Argonne NATIONAL LABORATORY

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IOFSL

Scalable HEC I/O Forwarding Layer

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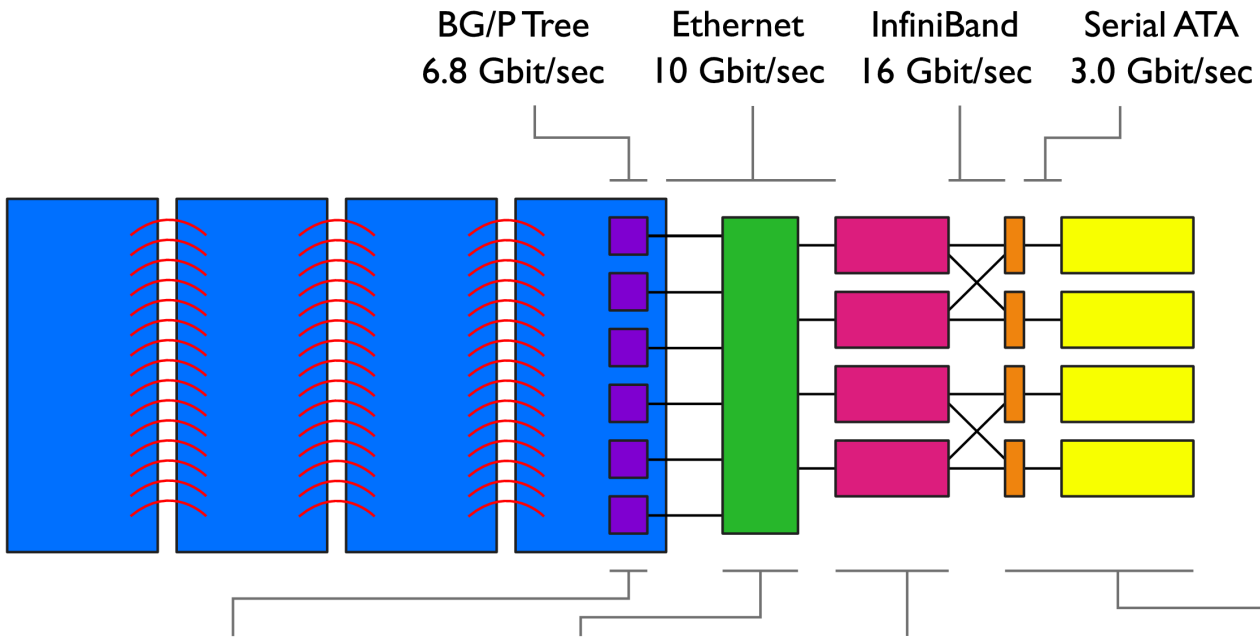
Contents

Motivation

Research into I/O infrastructure for petascale architectures:

- Today: 100K nodes (LLNL BG/L), 300K cores (Juelich BG/P)
  - will filesystems be able to handle an order of magnitude more?
- Argonne's 557 TF Blue Gene/P (Intrepid):
  - 20% of the money spent on I/O
  - full memory dump takes over 30 minutes
- I/O quickly becoming *the* bottleneck

Hardware Overview



Gateway nodes run parallel file system client software and forward I/O operations from HPC clients.

640 Quad core PowerPC 450 nodes with 2 Gbytes of RAM each

Commodity network primarily carries storage traffic.

900+ port 10 Gigabit Ethernet Myricom switch complex

Storage nodes run parallel file system software and manage incoming FS traffic from gateway nodes.

136 two dual core Opteron servers with 8 Gbytes of RAM each

Enterprise storage controllers and large racks of disks are connected via InfiniBand or Fibre Channel.

