SDC 20

BY Developers FOR Developers

Storage Developer Conference
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Marchive

Extending MarFS to a Long Term Archive

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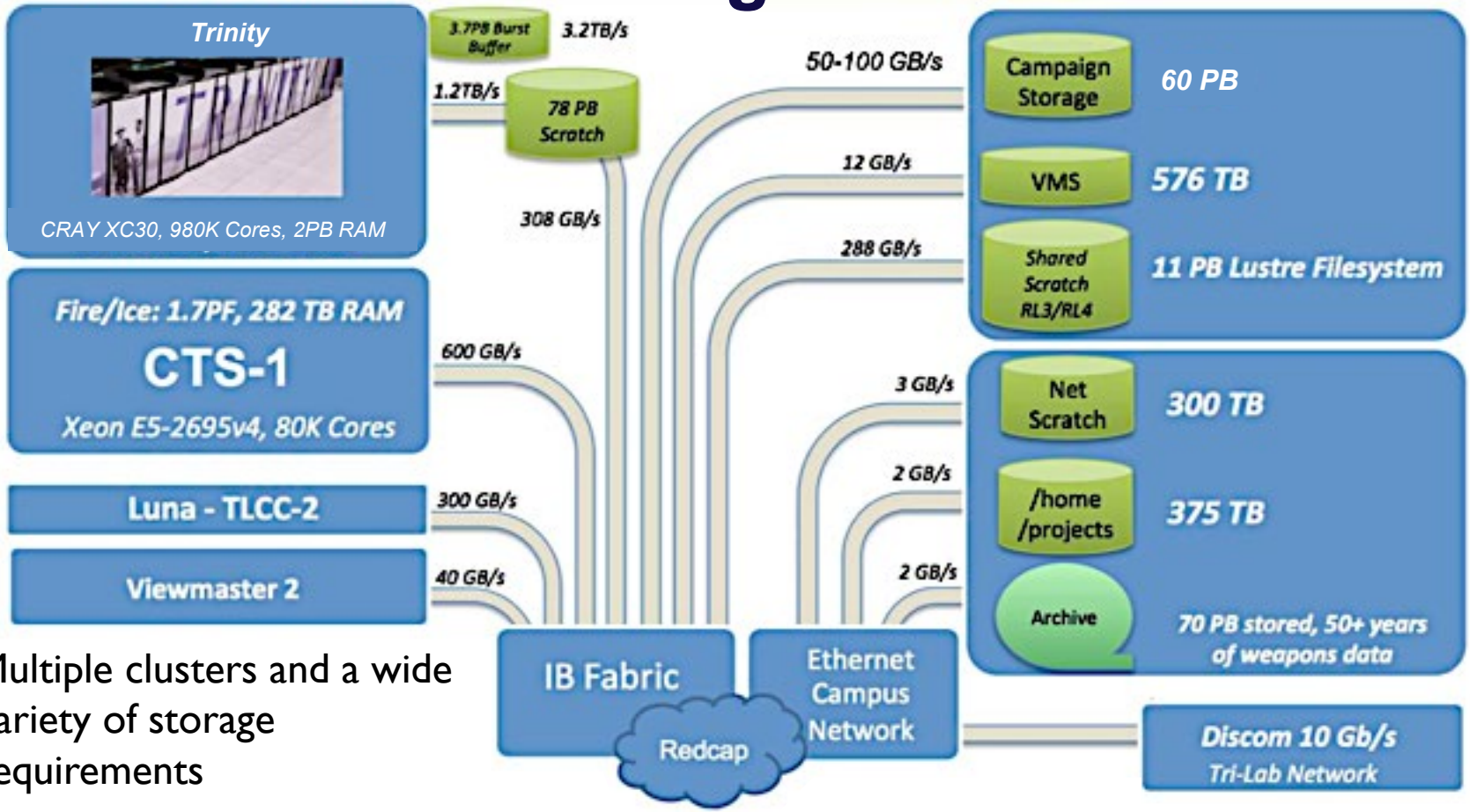
LA-UR-20-26667

HPC Storage at LANL



Multiple clusters and a wide variety of storage requirements

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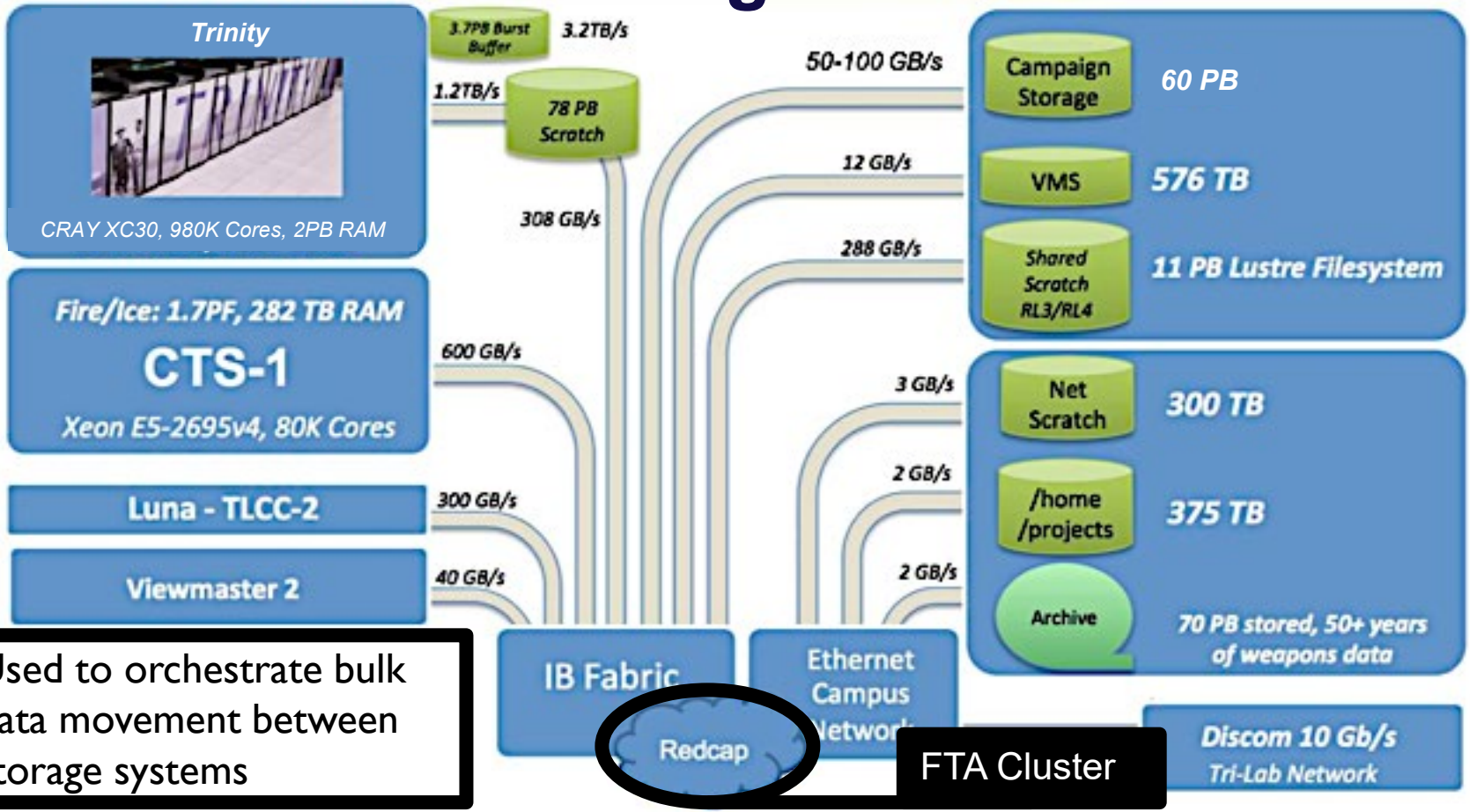
HPC Storage at LANL



