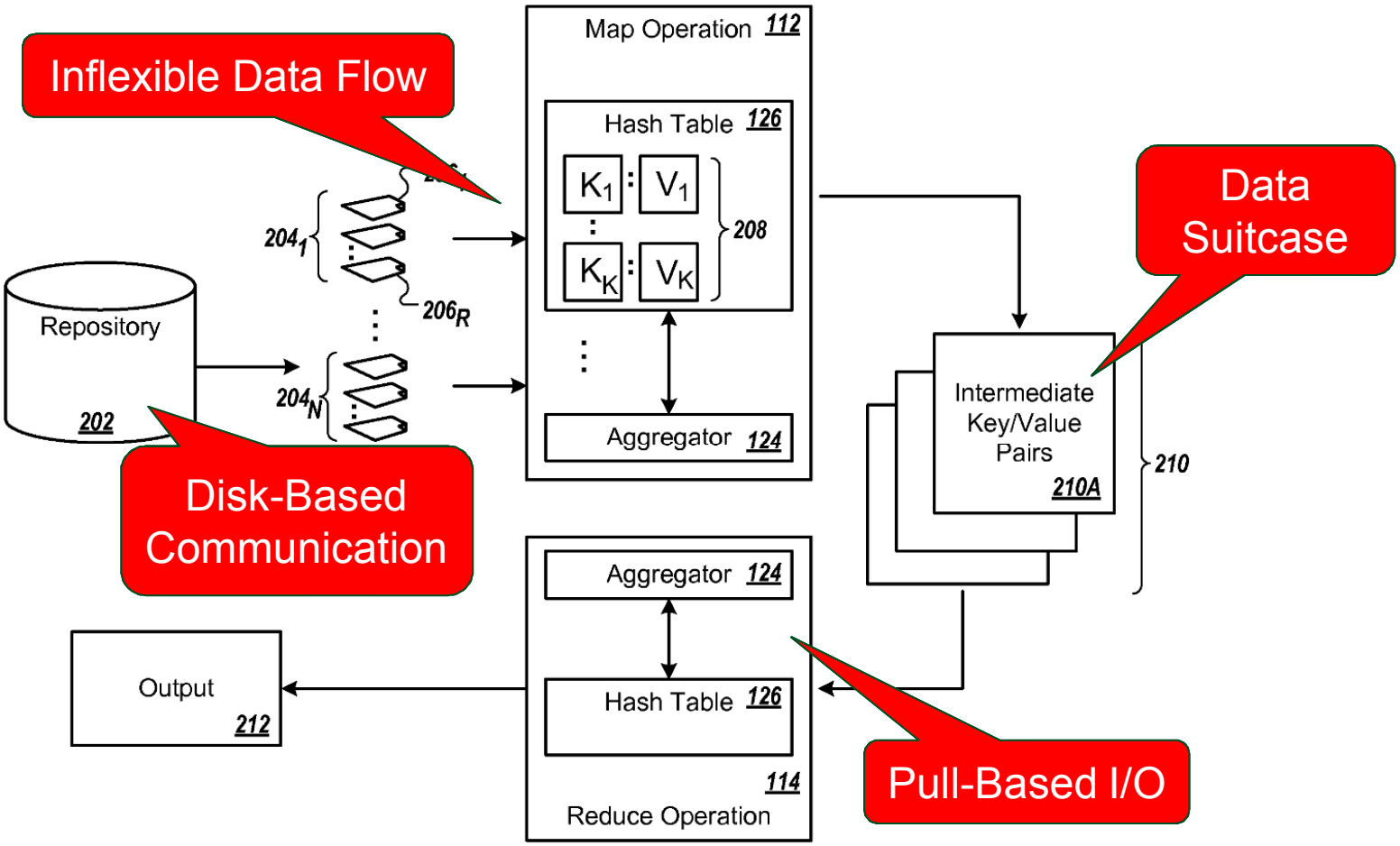


FIG. 2

Other Lessons from NoSQL

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- Frameworks trick users into providing useful info
  - Atomic operations, data boundaries
- Indirection is worthwhile
  - Frameworks can do more, Users micromanage less
- Basic functionality is often good enough
  - HDFS: Append-only writes
- 2D Stores > 1D Stores
  - Accumulo: Use a row to build an index generated by multiple writers
- Be open to alternatives
  - SQL vs NoSQL