17 DataDirect S2A9900 controller pairs with 480 1 Tbyte drives and 8 InfiniBand ports per pair

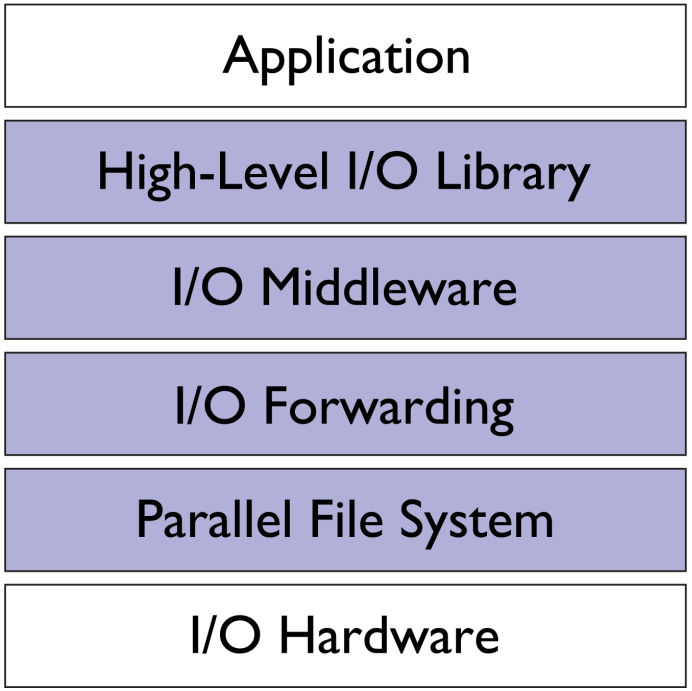
Software Overview

High-Level I/O Library
maps application abstractions onto storage abstractions and provides data portability.

HDF5, Parallel netCDF, ADIOS

I/O Forwarding
bridges between app. tasks and storage system and provides aggregation for uncoordinated I/O.

IBM ciod



I/O Middleware
organizes accesses from many processes, especially those using collective I/O.

MPI-IO

Parallel File System
maintains logical space and provides efficient access to data.

PVFS, PanFS, GPFS, Lustre

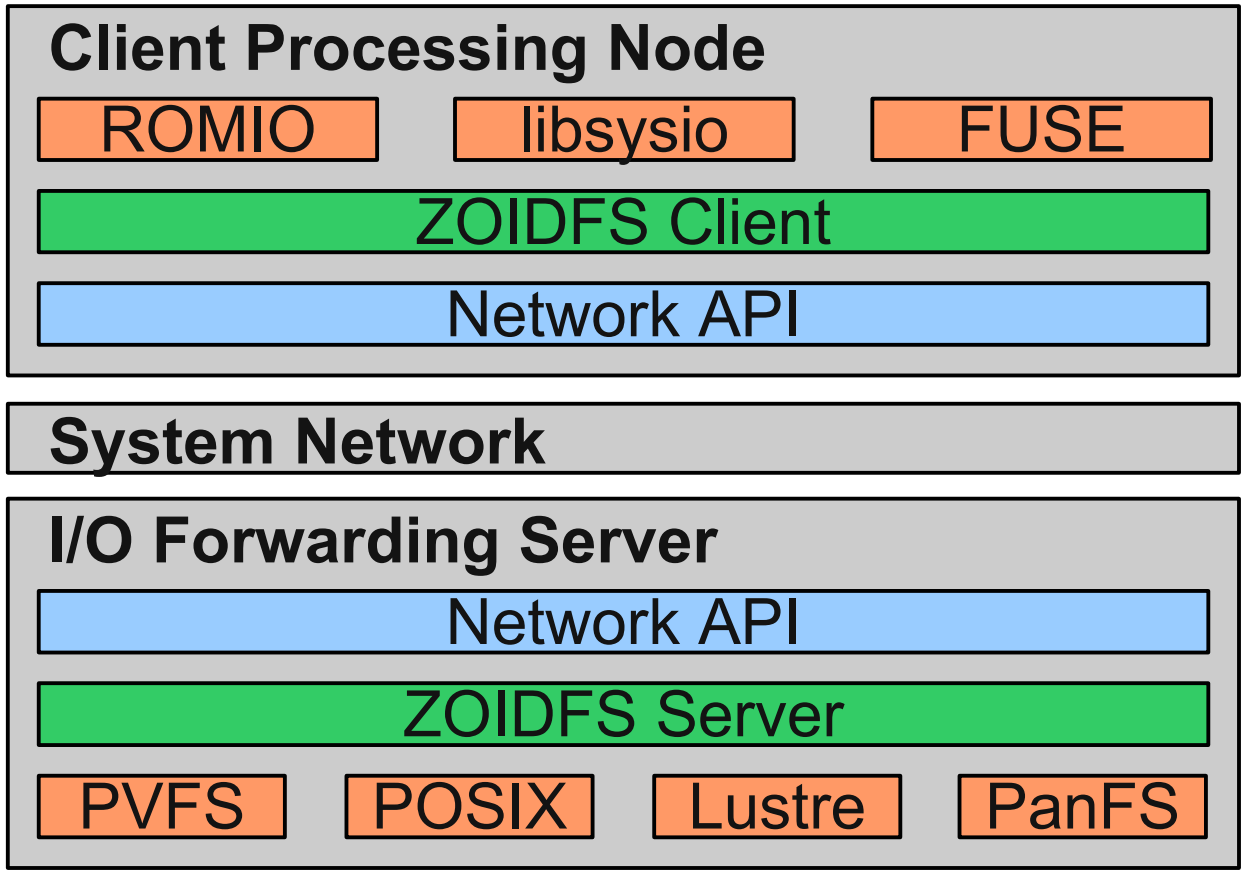
- We need to make I/O software as efficient as possible

Mission

Design, build, and distribute a scalable, unified high-end computing I/O forwarding software layer that would be adopted and supported by DOE Office of Science and NNSA.

