Comparing Parallel File Systems

- Block Management
- How Metadata is stored
- What is cached, and where
- Fault tolerance mechanisms
- Management/Administration

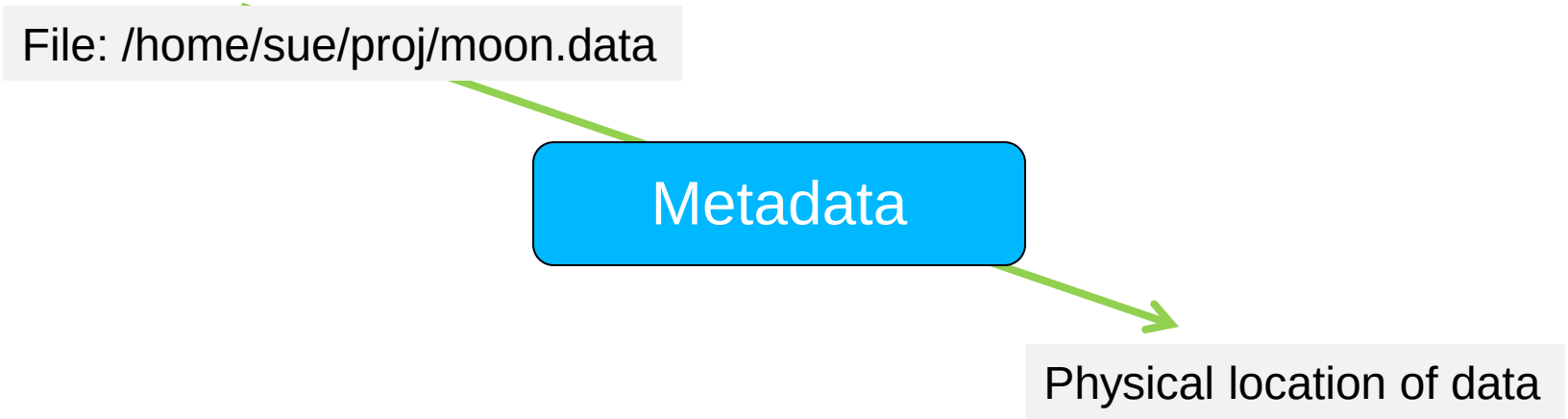
Designer cares about

- Performance
- Reliability
- Manageability
- Cost

Customer cares about

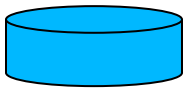
Meta Data Review

- Metadata names files and describes where they are located in the distributed system
  - Inodes hold attributes and point to data blocks
  - Directories map names to inodes
- Metadata updates can create performance problems
- Different approaches to metadata are illustrated via the File Create operation

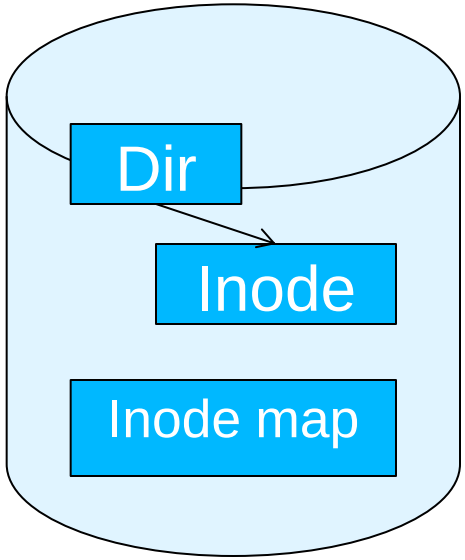


File Create on Local File System

- 4 logical I/Os
  - Journal update
  - Inode allocation
  - Directory insert
  - Inode update
- Performance determined by journal updates
  - Or lack there of – Journal protects integrity after a crash
  - Details vary among systems



Fast Journal device (SSD)