Back to the HPC World

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- Are any of these ideas relevant to HPC?
- What are the main concerns in HPC today?
  - Reliability concerns
  - Architecture changes: Fat nodes
  - Application pipelines
  - New programming models
- Building blocks: Key/Value Stores

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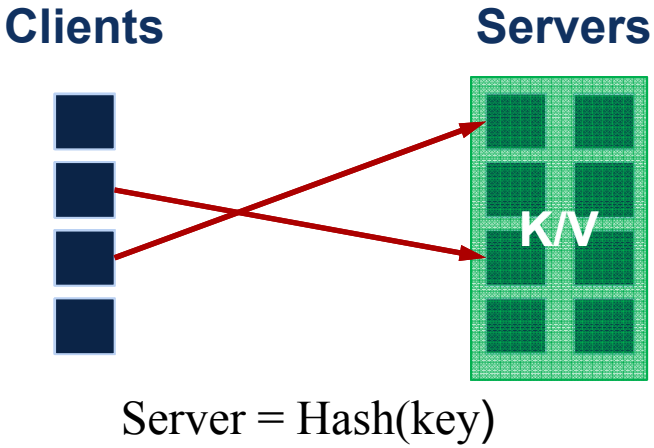
KEY/VALUE STORES

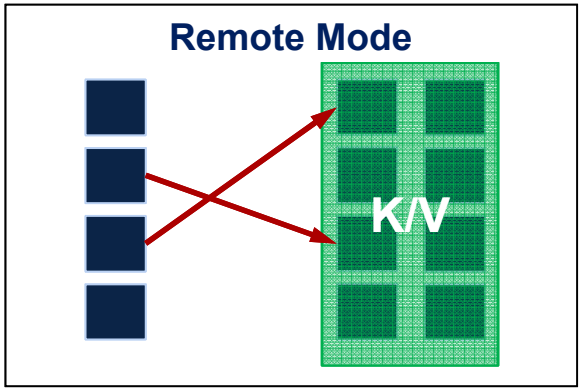
In-Memory, Key/Value Stores

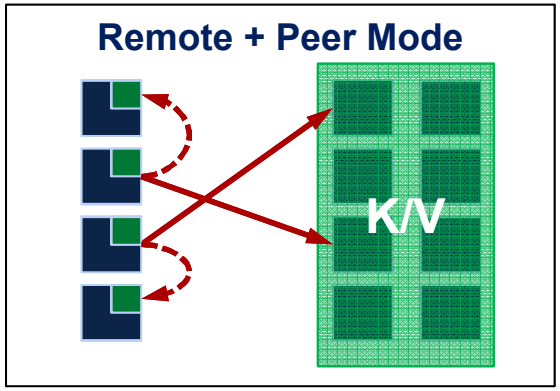
- KV Stores: an old idea with renewed interest
  - Distribute a number of servers to hold values
  - Use a key label to reference data
  - Put/Get interface
- Many existing packages
  - Cluster: Memcached, Redis, Kyoto Cabinet, RAMCloud,…
  - HPC: IBM PIMD