- Reduce the number of file system operations/clients that the parallel file system sees
- Provide function shipping at the file system interface level
- Offload file system functions from simple or full OS client processes to a variety of targets
- Support multiple parallel file system solutions and networks
- Integrate with MPI-IO and any hardware features designed to support efficient parallel I/O

I/O Forwarding Framework



ZOIDFS Protocol

- Stateless
- NFSv3-like protocol
- opaque, 32-byte **`zoidfs_handle_t`** (no file descriptors)
- **`zoidfs_lookup`**, **`zoidfs_create`** (no open, close)
- **`zoidfs_getattr`** retrieves only the requested attributes
- **`zoidfs_readdir`** can do **`getattr`** if requested
- Maximally flexible **`zoidfs_read`**, **`zoidfs_write`**:

```
int zoidfs_read(const zoidfs_handle_t *handle,
                size_t mem_count,
                void *mem_starts[],
                const size_t mem_sizes[],
                size_t file_count,
                const uint64_t file_starts[],
                uint64_t file_sizes[]);
```

BMI

- Buffered Message Interface
- Designed for PVFS2
- Asynchronous
- Thread-safe
- Support for multiple networks:
  - TCP
  - IB
  - GM, MX
  - Portals
  - (need to write one for Blue Gene)
- XDR-encoded metadata between clients and servers
  - data payload sent using expected messages

ZOIDFS Server

- Two server designs (basic and advanced)
- Multi-threaded or state machine
- “native” PVFS and POSIX drivers
- Will also use libsysio as file system abstraction layer
- Planning to leverage a cooperative caching layer from a related NSF project
- Planning to use pipelining for large requests
  - instead of fragmenting of requests on the client side
  - requires careful buffer management

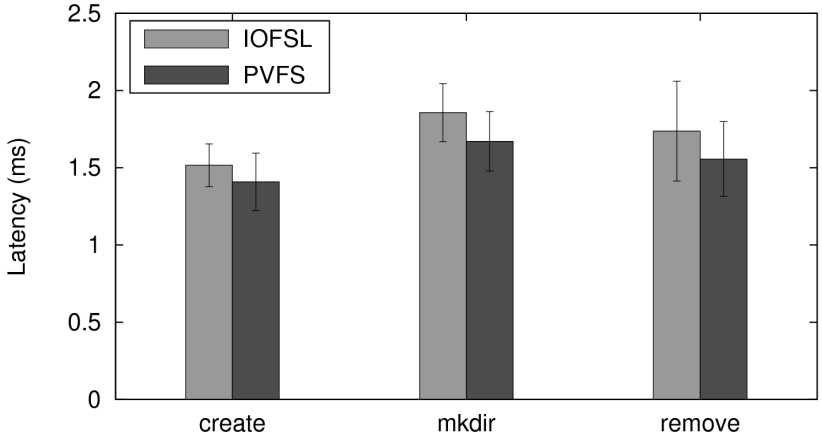
POSIX Support

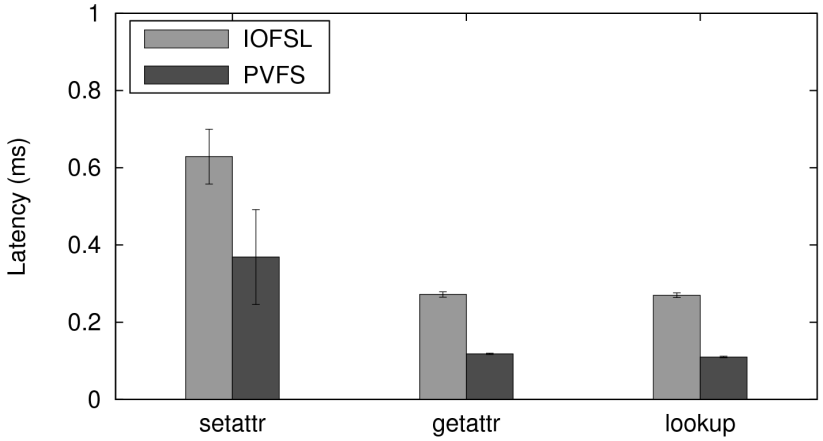
- Client-side:
  - FUSE (works, but performance not explored)
  - SYSIO (still to be implemented)
- Server-side:
  - SYSIO (still to be integrated) has a “native” POSIX driver
  - Custom ZOIDFS POSIX driver
  - How to translate between file handles and file descriptors?
    - *File handles are stateless, persistent, and global*
    - *Globally accessible database?*
    - *ESTALE for unknown handles forces a re-lookup*

