HPSS/DFS: Integration of a Distributed File System with a Mass Storage System

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HPSS
High Performance Storage System

ornl

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Los Alamos

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Motivation

- Information intensive era
- Cost effective storage of data
- Efficient and seamless access to data

Storage of data

Memory hiearchy

Primary	RAM	60ns	$2 per MB
Secondary	Disk	8ms, ~40MB/s	$0.10 per MB
Tertiary	Tape	>4 min, ~5MB/s	$0.002 per MB

⟹ **Mass storage systems**

Access to data

- Integrated access
- Data integrity
- Security

→ File system

- Scalable across geographically disparate locations

→ Distributed file system

- High speed I/O

→ Parallel paths
Third party transfers

Solution

- Integrate filesystem with mass storage system
- Migrate data from filesystem to mass storage system
- Cache data from mass storage system to filesystem
- Transparent migration / caching
- Efficient migration/caching mechanism

Previous approaches

- Filesystem uses mass storage system at backend
  - DMF, AMASS
  - Needs kernel modifications with OS upgrades by mass storage system vendor

- Mass storage system implements a filesystem interface
  - CFS, Unitree, HPSS
  - Lacks benefits of distributed filesystems
  - May need specialized clients

Our approach

- DMAPI
  - Recent standard interface between filesystem and data management apps
  - Adopted by X/Open - XDSM

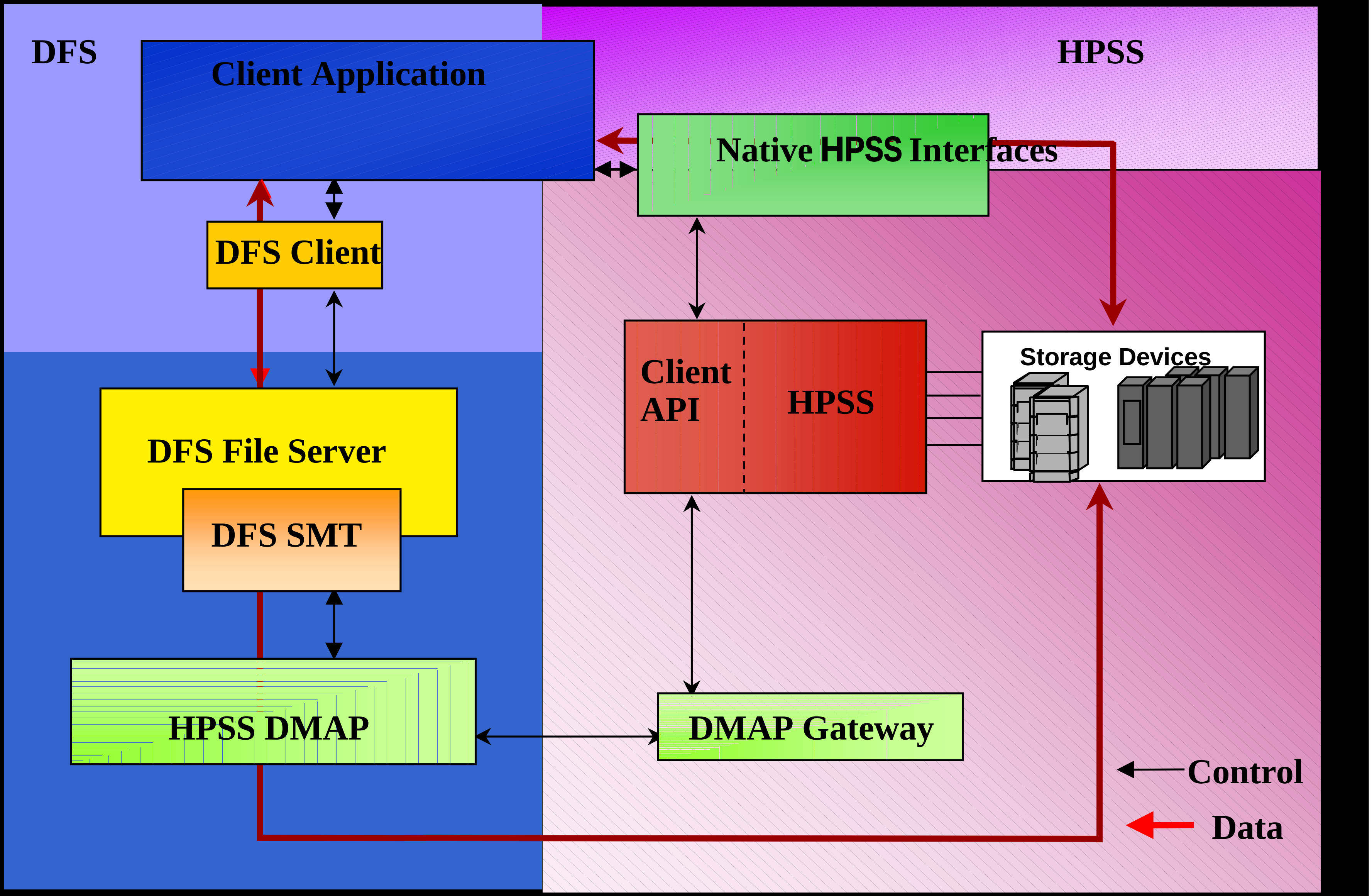
- Integrate
  - DFS ^{TM} distributed file system with
  - HPSS mass storage system
  - via DMAPI