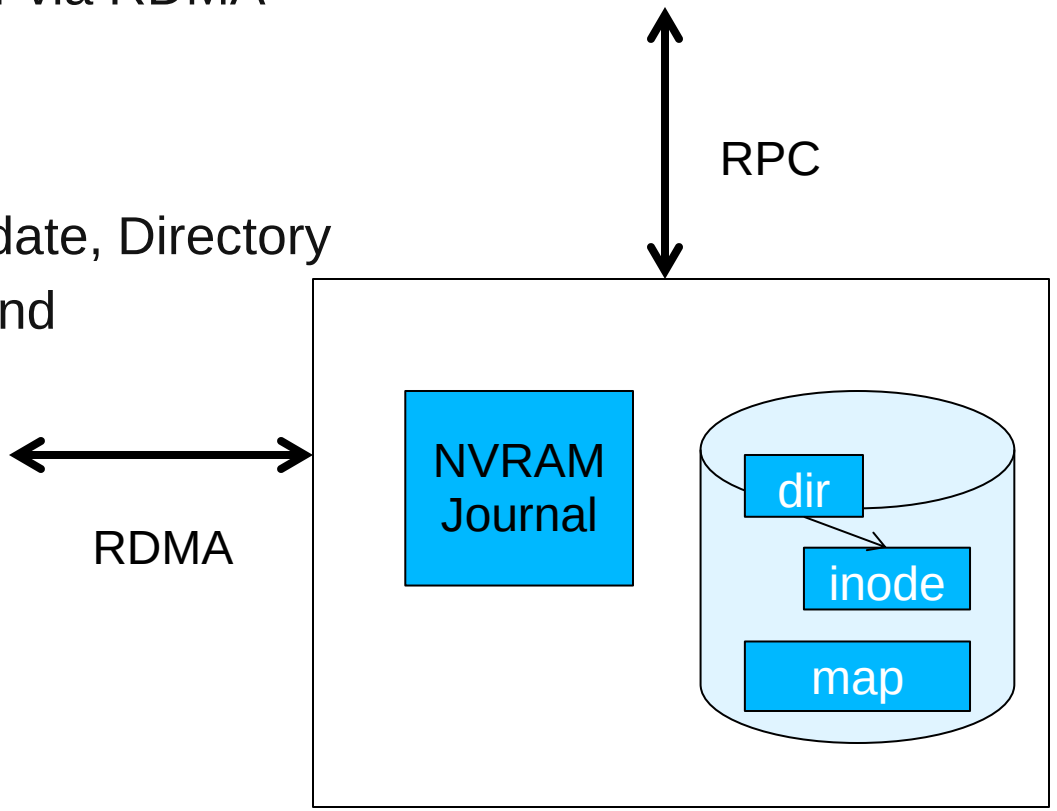


Inode	Name
0017	Fred
2981	Yoshi
7288	Racheta

Directory

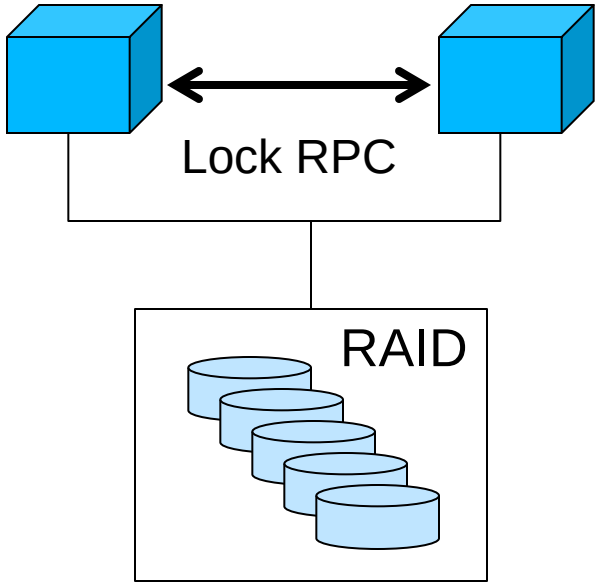
File Create on NFS Server

- RPC
  - Client to NFS server RPC
- NVRAM update
  - Mirrored copy on peer via RDMA
- Reply to client
- Local I/O
  - Inode alloc, Inode update, Directory
  - Done in the background
- Performance from
  - NVRAM+RDMA