Used to orchestrate bulk data movement between storage systems

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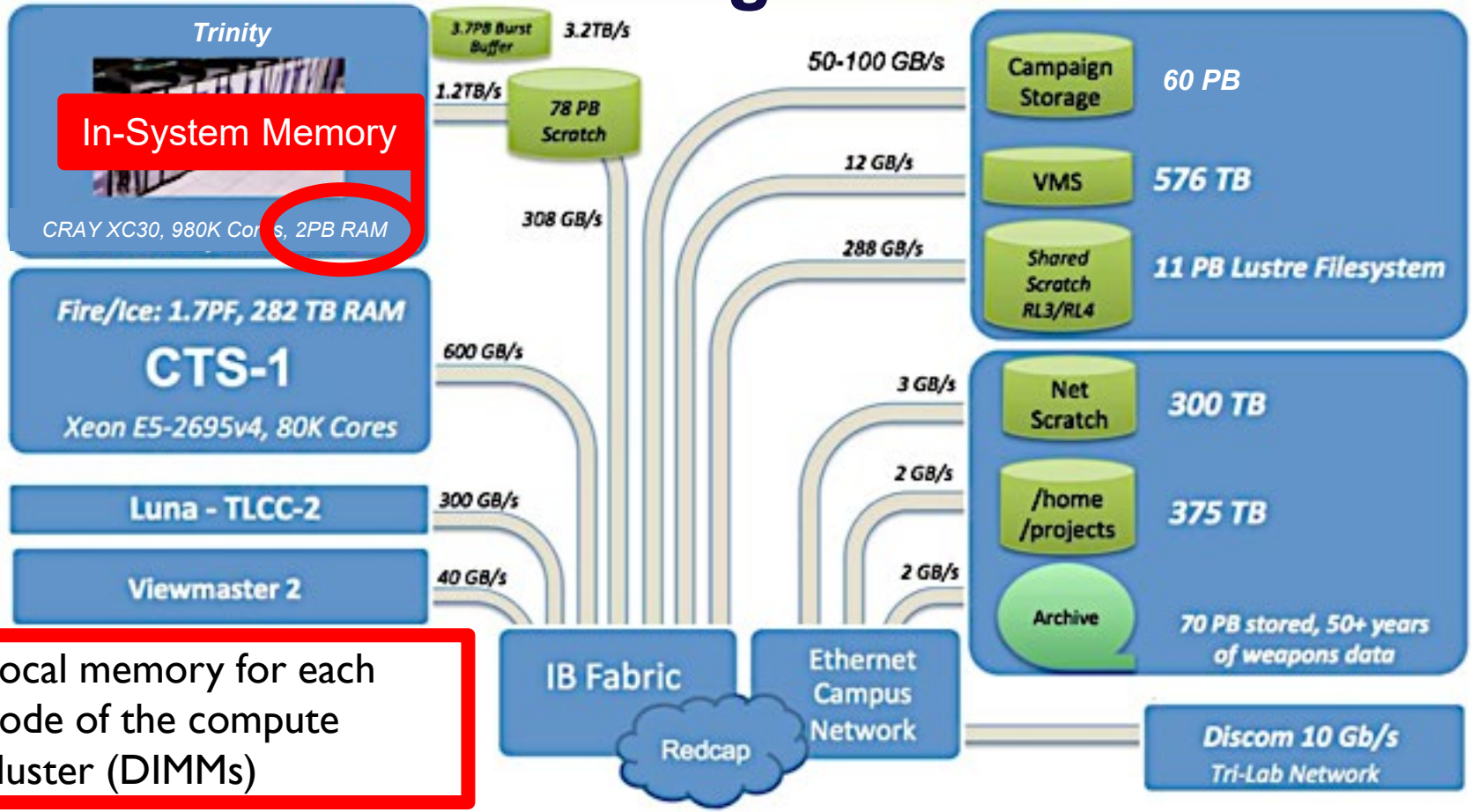
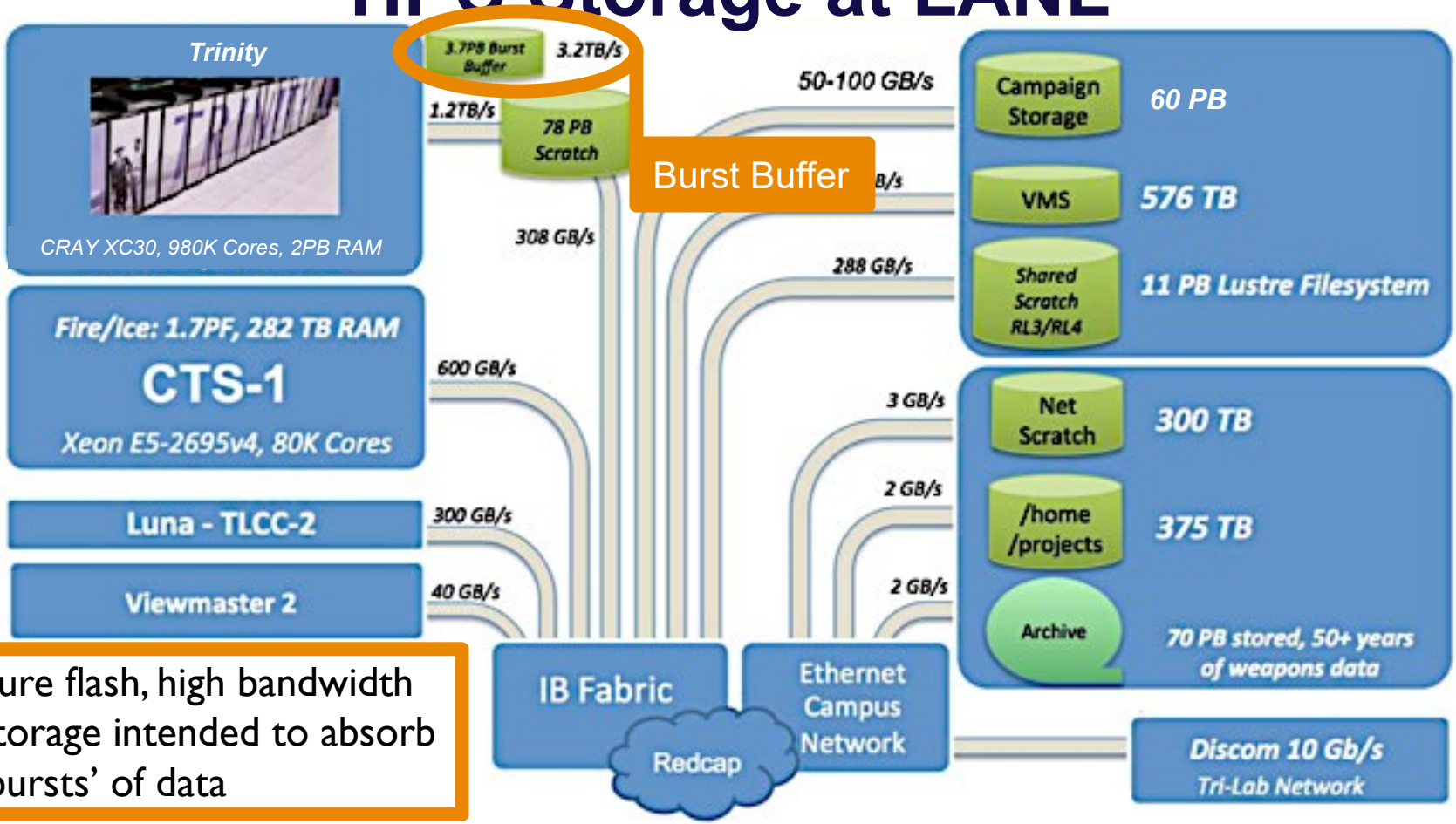
HPC Storage at LANL



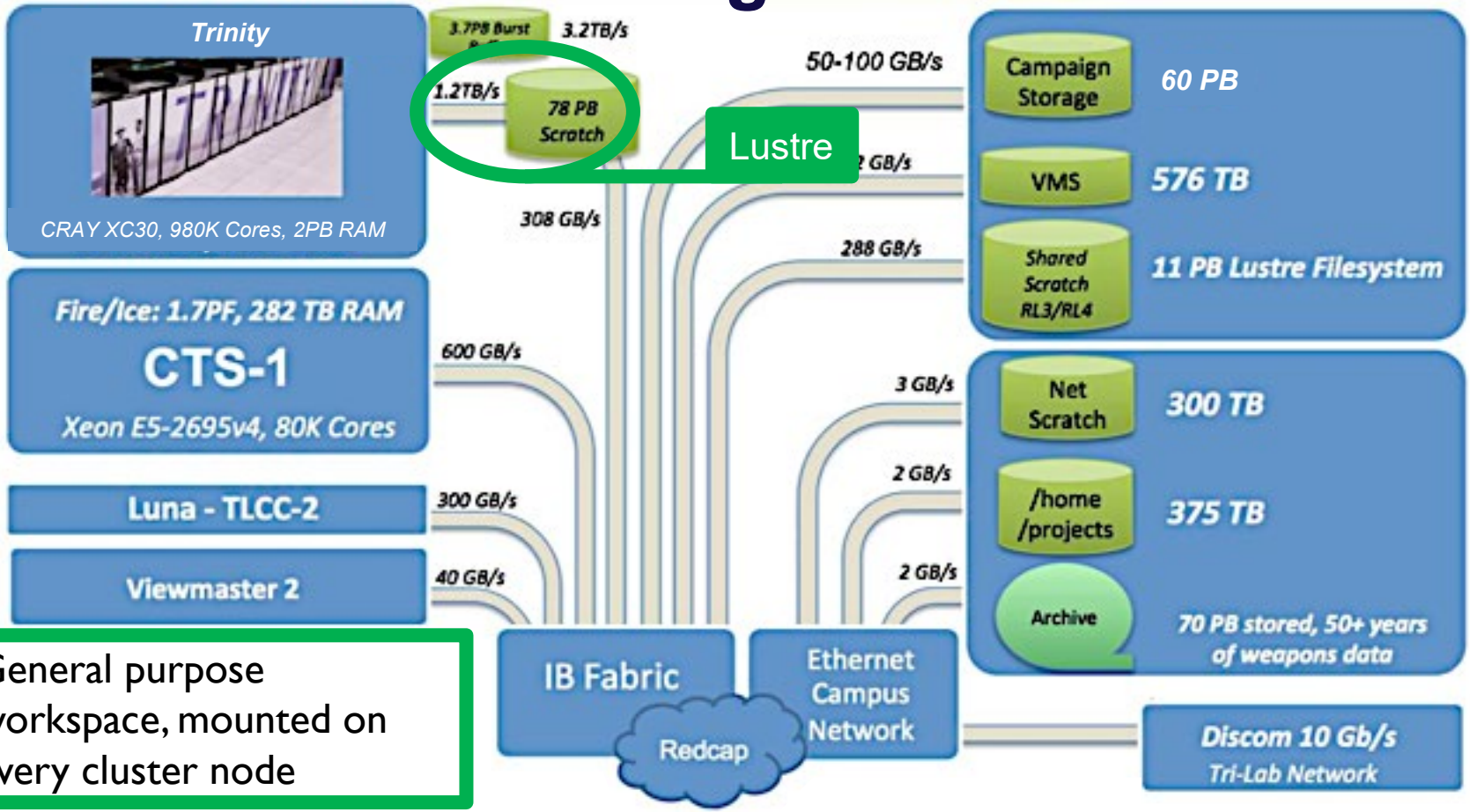
Local memory for each node of the compute cluster (DIMMs)