- DFS Storage Management Toolkit (DFS SMT) layer
  - An implementation of the DMAPI standard for DFS
  - HPSS interface layer using DFS SMT

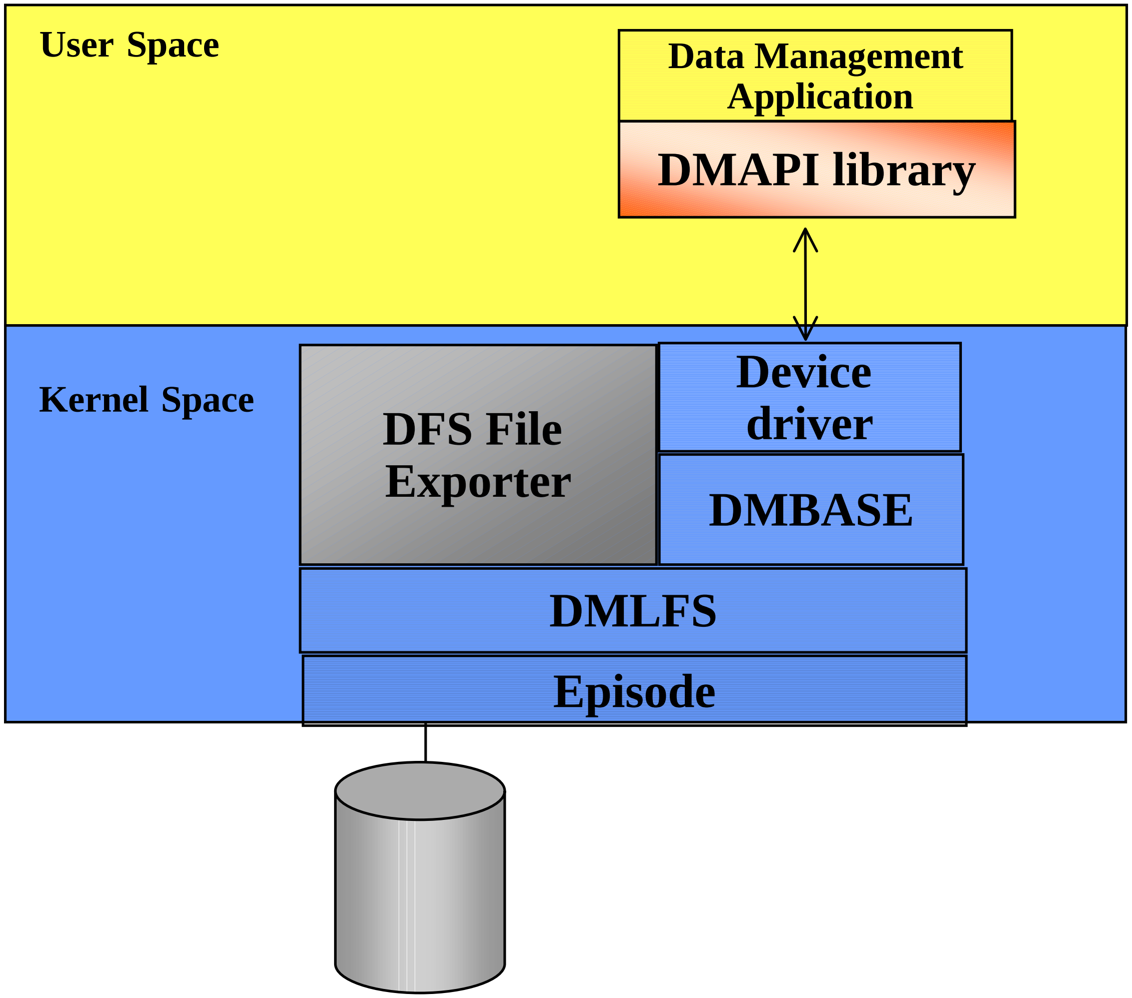
Our Requirements

- **Transparent archiving and caching of data**
- **Partial file residency**
- **No kernel mods by mass storage vendor across OS updates**
- **Preserve existing functionality/performance of DFS and HPSS**
    - **Add a mode where file modifications are visible in both DFS and HPSS**