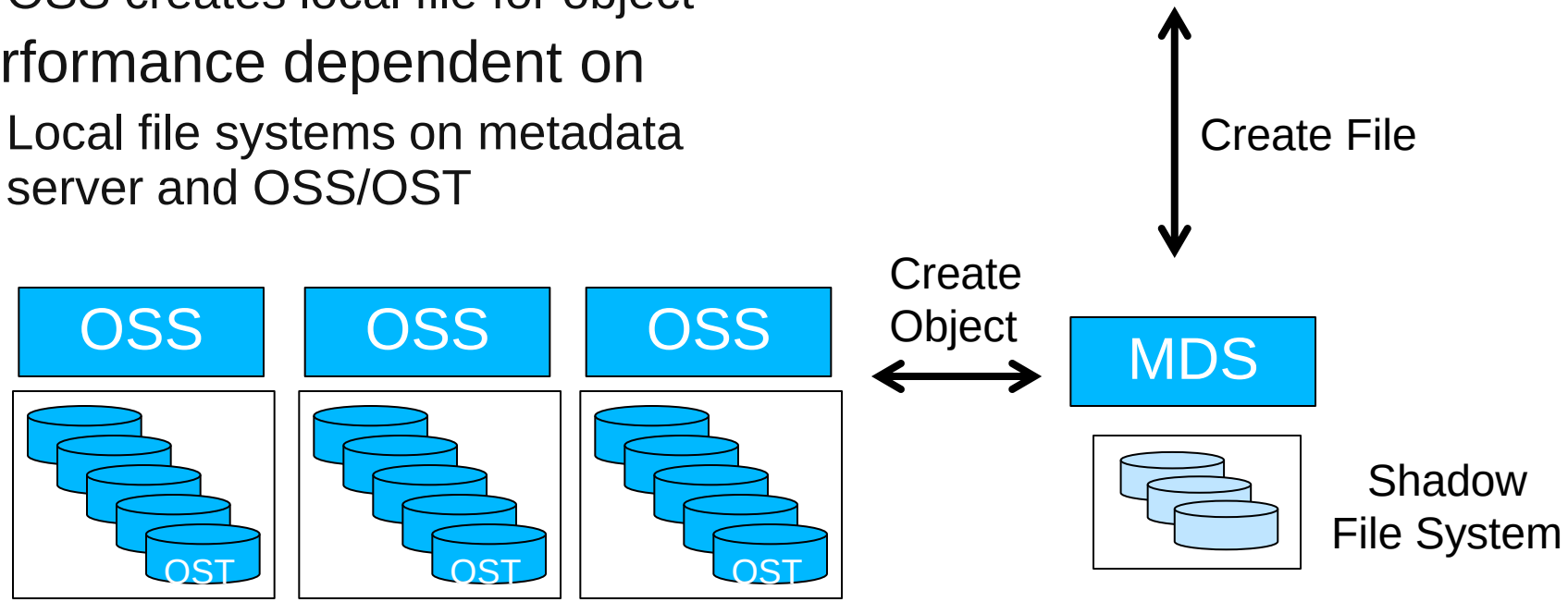
File Create on SAN FS

- Lock RPC for inode allocation
- Lock RPC for directory insert
- Journal update
- SAN I/O for inode and directory
  - Done in the background
- Performance dependent on
  - Journal updates
  - Lock manager updates
  - GPFS cache of lock ownership
  - SAN I/O