HPC Storage at LANL



Pure flash, high bandwidth storage intended to absorb 'bursts' of data

HPC Storage at LANL



General purpose workspace, mounted on every cluster node

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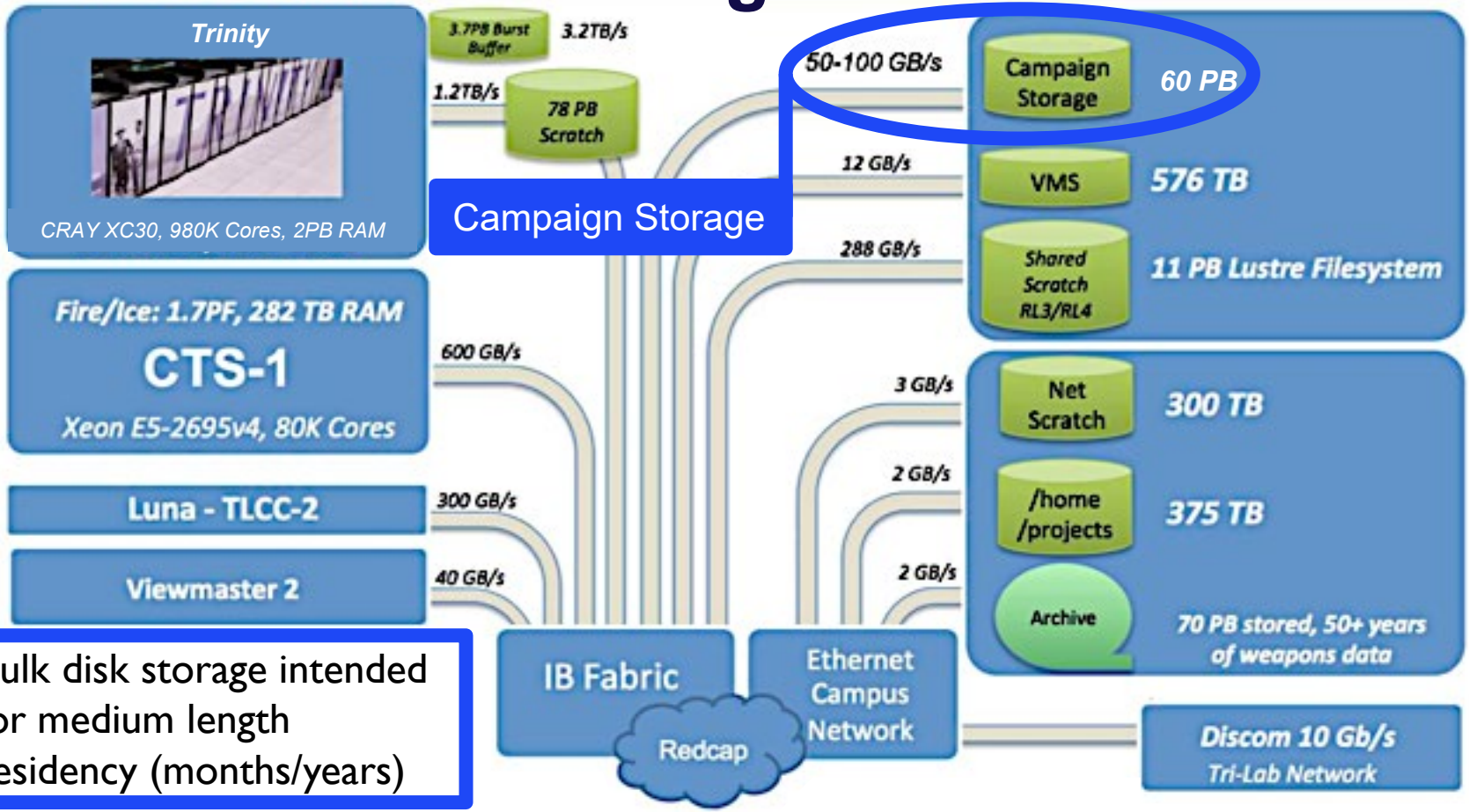
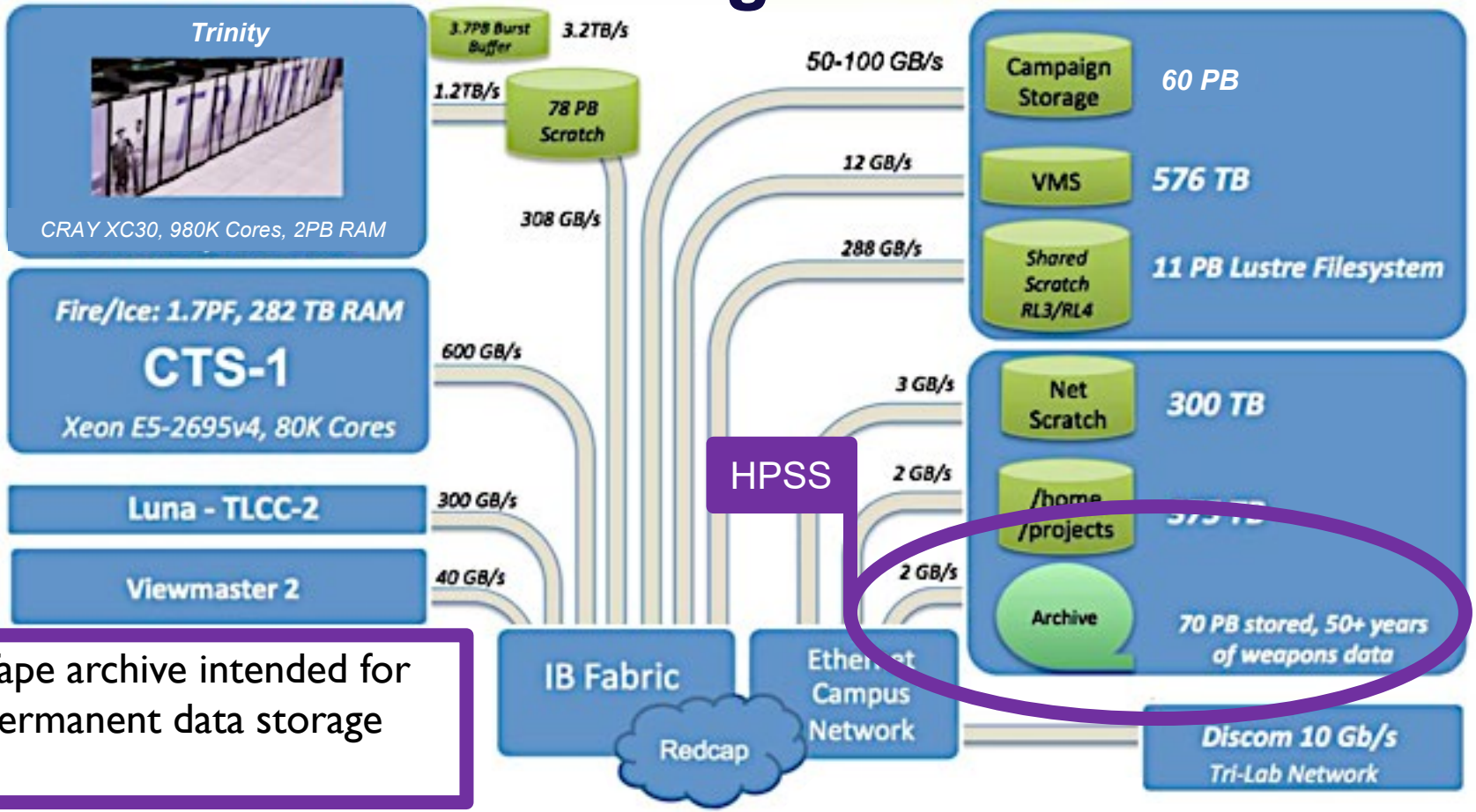
HPC Storage at LANL