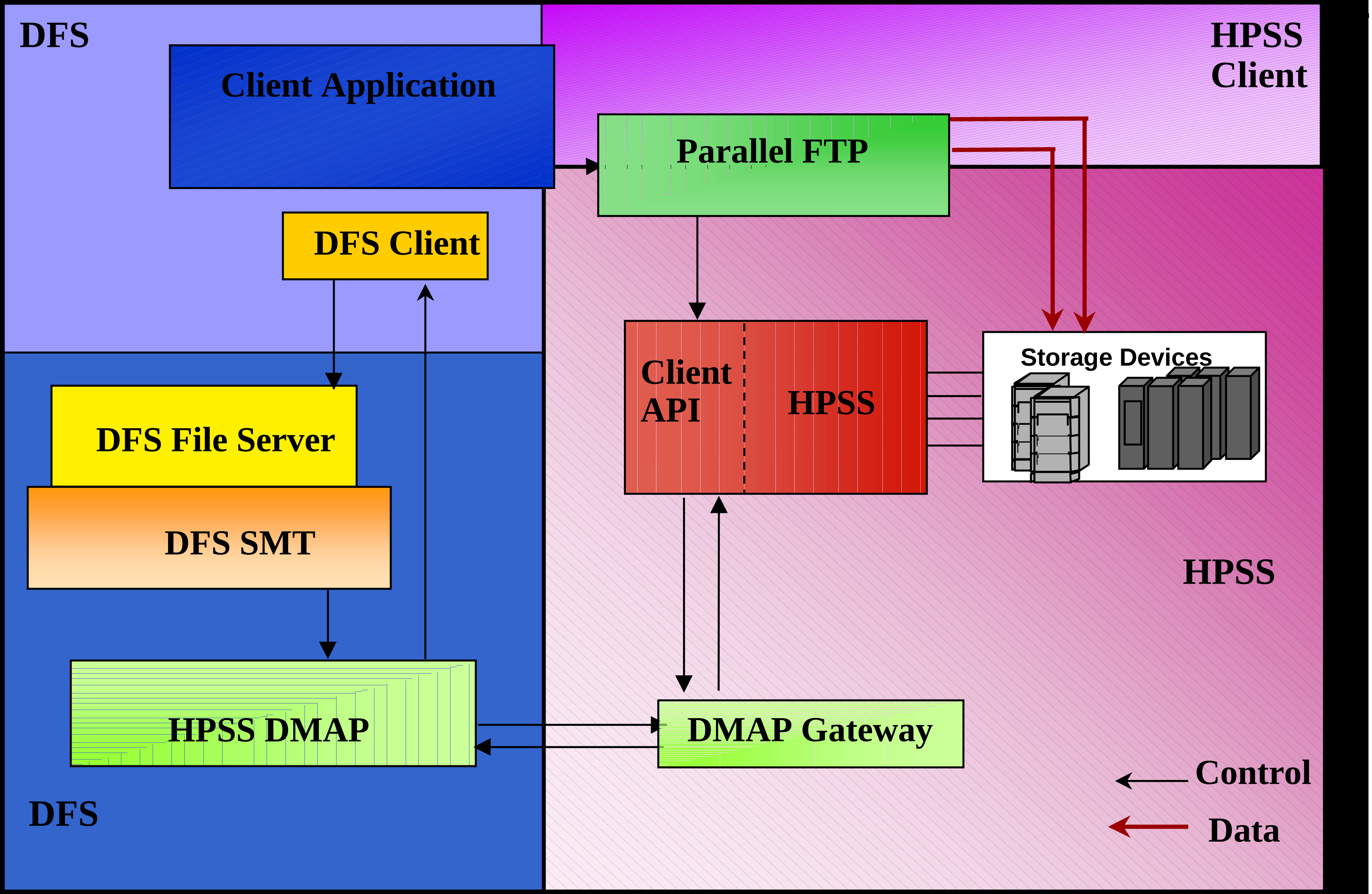
Integrated HPSS-DFS Architecture



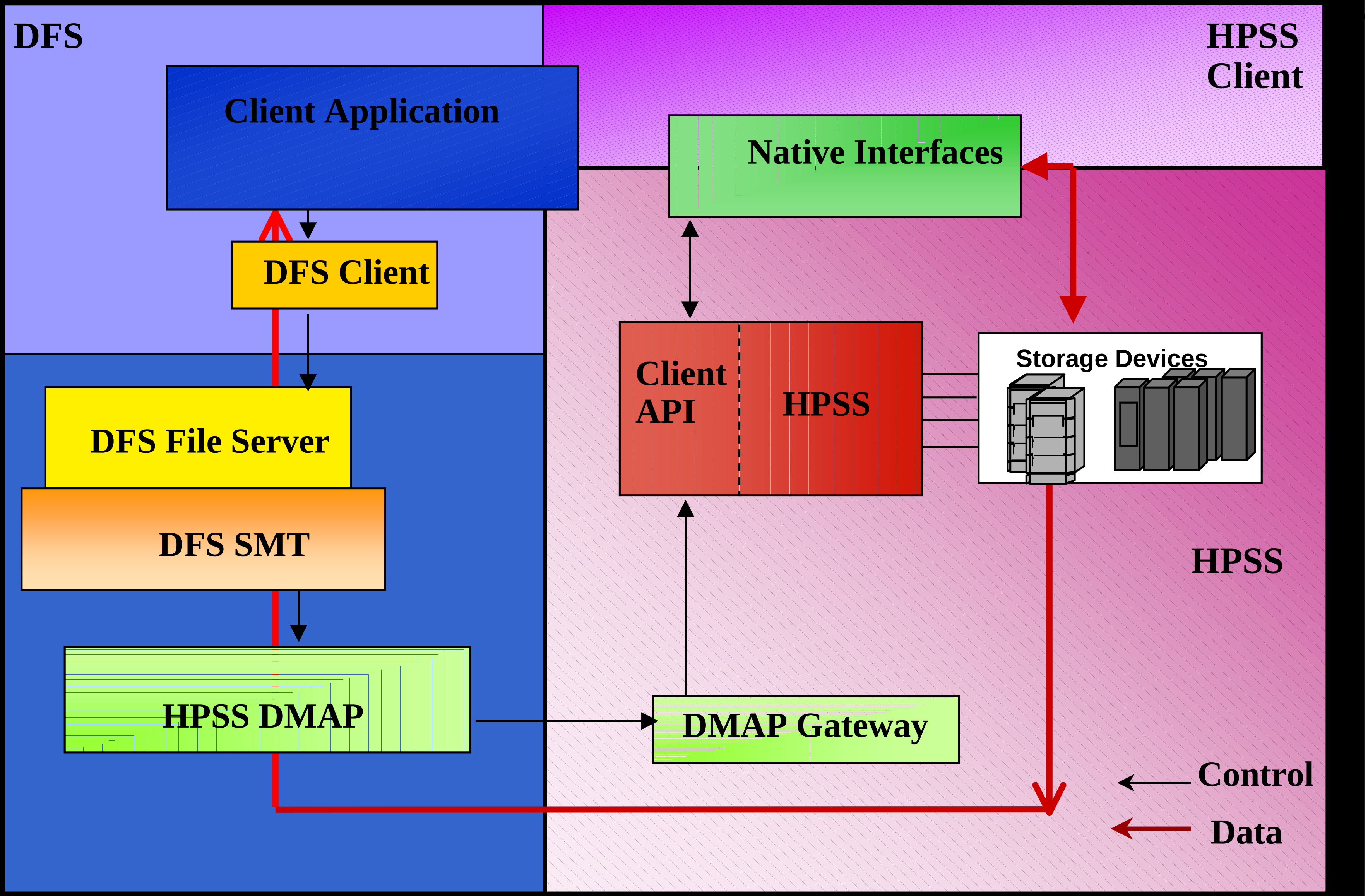
DFS Storage Management Toolkit (SMT) Architecture