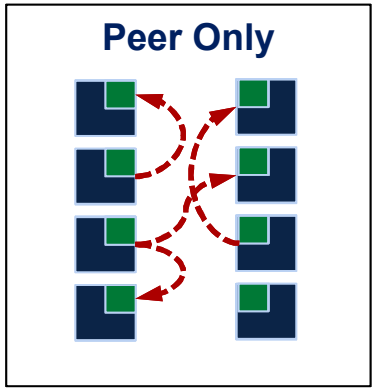


Kelpie: Distributed KV Store

- SNL Developing experimental KV Store for HPC
- Built on top of NESSIE
  - Portable RPC+RDMA library (IB, Gemini, BG/P, Portals, MPI)
- Typical KV with tweaks
  - 1D or 2D Keys
  - Optional Backing store (local/remote disks)
  - Different modes with *Location Hints*







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KV USE STORIES

[1/4] Application Caching and I/O

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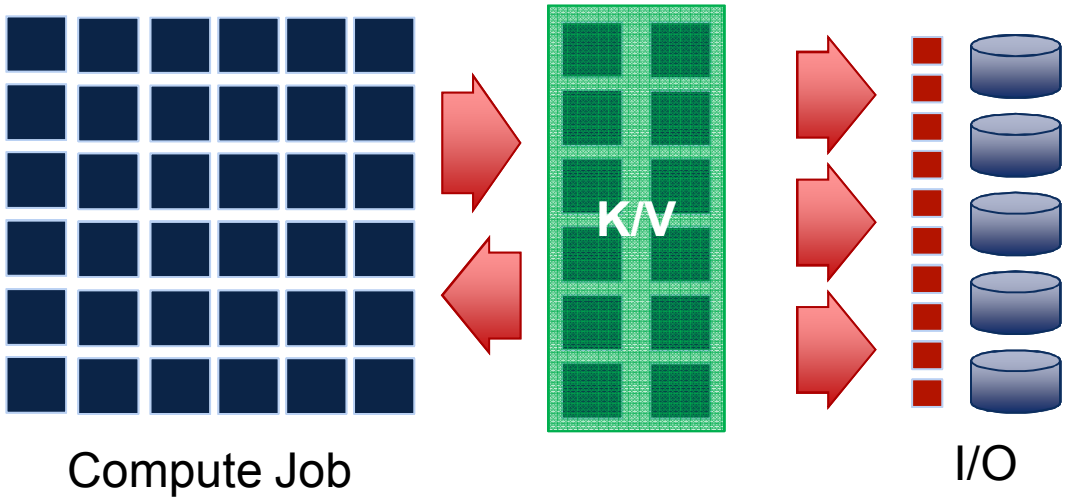
- Leverage K/V store simply as a way to store intermediate data
  - Users put/get blocks of data via references
  - Scale performance tradeoffs by adjusting K/V store size
  - Also useful for I/O swells