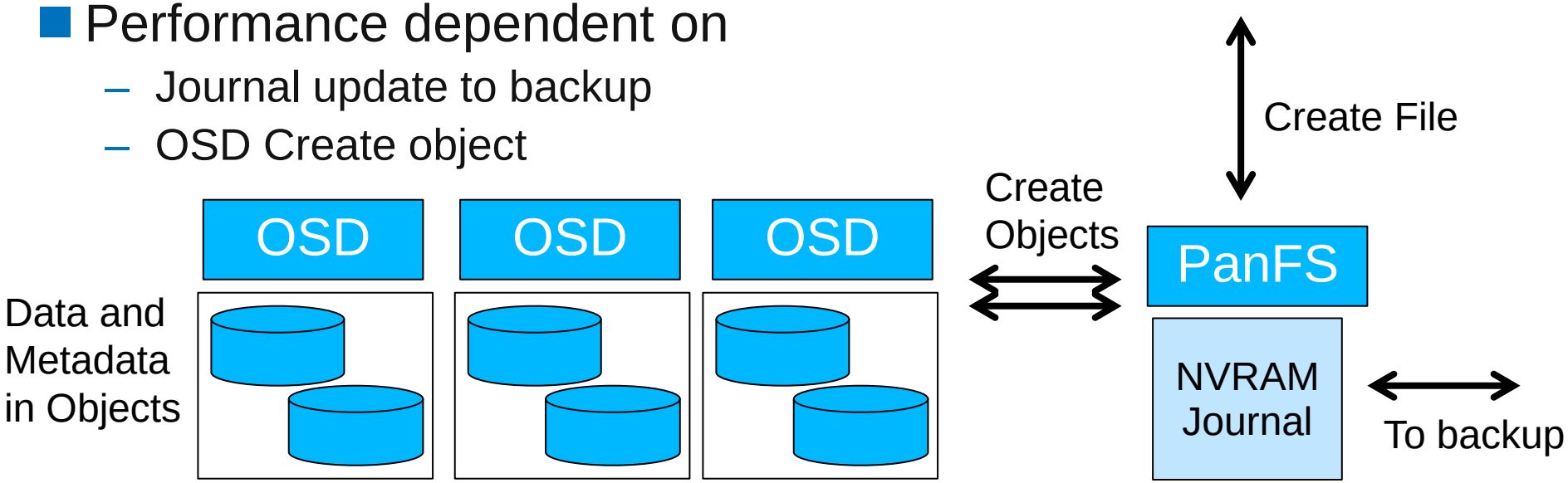
File Create on Lustre

- Client to Server RPC
- Server creates local file to store metadata
  - Journal update, local disk I/O
- Server creates container object(s)
  - Object create transaction with OSS
  - OSS creates local file for object
- Performance dependent on
  - Local file systems on metadata server and OSS/OST



File Create on PanFS

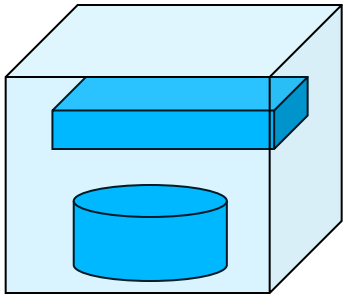
- Client to Server RPC
- MDS updates journal in NVRAM (locally and on backup)
- MDS creates 2 container objects (iSCSI/OSD Create Object)
  - OSDFS journals object create in NVRAM
  - MDS annotates objects with its own metadata (as attributes)
- Reply to client
- Update directory (mirrored OSD write) in background
- Performance dependent on
  - Journal update to backup
  - OSD Create object



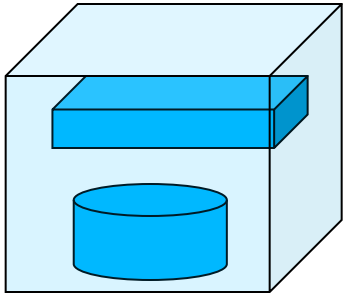
File Create on HDFS

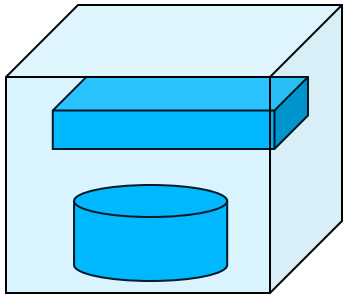
- RPC to Name Node
- Key-value store update
- Container Create
  - One on the client node
  - One replica “in rack”
  - One more replica “out of rack”
- Performance depends on
  - Metadata memory size
  - Local file system updates on Data Nodes
  - # Copies created before sending reply