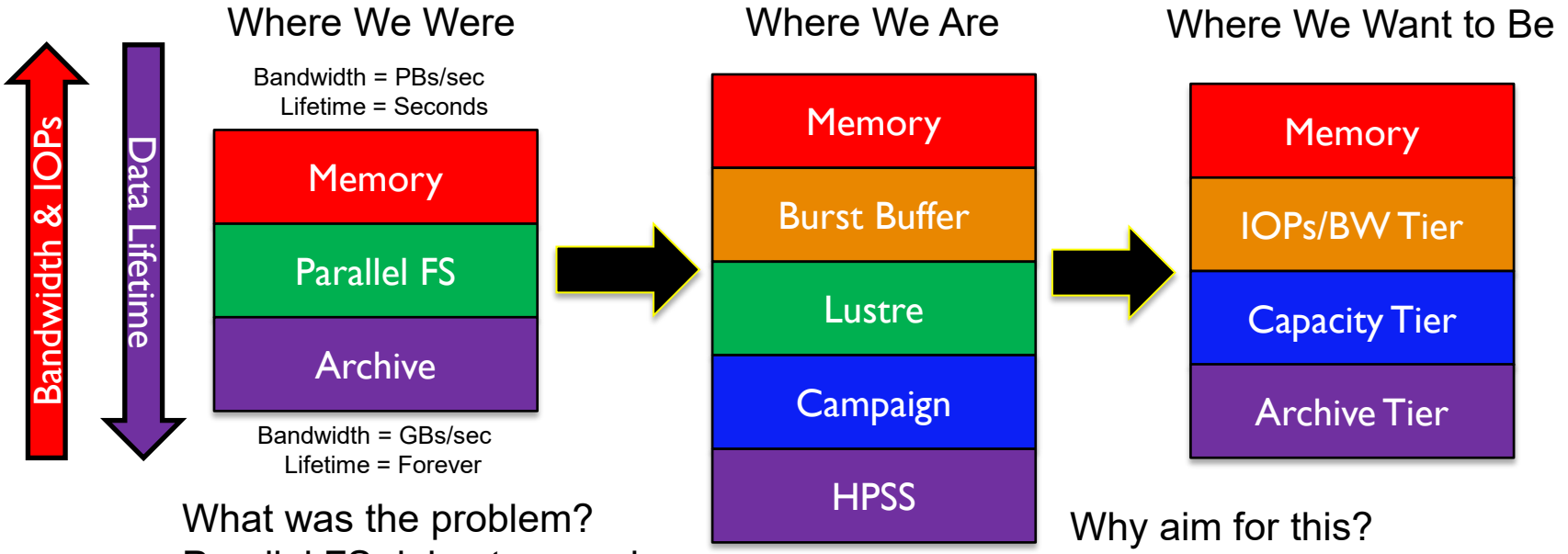
Bulk disk storage intended for medium length residency (months/years)

HPC Storage at LANL



Tape archive intended for permanent data storage

Storage - Past and Future



What was the problem?
Parallel FS doing too much:

- Low Latency
- High Bandwidth
- High Capacity
- Long Residency

Why aim for this?
Trying to **avoid**:

- Buying flash for capacity
- Buying tape for bandwidth
- Keeping bulk data forever

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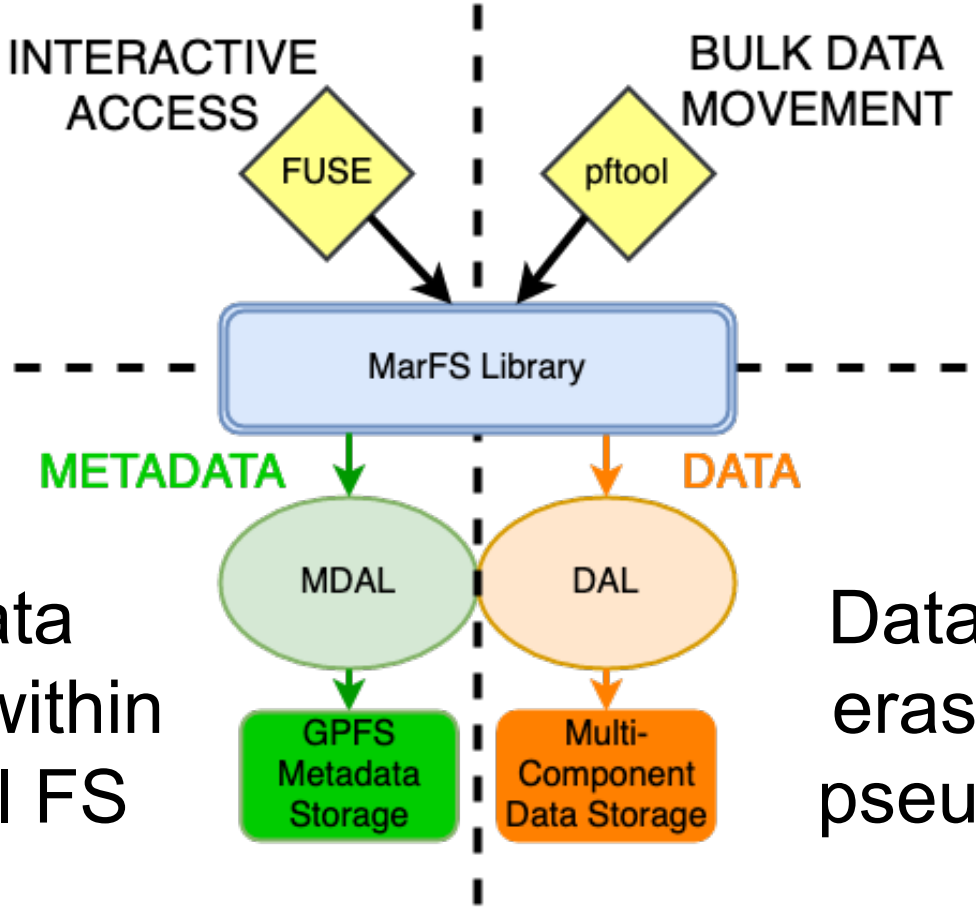
Campaign Storage Implementation

- Object storage has benefits
  - Easy scalability and resilience
- Object storage has limitations
  - Machines love object-IDs, people generally don't
  - Applications expect POSIX file trees
- MarFS is LANL's attempt to reconcile POSIX semantics with object storage
  - Focus on data protection and simplicity of design

What is MarFS?

- A near-POSIX interface layered over distinct metadata and data implementations
  - Scalability and resiliency of object storage for data
  - Actual POSIX metadata
- With tradeoffs, of course
  - No update in place
  - Restricted interactive use

What is MarFS?

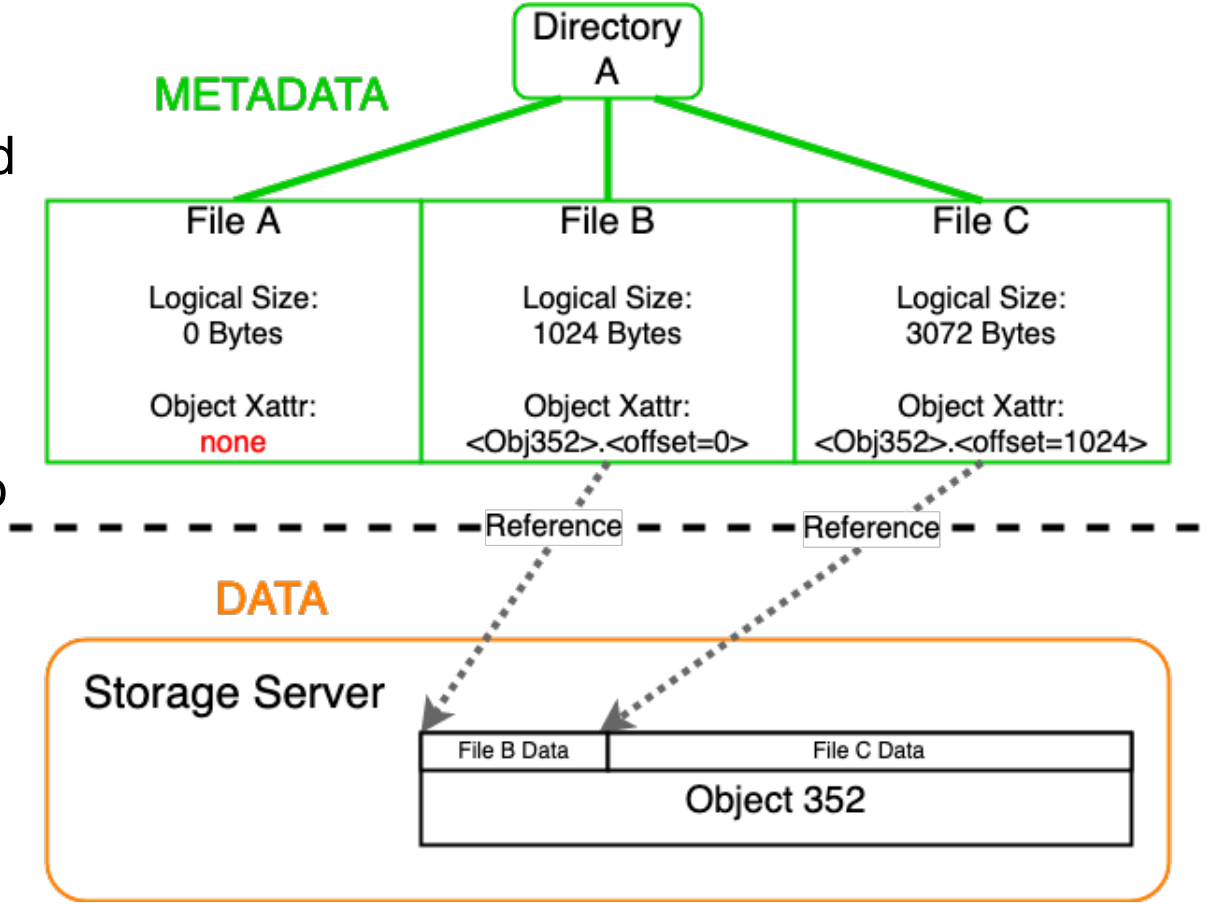


Metadata mirrored within a parallel FS

Data stored as erasure coded pseudo-objects

What is MarFS?