HPSS Create Example



DFS Read Example



DFS SMT Features

- Filesystem sends notifications to DM application
- Then if necessary waits for response from DM application
- DM application processes notification
  - e.g. caches data into the filesystem from mass store
- DM application responds to the notification
- DM application can initiate operations on files via DMAPI
  - e.g. migrating data from filesystem to mass store
  - e.g. making migrated data non-resident in the filesystem

DFS SMT Features - 2

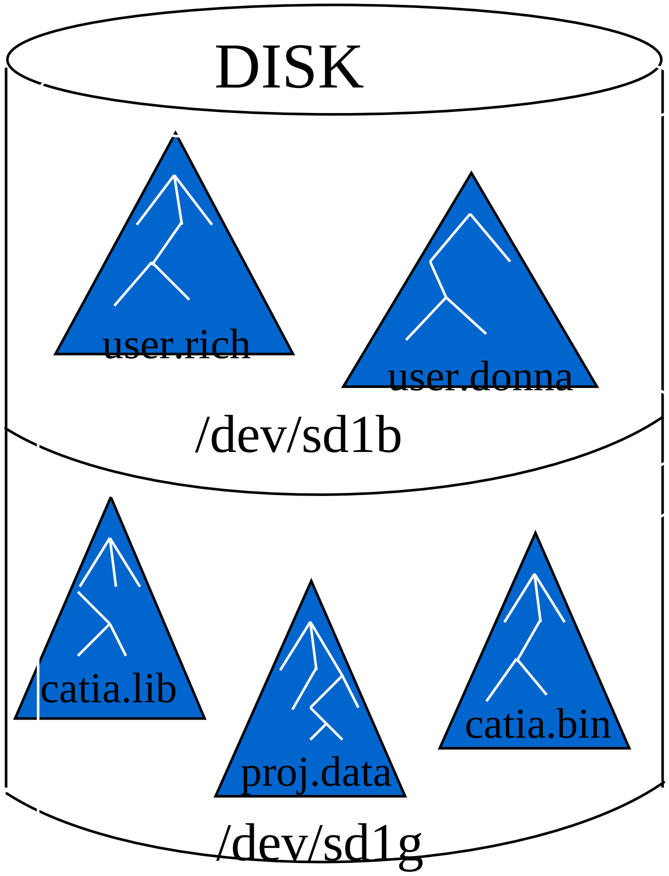
- Provides for storage of DM attributes with files
    - Filesystem visible attributes
        - e.g. filesystem operations which should generate notifications to DM app
    - Filesystem opaque attributes
        - Understood by DM application
        - e.g. pointers to migrated data
- Implements all required DMAPI features

DFS SMT Features - 3

- Many optional DMAPI features provided
    - Persistent event masks
    - Persistent managed regions
    - Persistent attributes
    - Real removal of residency of migrated data
    - Punch holes in files
- Non-blocking lock upgrades