Client and Local Copy



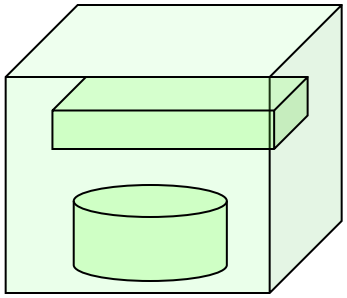
Remote Copy1



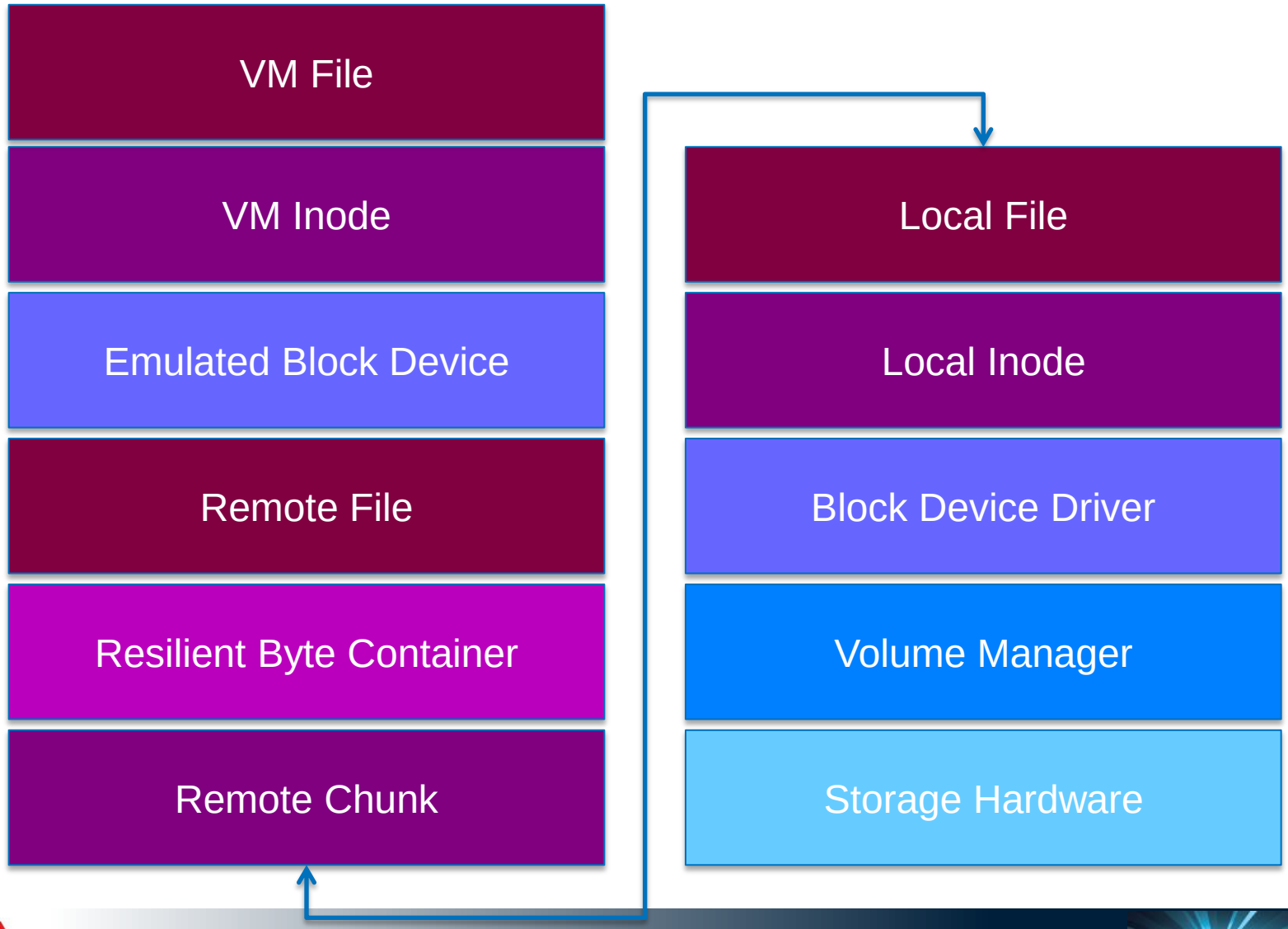