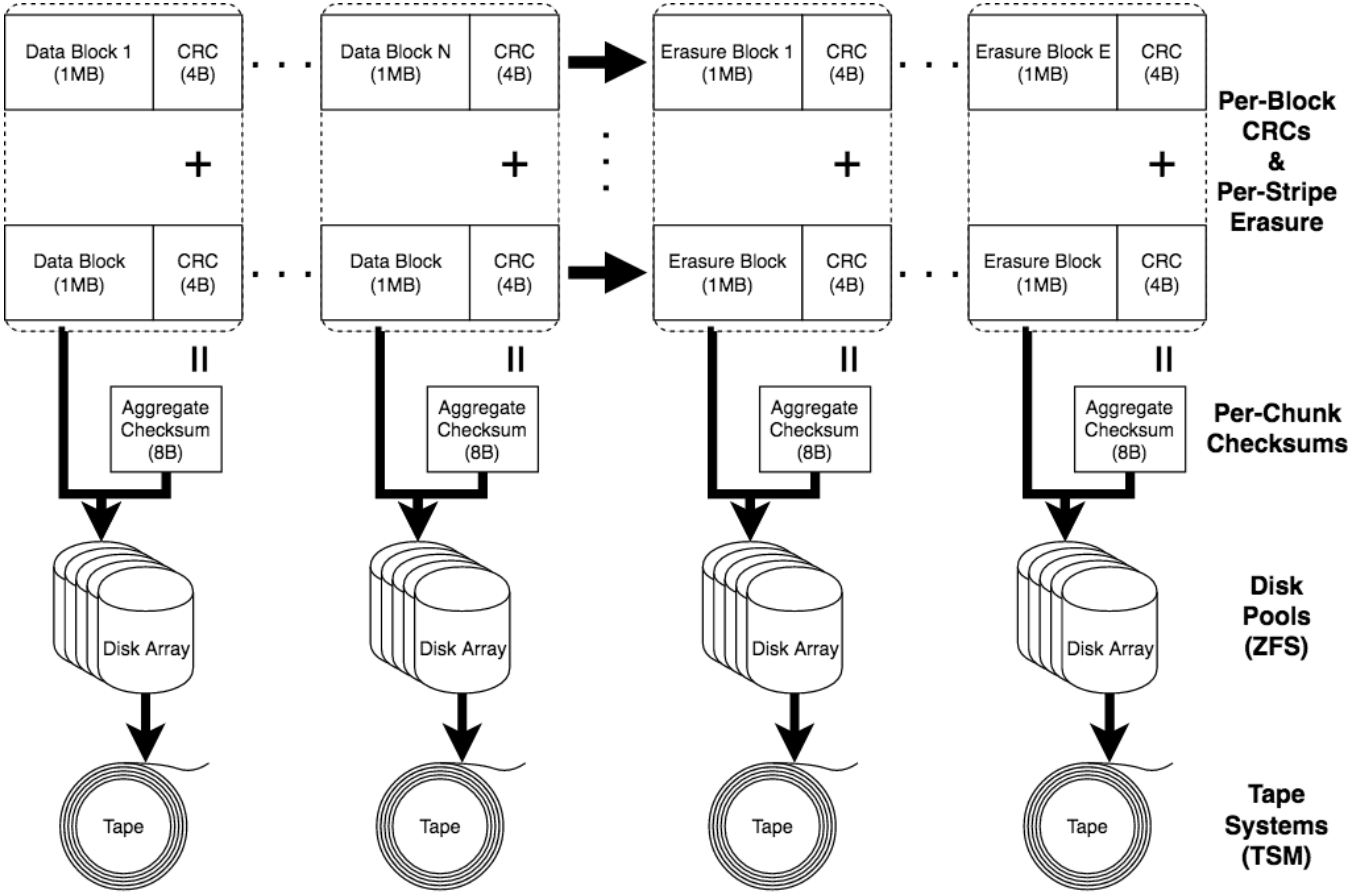
- Object references stored as extended attributes of metadata files
- Multiple small files ‘packed’ into single objects
- Large files ‘chunked’ (broken up) over multiple objects



A MarFS-based Archive

- MarFS already offers:
  - Data validation via CRCs
  - Cross-server failure protection
  - Consistently sized objects via packing/chunking
  - Asynchronous garbage collection
- These sound like useful archive features
  - We can easily adapt the existing design to incorporate tape media