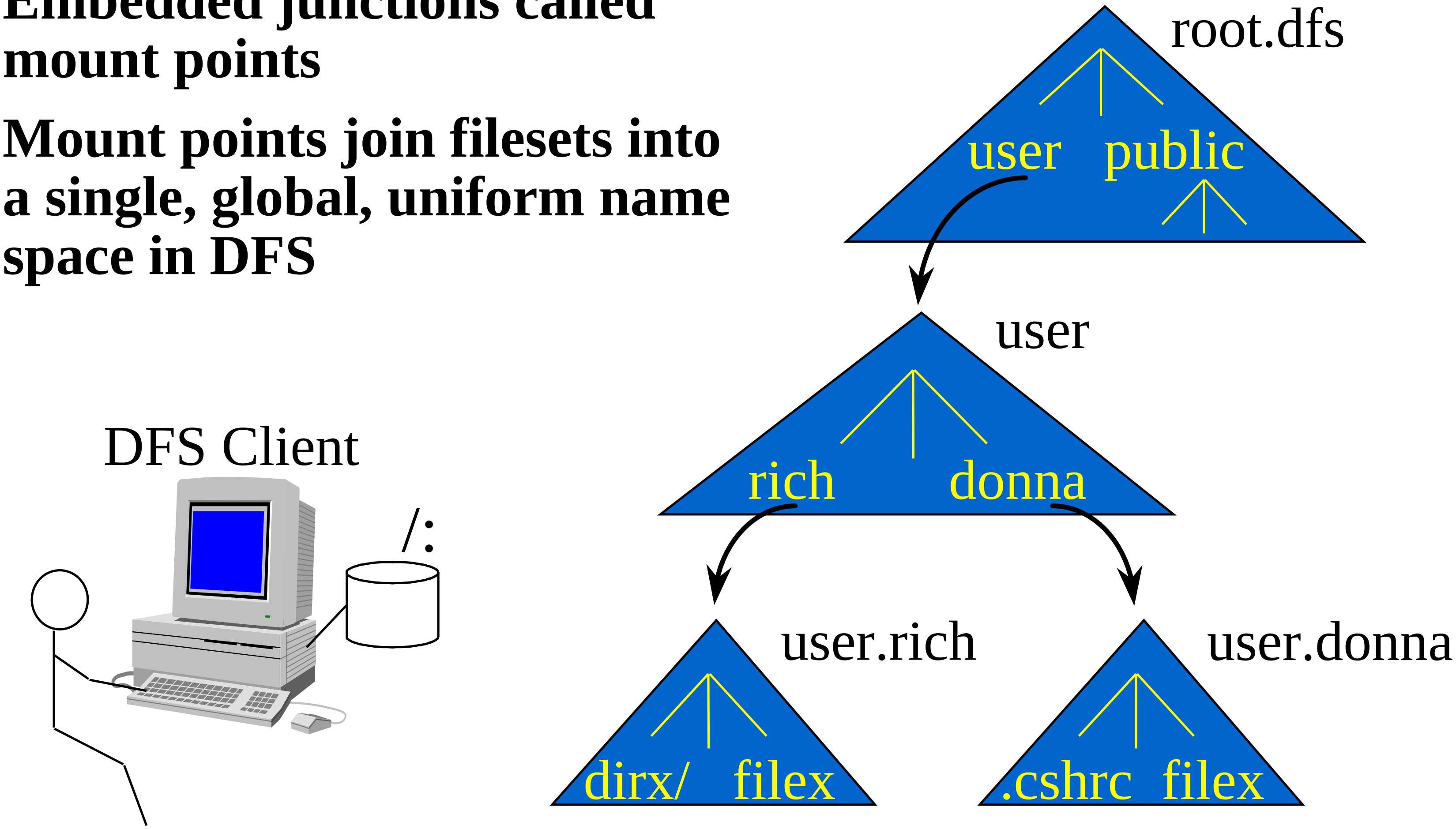
Concept - DFS Filesets

- Total file space at fileservers divided into *filesets*
- Each fileset is a separate tree-like filesystem
- Fileset: collection of related files
- Unit of administration, backup, replication



How are filesets linked in DFS?

- **Embedded junctions called mount points**
- **Mount points join filesets into a single, global, uniform name space in DFS**



Other DFS Additions

- Episode
  - Support for punching holes in files
    - Ability to mark holes as *offline* data for purged data
  - Support for storing file attributes for files
    - Attributes inherently linked with respective file (No auxiliary file)
- Data backup
  - Filesets are unit of data dump and restore
  - Dump/restore facilities extended for file attributes, purged holes
  - Migrated and purged data not recalled currently when dumping