Remote Copy2

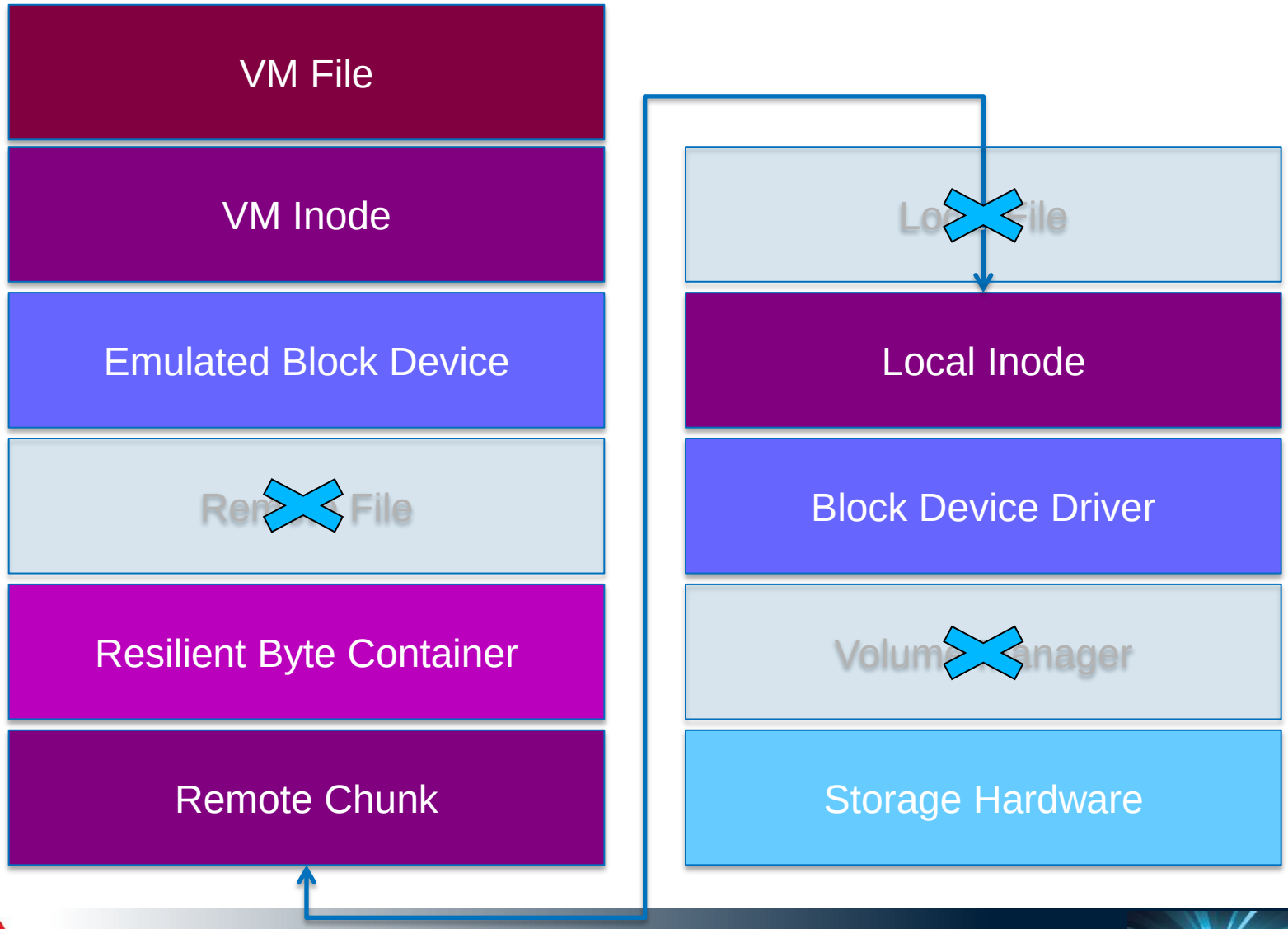
Name Node



Layers upon Layers



Layers upon Layers (Optimized, e.g., VMFS)