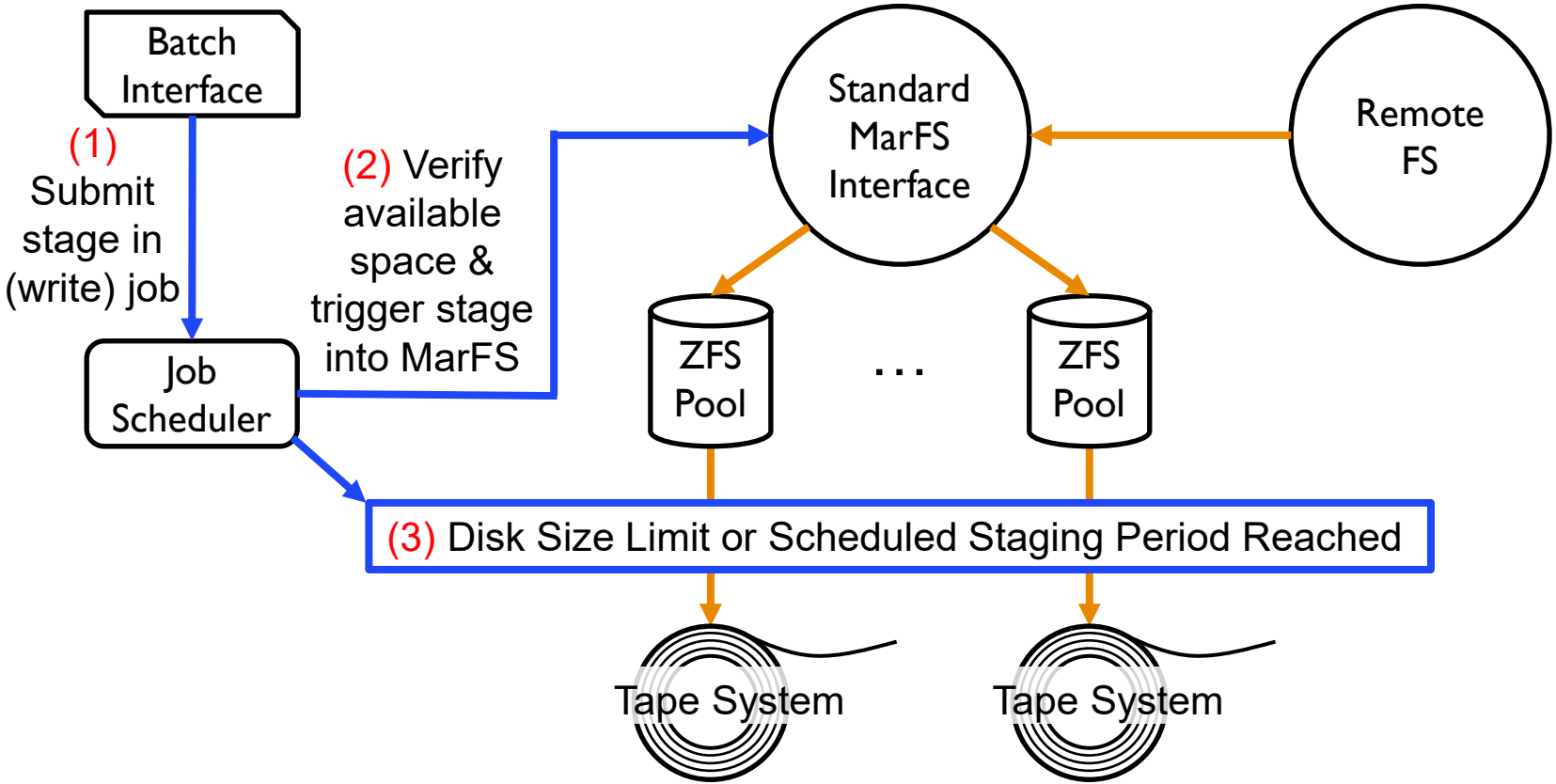
Marchive



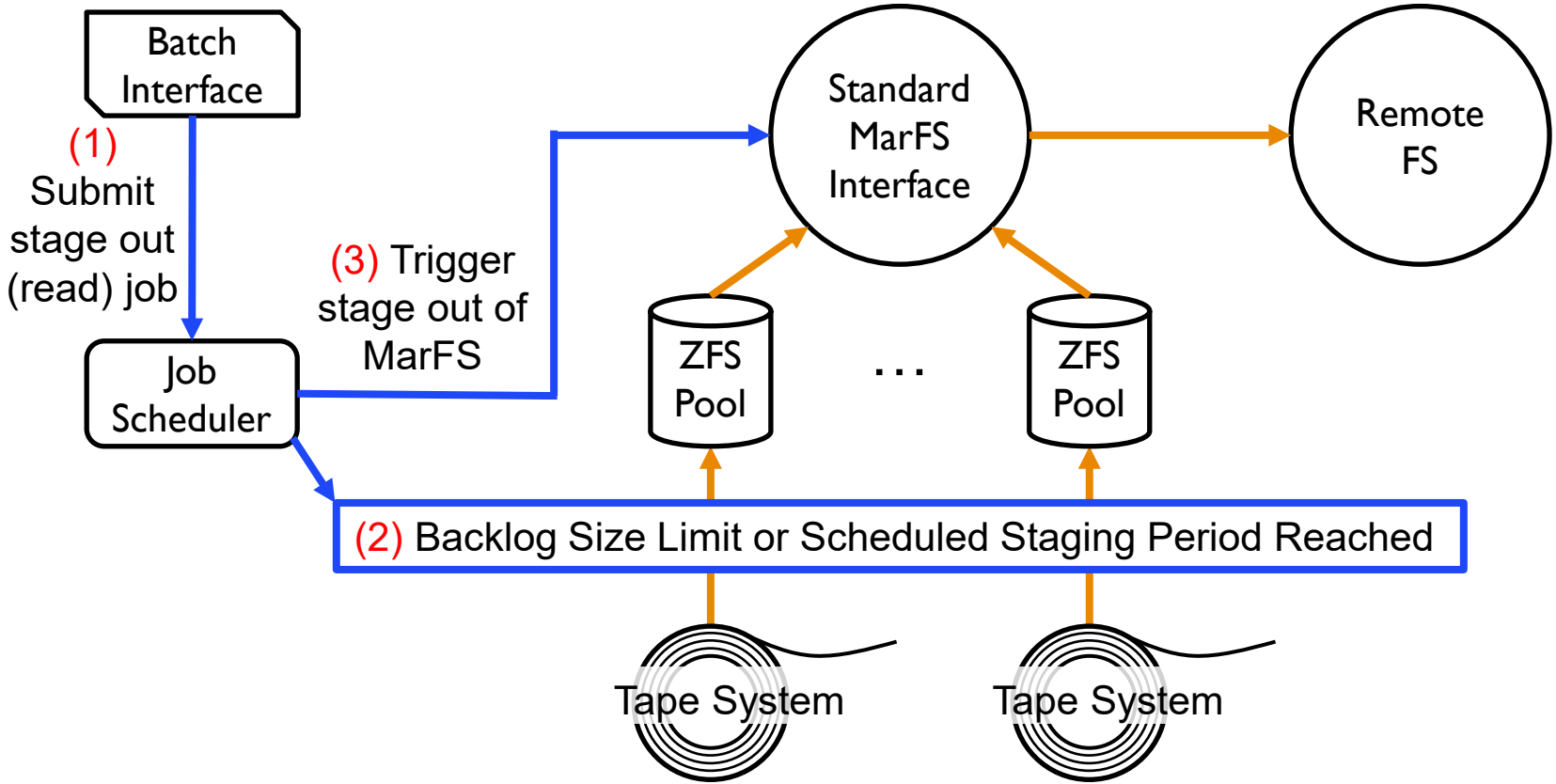
Marchive Interface

- Interactive access is not a good fit
  - Waiting for tape mounts is slow, regardless
  - Simultaneous user access compounds problems
  - Per-file I/O is likely grossly inefficient for tape
- A batch interface seems more promising
  - Far more efficient tape I/O
  - Far less abusive of tape media
  - Job priority can reduce wait time for essential tasks

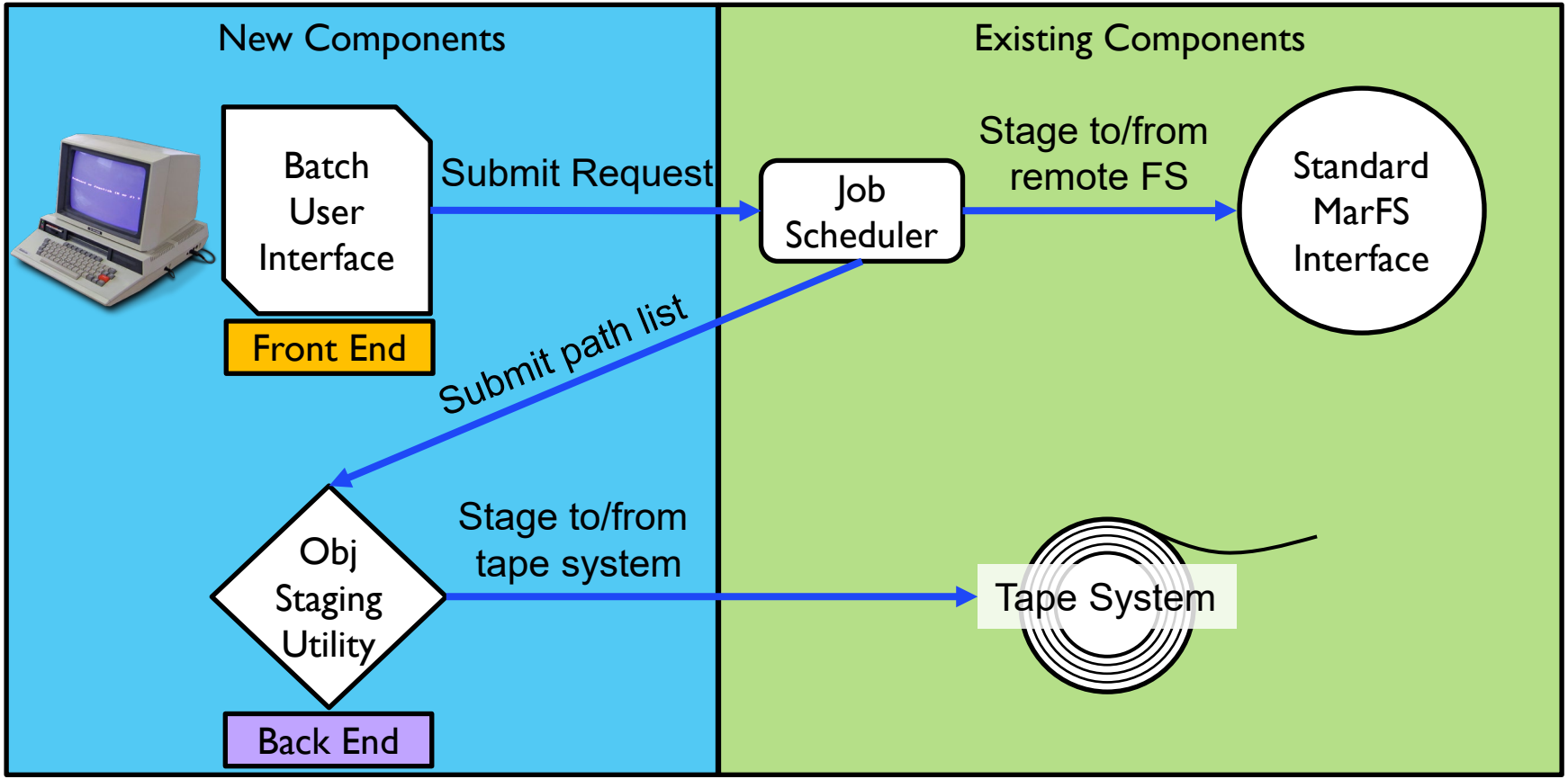
Marchive Interface – Stage In



Marchive Interface – Stage Out



Marchive Components



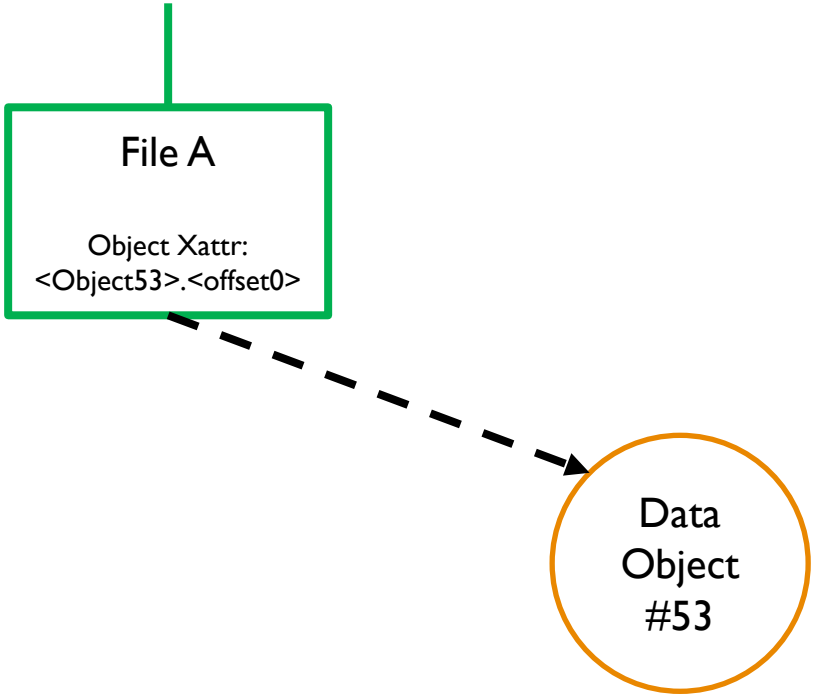
MarFS Improvements

- Extension to an archive system will require more functionality and stability from MarFS
  - Improved administration tools
  - Erasure code optimization
  - Improved config parser
  - Altered deletion / garbage collection process