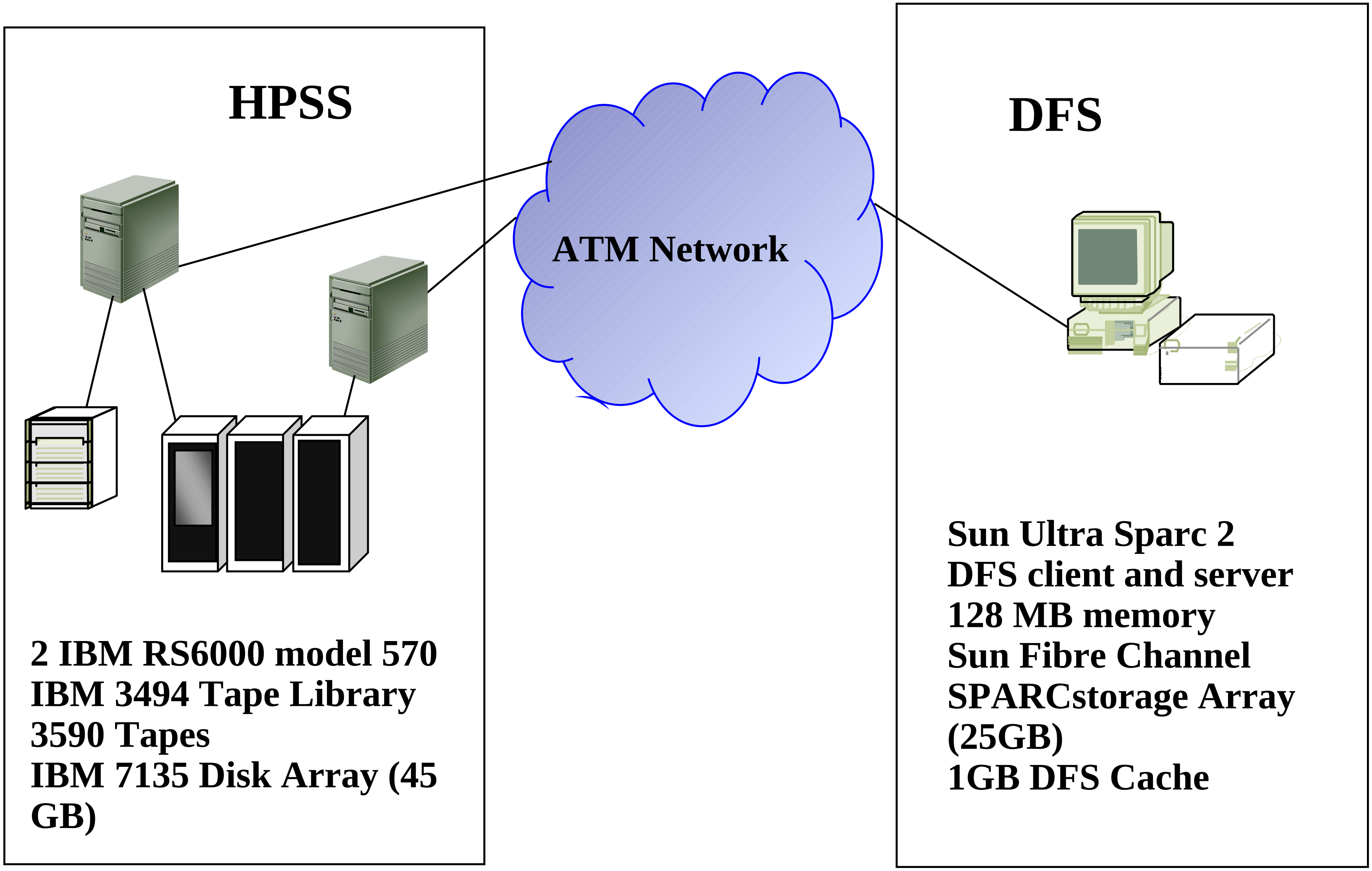
DMAPI Extensions for DFS SMT

- Filesets and aggregates
  - mounting/unmounting aggregates
  - fileset destruction
  - enumerate fileset information
- Management interfaces
  - Scan by attribute
  - DCE security authentication information
  - ACL / permission events
- Mirrored fileset support
  - Synchronous post events for name space modification
  - Events for permissions changes
  - Association of pre and post events

HPSS Additions

- Data residency supported in HPSS
  - HPSS Only
  - Archived
  - Mirrored
- Name Server
  - Fileset type
  - Junctions to link filesets into HPSS tree
- Client API
  - Fileset behavior
  - Junction processing
  - Shared transactional boundaries to support atomic behavior between DFS and HPSS
- Bitfile Server - data consistency
- File families