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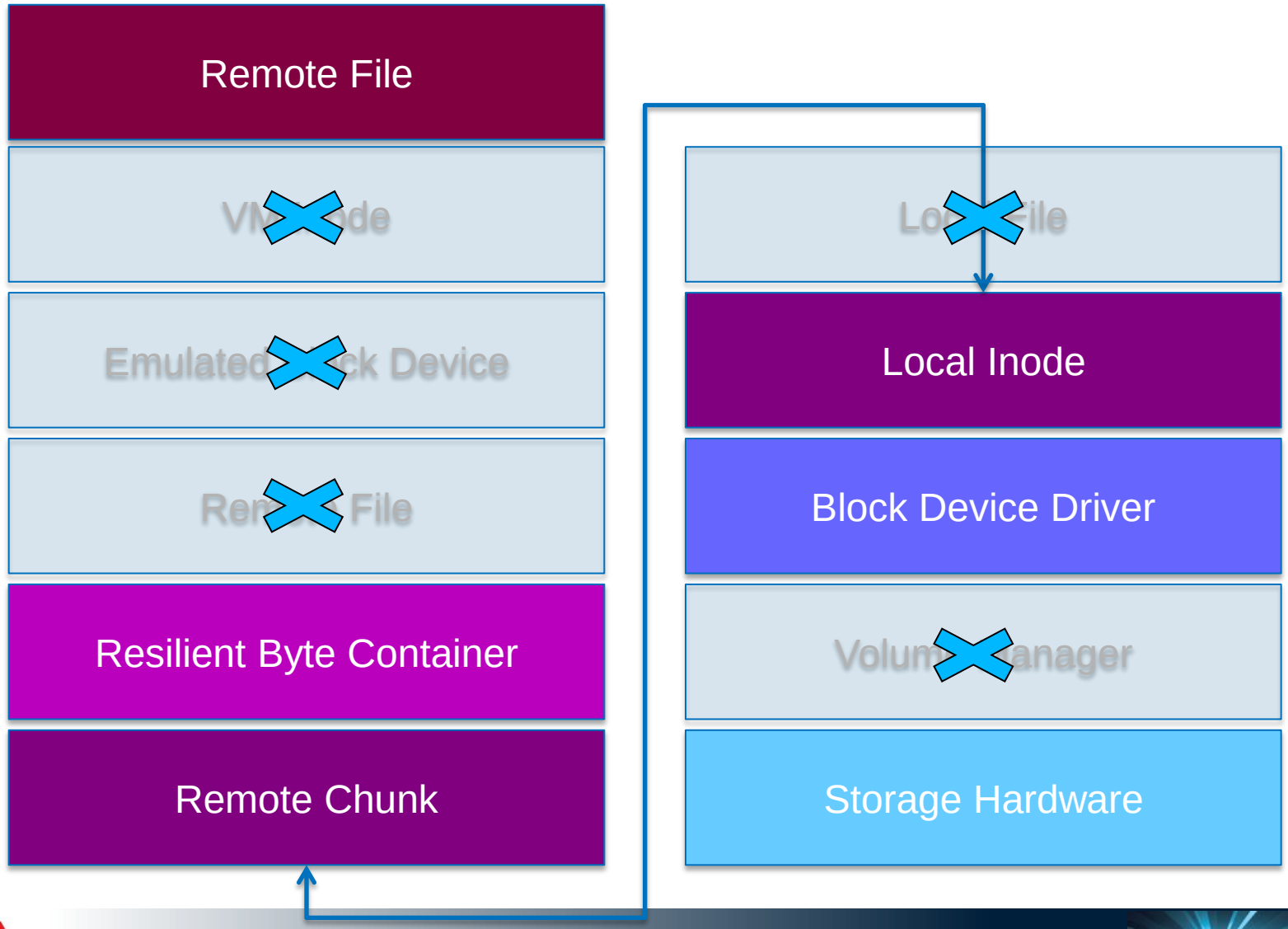
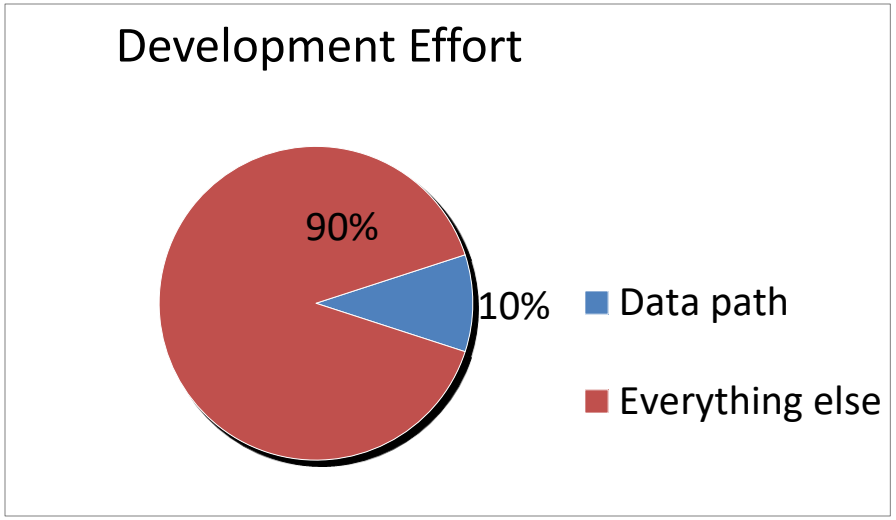


Other Issues

What about…

- Monitoring & troubleshooting?
- Backups?
- Snapshots?
- Disaster recovery & replication?
- Capacity management?
- System expansion?
- Retiring old equipment?
- Limitations of POSIX?



Things to remember

- Silicon bits cost 10x Magnetic bits
- Scale for performance demands reliability
- Parallel declustered data recovery
- Recurring pattern of layered storage abstractions
- Data vs. Metadata
- The power of smart clients and middleware