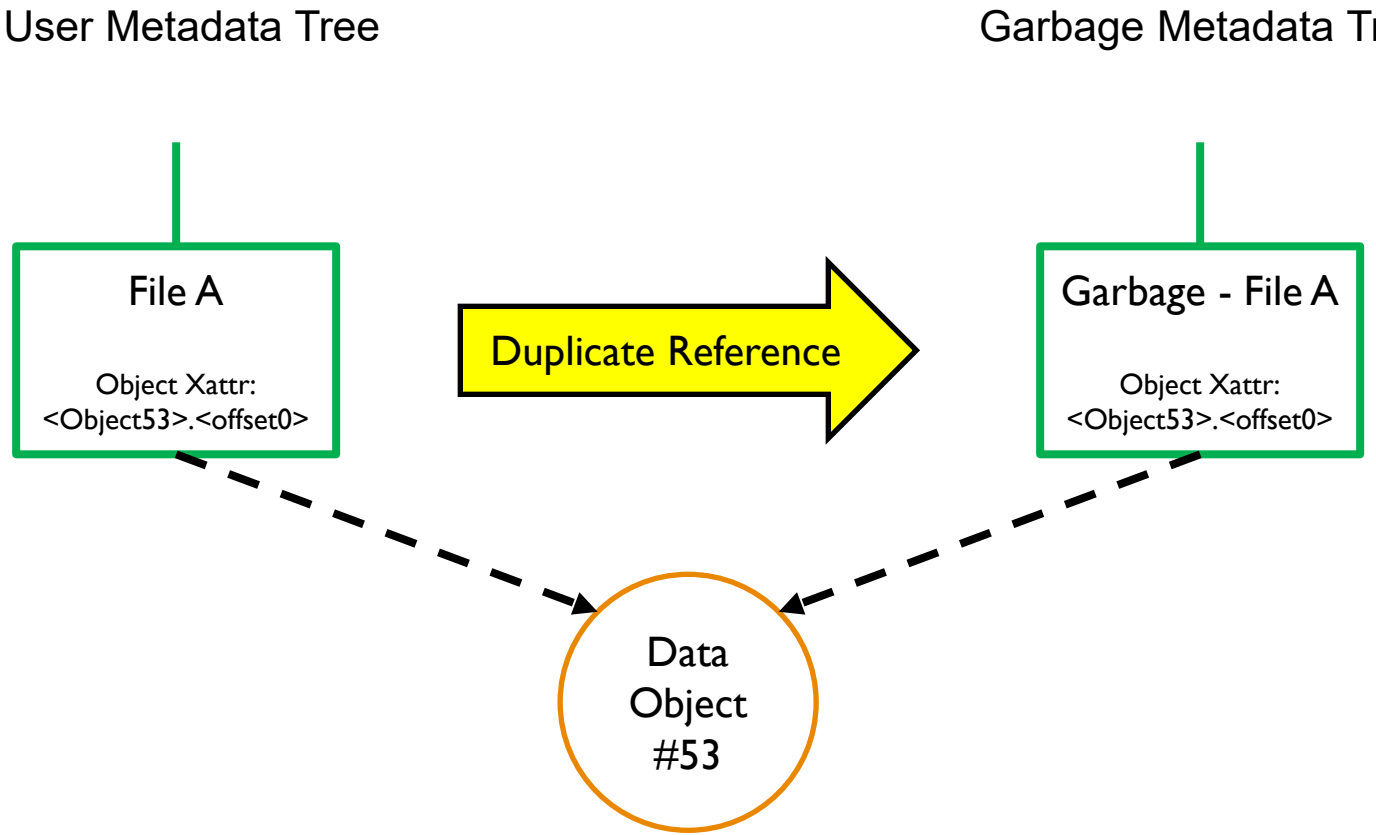
MarFS Deletion Process

User Metadata Tree

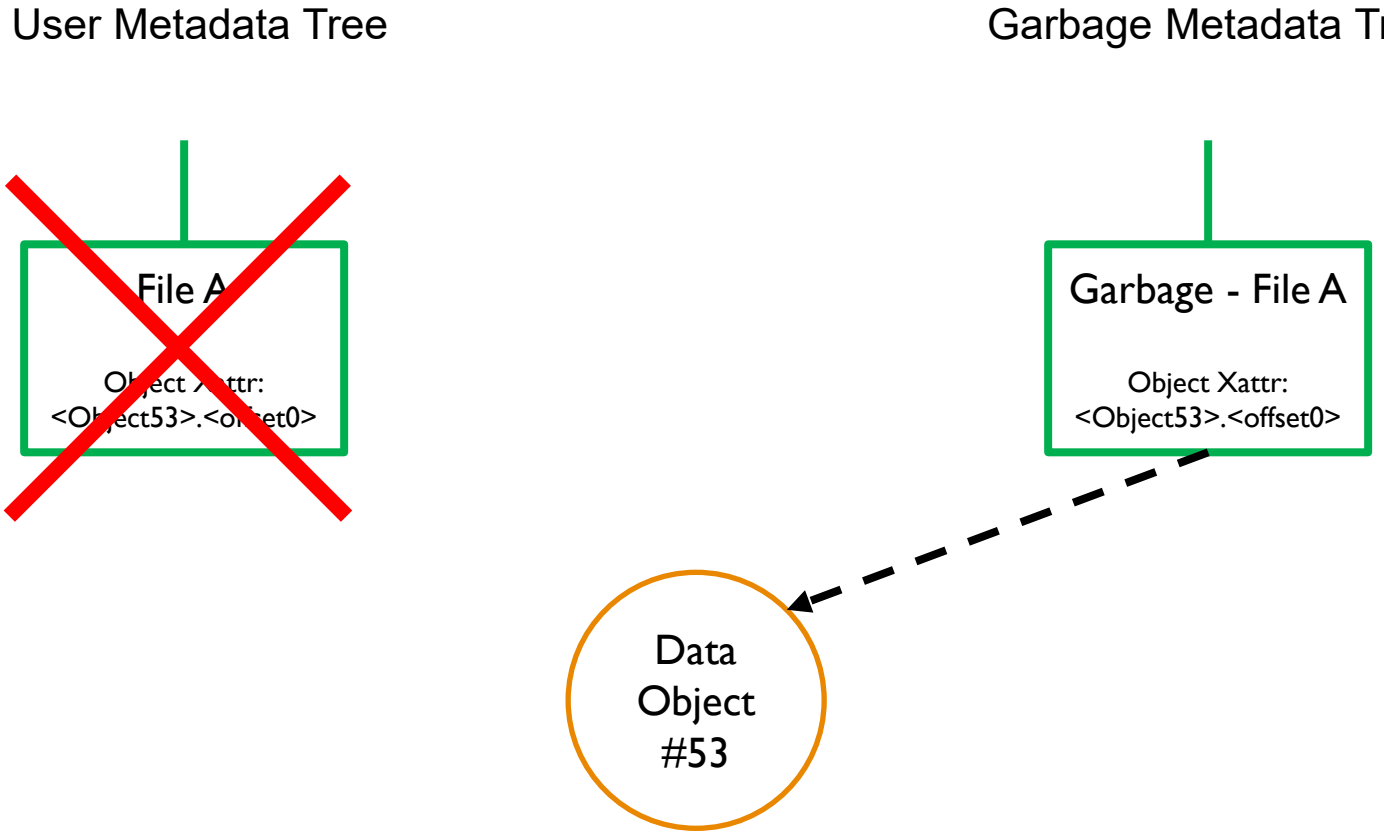
Garbage Metadata Tree



MarFS Deletion Process



MarFS Deletion Process



MarFS Deletion Problems

- Deletion is a non-atomic operation
  - Requires at least two syscalls (getxattr / unlink)
  - Interleaved operations could result in dropped object references
- For an archive, dropped references are a problem

Proc 1 -- Overwrite Target
Proc 2 -- Delete Target

Proc 1: Copy ObjRef
Proc 2: Copy ObjRef
Proc 1: Delete Target
Proc 1: Write new file
Proc 2: Delete Target
- LOST OBJECT REF -

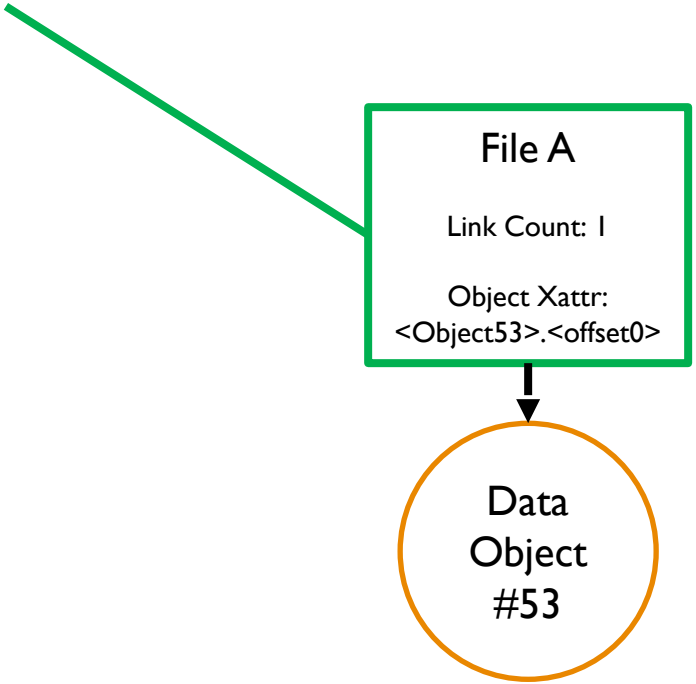
MarFS Deletion Problems

- Can we scan objects/metadata to correct this?
  - Yes, but that is prohibitively costly
- Can we rename into the ‘trash’ tree instead?
  - Possibility of overwriting other trash files
  - Few filesystems implement the “renameat2” syscall
- What if we’re looking at this backwards? Maybe we can create the ‘trash’ reference at creation time?