Performance Test Hardware Configuration at Sandia National Laboratories



HPSS

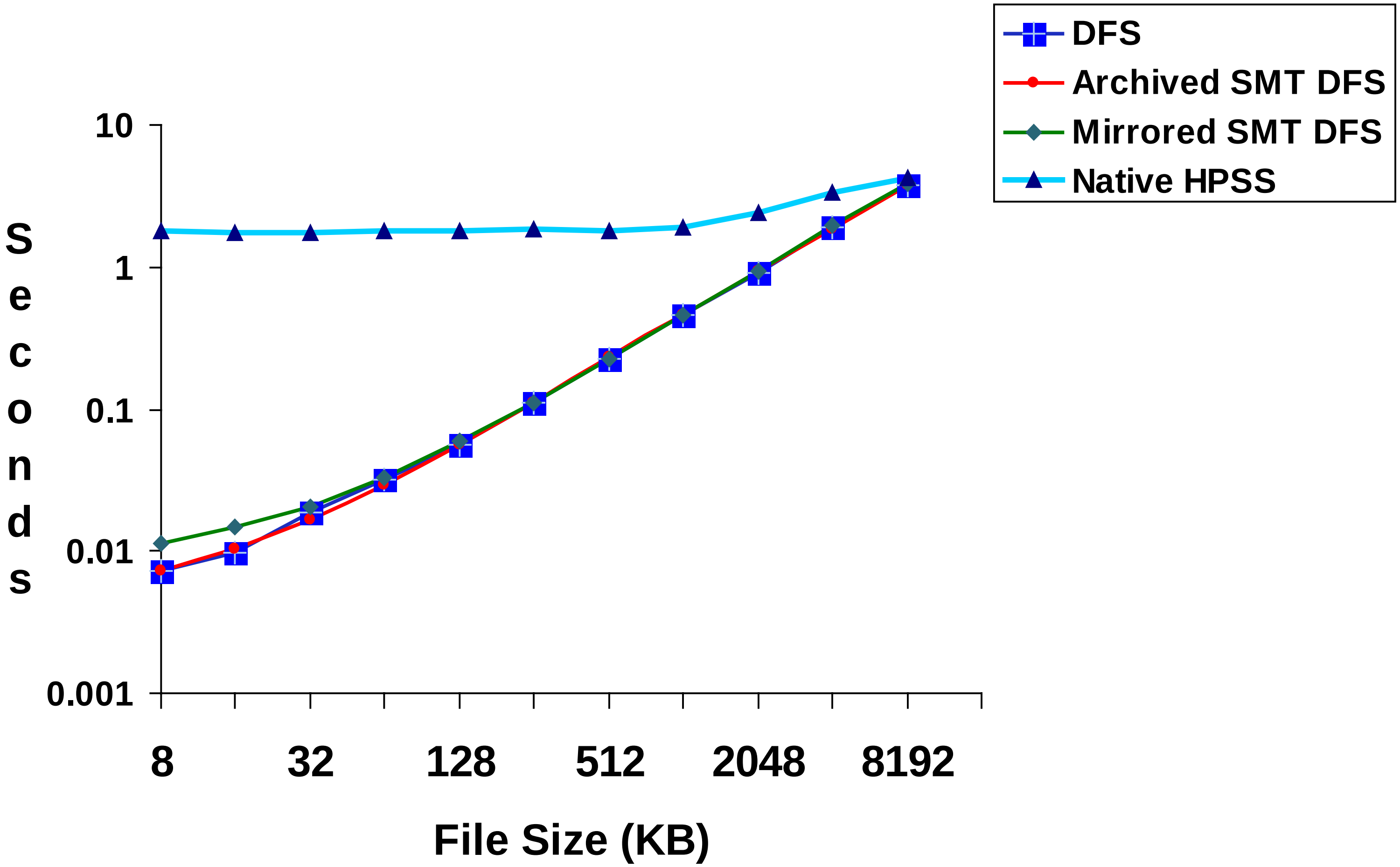
ATM Network

DFS

2 IBM RS6000 model 570
IBM 3494 Tape Library
3590 Tapes
IBM 7135 Disk Array (45 GB)

Sun Ultra Sparc 2
DFS client and server
128 MB memory
Sun Fibre Channel
SPARCstorage Array
(25GB)
1GB DFS Cache

Average Time to Write a File



Connectathon Test Description

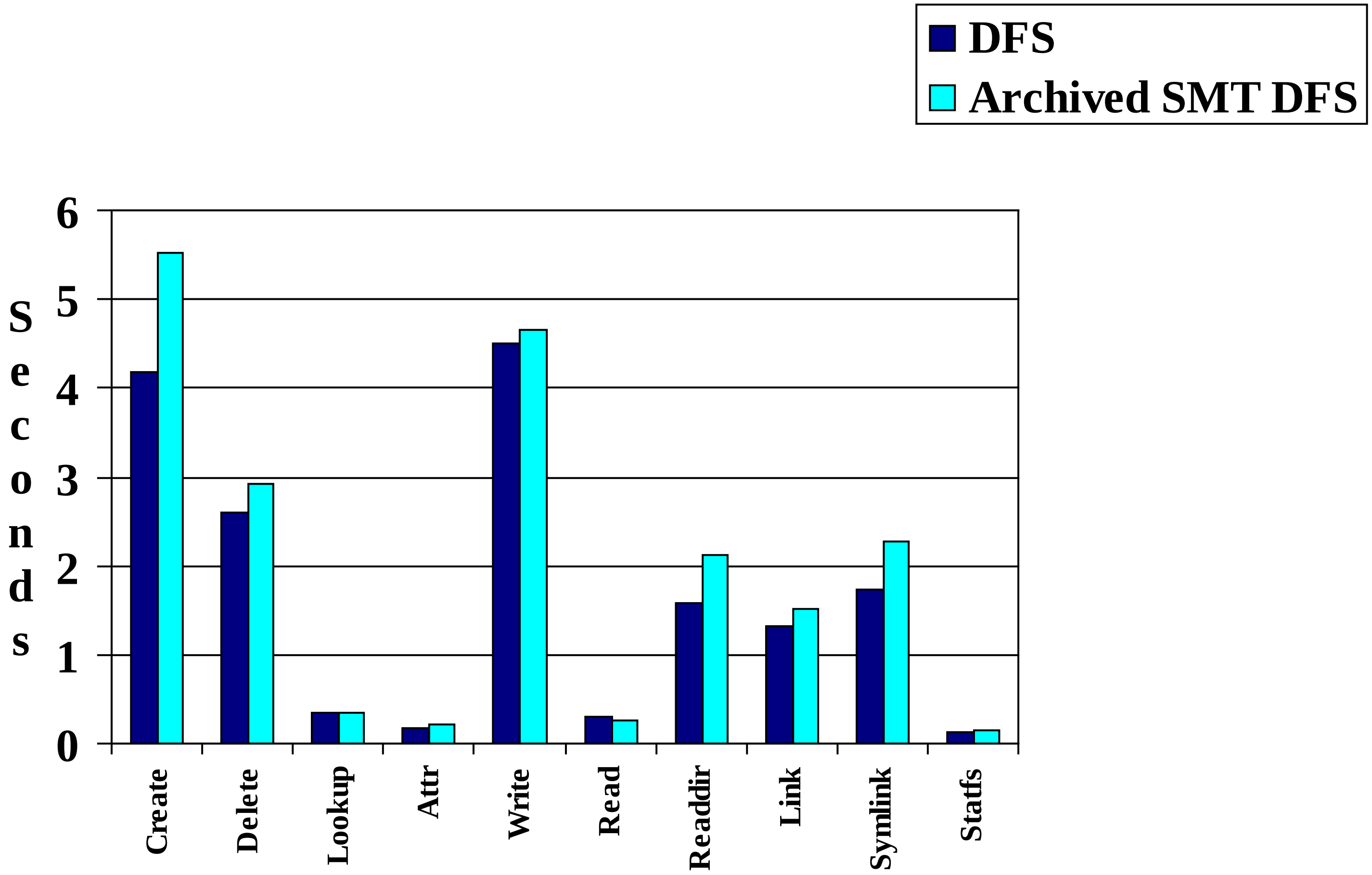
- **Create : create 155 files 62 directories 5 levels deep**
- **Delete: remove 155 files 62 directories 5 levels deep**