Forward/Reverse Cache

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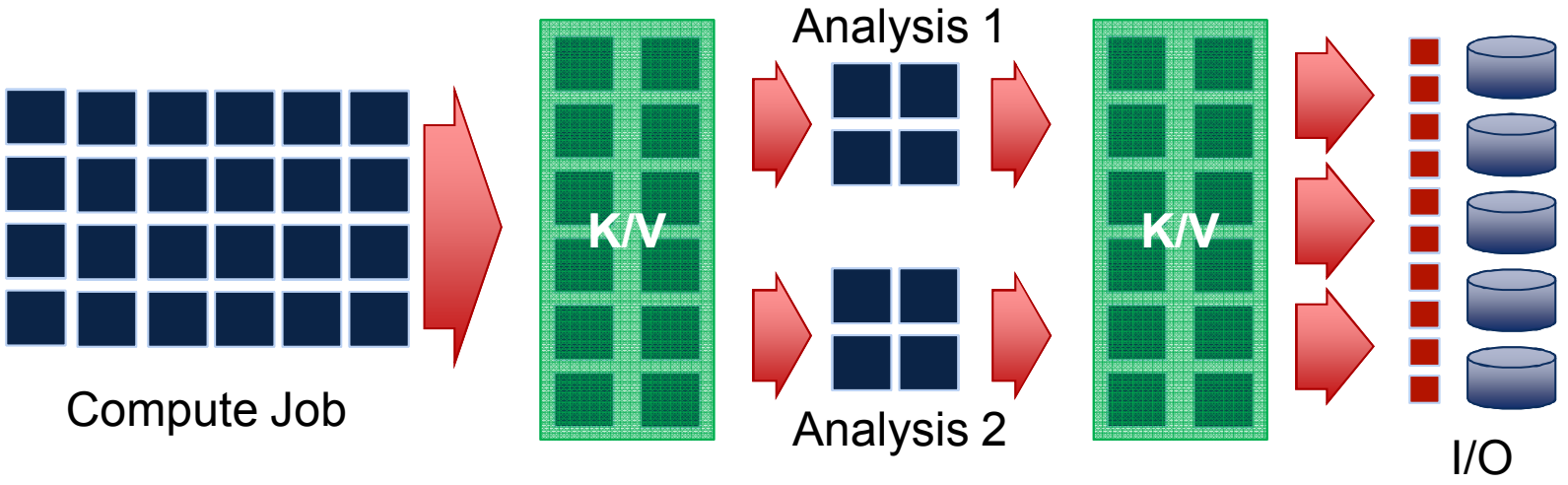
- BSP Code with forward/reverse dataflow
  - During reverse stages, reuse intermediates from forward stages
  - Requires in-memory storage to be practical
- Proxy application for tradeoff studies

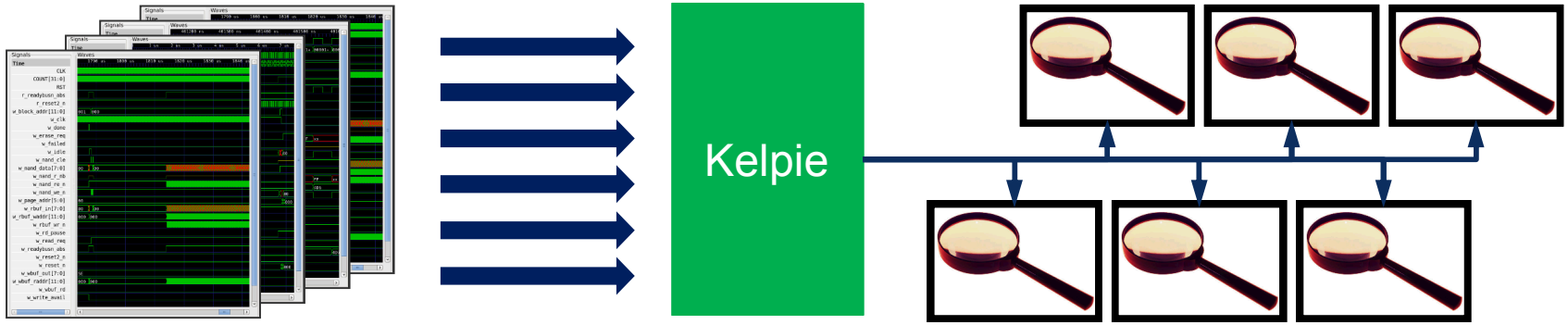
[2/4] Muli-Simulation Glue

- Many users need to join one monolithic job to another
  - Painful to add coupling – some use I/O as the medium
  - KV Stores provide a natural exchange point



Glue: Hardware Fuzzing

- SNL: Digital hardware fuzzing for reliability testing
  - Flight Recorder Design: Operates in RF-hostile environment
  - Will data corruption lock up the hardware?
- Parameter study: Many long-running VHDL/Verilog sims
  - Previously: Discovered two design problems over multi-month sim
  - Current: Capture waveforms, characterize, look for abnormalities



