whamcloud

Quota Enforcement for Orion

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Today's Quota

- Not portable to other backend filesystems
- Quota on/off is on a per-target basis
- Changing a quota limit requires all slaves to be up and running
- Qunit broadcast isn't optimal
- Can't deal with OST addition
- No proper way to decommission a dead OST
- Master recovery requires all targets to be up and running
- Full quotacheck required after e2fsck

A few words on space accounting …

- ZFS **permanently** tracks per-uid/gid disk usage
  - Even when there is no quota limit enforced
  - Only #blocks and not #inodes
- Same scheme adopted with ldiskfs
  - Quota as a new core ext4 feature
  - mkfs.lustre/mke2fs creates empty quota files
  - e2fsck can now fix quota files
- End of quotacheck
- Quota on/off **only** enables/disables **enforcement**
- Let’s talk about enforcement in details now …

Architecture Primer

- New Slave->Master connection
- Leverage the proven scalability of the LDLM for quota communications
- Master tracks on-disk quota space distribution
- Setquota can be issued with missing slaves
- Efficient handling of OST addition
- Huge fraction of the quota space granted to slaves initially
- Quota enforcement on/off managed globally
- DNE support
- Allow per-pool quota in the future

Slave - Master connection

- Tracking reverse MDT import on OST is a pain
- Cannot enqueue locks on reverse import
- Orion’s OSP hides the connection
- FIDonOST needs a connection to MDT0 too

- New connection set up from slave to master
- Master still has to run on MDT0 for now
- Slaves can now enqueue locks …

Quota Locks

- New class of locks to manage resources allocated to clients
  - Quota, grant, locks, permission to send RPCs, …
  - New DLM namespace and lock type
  - Each component (i.e. quota, grant …) is assigned a range of LDLM resource IDs
  - One step towards unification of grant and quota
- One global quota lock, namely **quota index lock**
  - Used to distribute the list of IDs having a quota limit
- Plus **per-ID quota locks**
  - Must be acquired by slave in order to hold unused quota space for that ID

Quota Index Lock

- Slaves enqueue one quota index lock per quota type
- Guarantee that the list of IDs with quota enforced is in sync between master & slave
- List of IDs is fetched via a bulk transfer
- Master sends glimpse callbacks to notify slaves of a new limit enforcement

Per-ID Quota Lock

- Slaves must hold the per-ID quota lock when caching unused quota space for a given ID
- Used to query/grant/cancel quota on that ID
- Master issues glimpse/blocking callbacks to claim quota space back for that ID
- Lock request packed in QUOTA_DQACQ/REL
  - If the slave does not own the quota lock for that ID, it packs the lock enqueue request in the DQACQ/REL RPC
  - If the slave already owns a lock for that ID, DQACQ/REL RPC just packs the lock handle
  - One exception is DQACQ requests issued after setquota to report initial usage

Quota Identifier

- Usually a 64-bit group or user ID
- Extended to support a FID
- Can be used to implement per-directory quota
  - As done by Fujitsu
- New quota_id union introduced:

```
union quota_id {
        struct lu_fid qid_fid;
        __u64         qid_uid;
        __u64         qid_gid;
};
```