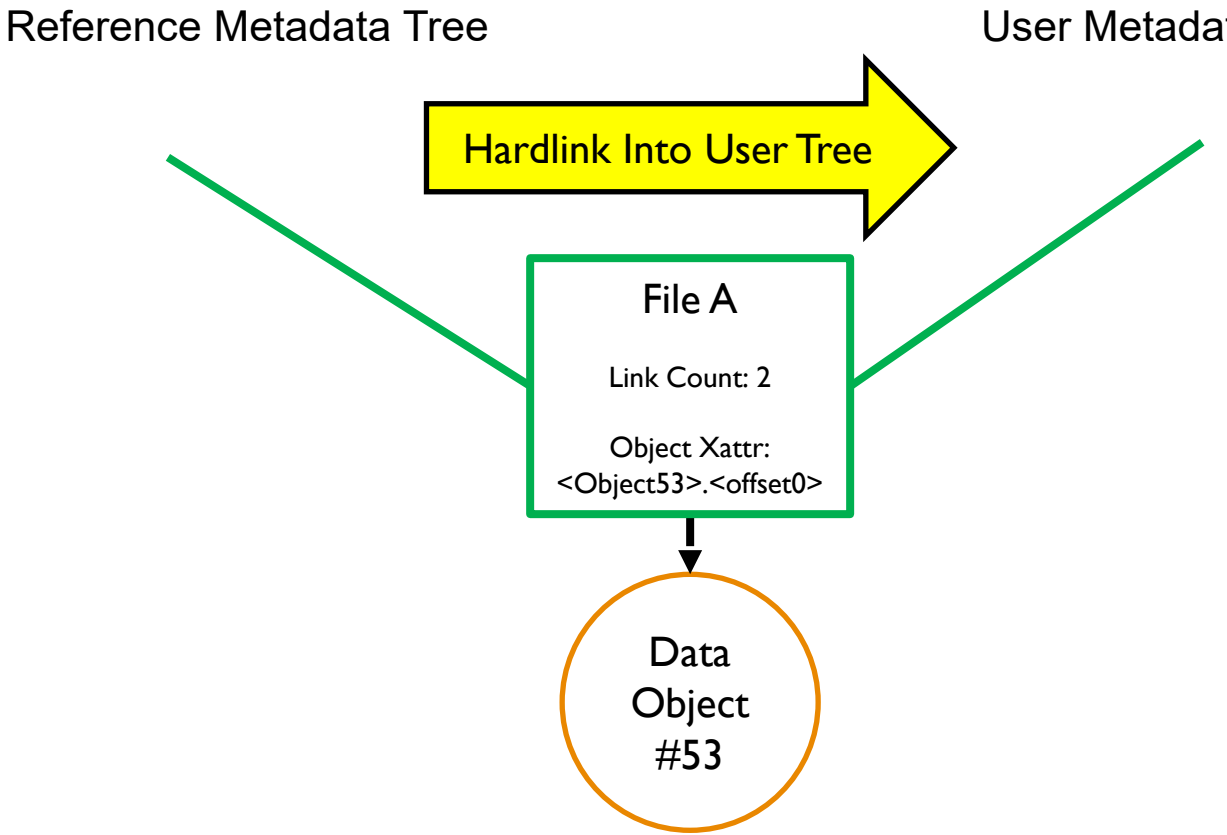
Modified MarFS Creation Process

Reference Metadata Tree

User Metadata Tree



Modified MarFS Creation Process



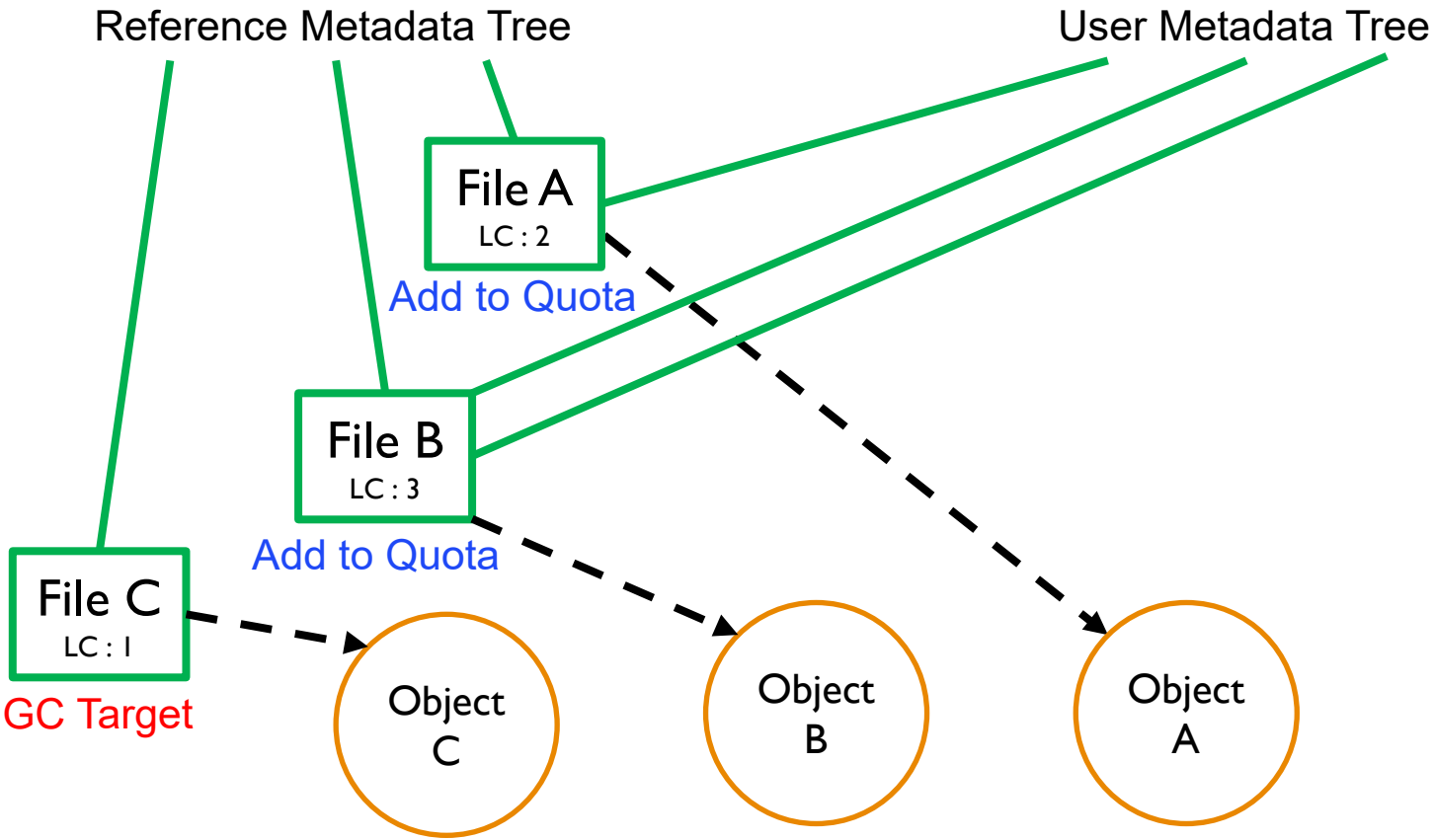
Modified Creation - Problems

- Won't this double the size of our metadata?
  - Not quite, though it will double the number of directory entries (usually far smaller than inodes)
  - Even at scale, metadata simply isn't that large
- What about collisions on creation?
  - The open syscall can avoid overwrites (O_EXCL)
  - Though unlikely, creation could fail with EBUSY

Modified Creation - Benefits

- Almost all metadata ops are trivial
  - Unlink / rename can freely target the user tree
- Garbage Collection and Quota calculation can be a single process
  - Scan the reference tree: inodes with a link-count of 1 are trash, otherwise they count against quota
  - Scans are highly parallelizable; likely no need for filesystem-specific scanning utilities

Modified Metadata Structure



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