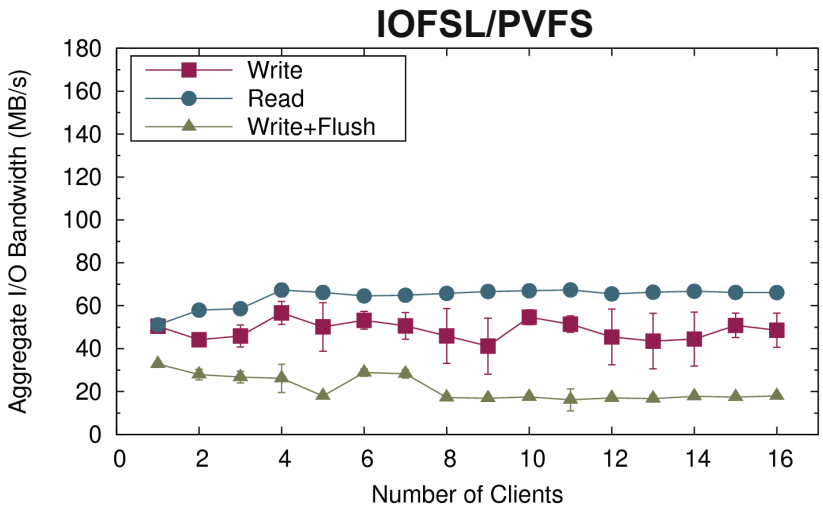
Security

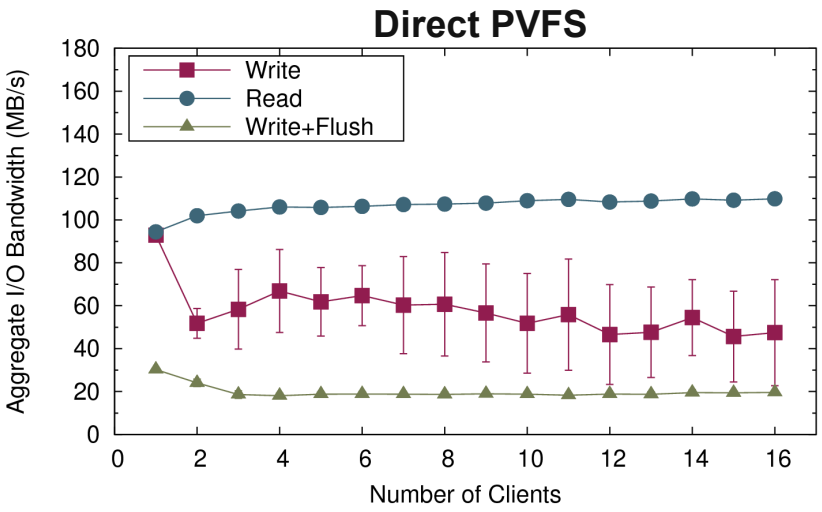
- NNSA labs care...
- Concerns:
  - authentication
  - authorization
- I/O forwarding servers might need to forward data of multiple users
- Add credentials to requests
- We will use POSIX test suite from The Open Group, which includes a security module

Early Measurements









- On this platform, IOFSL just introduces overhead

Current Status

- Client:
  - FUSE client implemented
  - Basic ROMIO driver implemented
- Networking:
  - BMI extracted from PVFS
  - ZOIDFS over BMI implemented
- Server:
  - Several server designs explored
  - libsysio file handle and credentials interfaces implemented
  - ZOIDFS to PVFS and POSIX drivers implemented

Future

- Integrate libsysio on both client and server
- Pipelining
- Test on Cray XT
- Support for Blue Gene
- Cooperative caching between servers
- Security

- http://www.iofsl.org/ (mostly a placeholder for now)

(if you see this slide, then I must have pressed End instead of PgDn)