- **Lookup: 500 getwd and stat calls**
- **Attr: 1000 chmods and stats on 10 files**
- **Write: write 1MB file 10 times**
- **Read: read 1MB file 10 times**

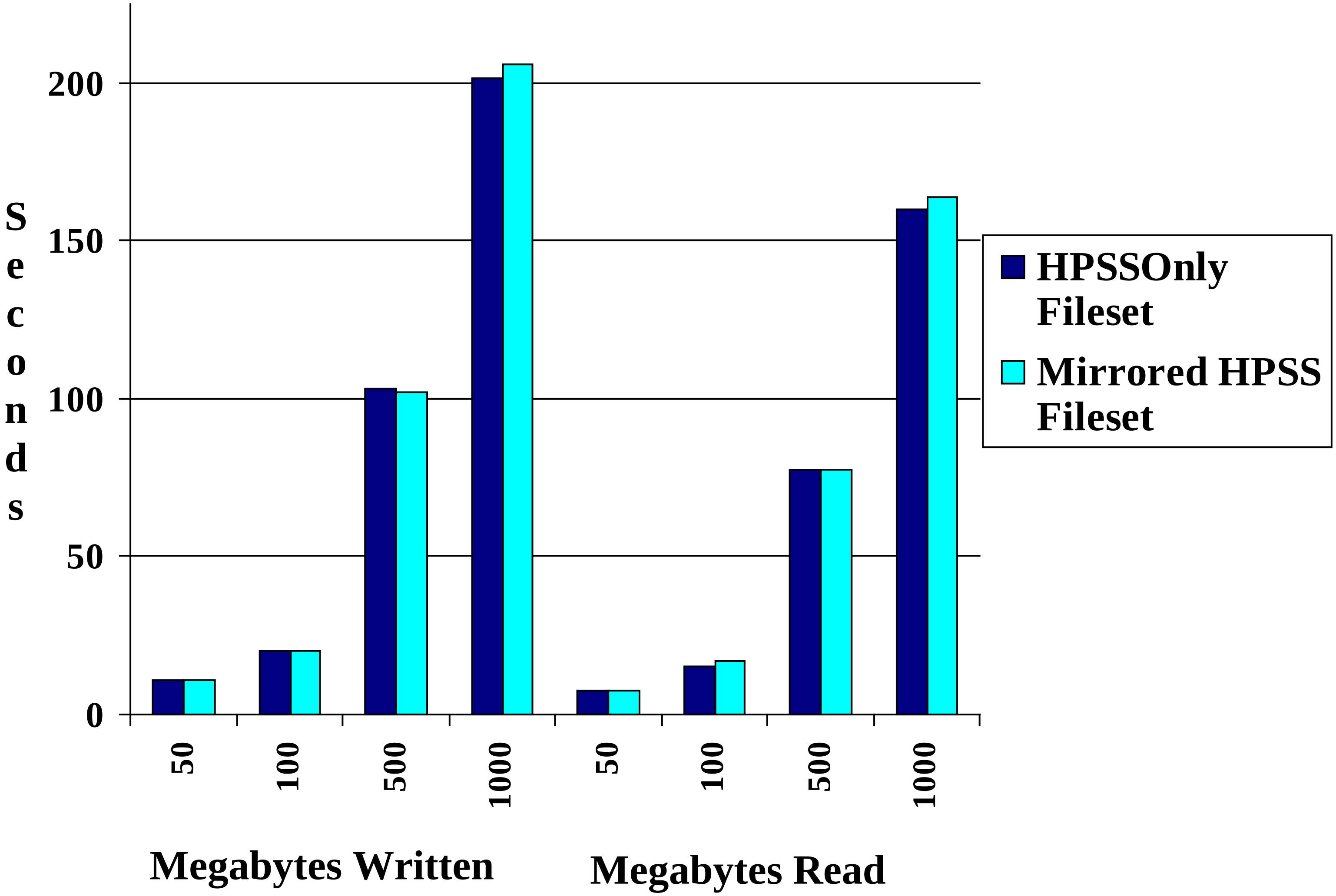
- **Readdir: 20500 entries read, 200 files**
- **Link: 200 renames and links on 10 files**
- **Symlink: 400 symlinks and readlinks on 10 files**

- **Statfs: 1500 statfs calls**

Integrated DFS Connectathon Performance



Integrated HPSS I/O Performance



Conclusions

- Flexible DFS/HPSS Integration

- Minimal impact on data I/O rates
  - Archived DFS file creation equivalent to DFS at 8KB
  - Mirrored DFS file creation equivalent to DFS at 32KB
  - Mirrored HPSS performance equivalent to native HPSS (<3% difference)

- Connectathon performance overhead
  - archived DFS connectathon performance overhead ~20%

- Greater administrative complexity

Future Work

- **DFS**
  - **Support for fileset movement and replication**
  - **Support for full fileset dumps**
  - **Client visible DM attributes**
- **HPSS DMAP ports to other platforms**
- **Easier administration tools**
- **Performance enhancements**
- **DMAPI extensions**
  - **better support for distributed systems**
  - **name space synchronization**
  - **parallel file system support**

Additional Information

- **HPSS URL:**

  www5.clearlake.ibm.com:6001

- **DFS URL:**

  www.transarc.com

- **Availability:**

  Sun Solaris and IBM AIX platforms

  July - September