[3/4] Communication without MPI

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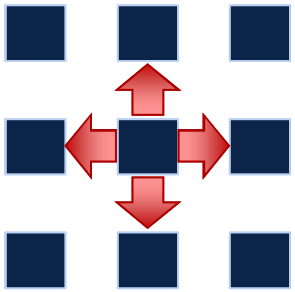
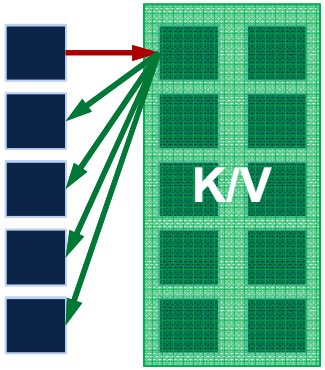
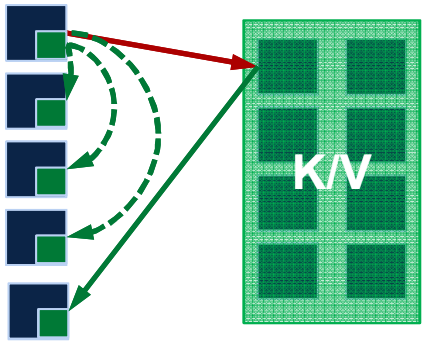
- Use KV Store for Inter-Process Communication
  - Work at a higher level of abstraction
  - May be of use in workloads with dynamic data flows
  - **Warning**: MPI does IPC very, very well
- Early experiences porting **Mantevo** applications
  - Positive: Feels more like symbolic language
  - Negative: Performance loss due to indirection



Direct



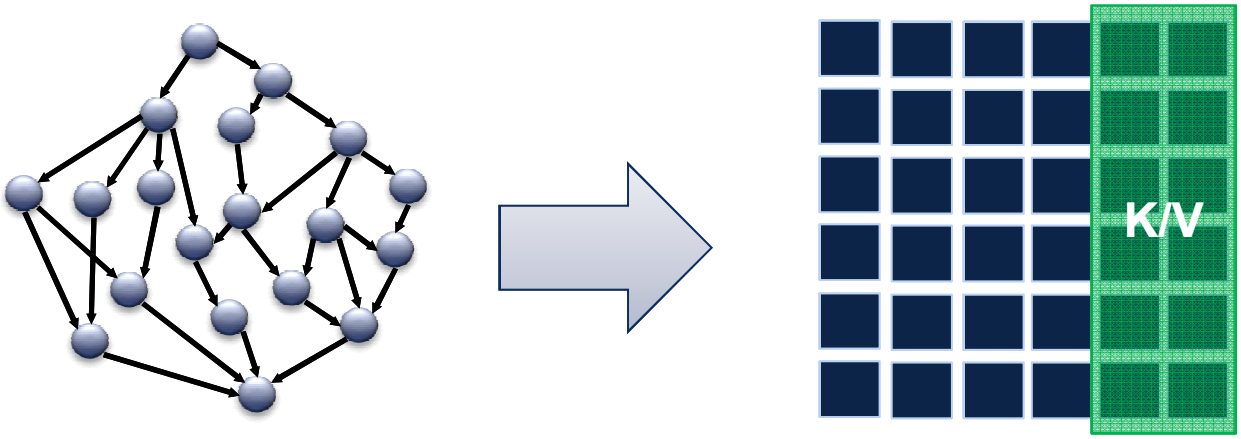
Indirect



Indirect with Peer Help

[4/4] Frameworks

- Many are working on computational frameworks for HPC
  - ASCR FOX: Fault-Oblivious eXecution
  - SNL: DAG Task Scheduling for Reliability
- KV Stores provide a useful starting point
- Go/MR: GoLang implementation of MapReduce
  - Utilizes Kelpie for storing objects
  - 2D Keys useful for collecting related items



Summary

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- NoSQL efforts tested out a variety of interesting concepts
- Key/Value Stores are a valuable service for HPC
- Kelpie
  - Currently tested at small scale on IB, BG/P, and Gemini
  - Expanding our user examples and making more robust
  - Planned external release in June