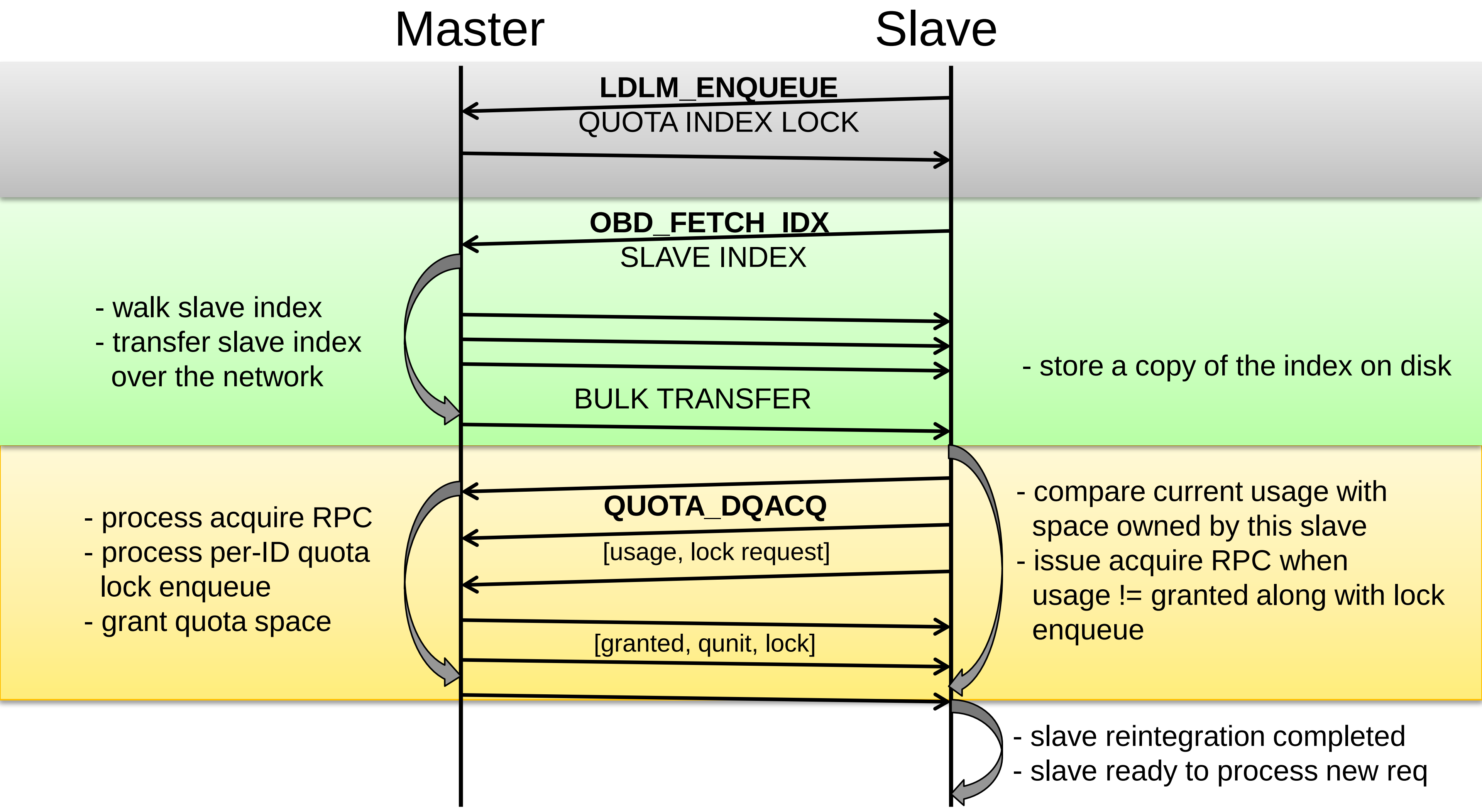
Quota Space Allocation Tracking

- Master now aware of the quota space distribution
- One index per slave in addition to the global index
- Global index records for each ID:
  - global soft/hard limits
  - how much space is granted in total
  - grace time
- Per-slave index tracks how much quota space is owned by the slave for each ID
- Slaves fetch their dedicated index from the master just after enqueueing the quota index lock
- Master's indexes are the reference
  - Slaves' on-disk copy of the index is just a cache, crushed each time the quota index lock is re-acquired

Slave (re)Integration Procedure

- Replace existing quota recovery
- #1 slave enqueues the quota index lock
  - After this point, the slave will be notified of IDs added/removed to/from the enforced list via glimpse callbacks
- #2 slave fetches their private index via a bulk transfer
  - That's the current list of IDs subject to a quota limit
  - This index also includes how much space is granted to this slave for each ID
- #3 slave re-acquires quota space
  - If current usage == granted, no need to send any acquire RPC
  - If current usage != granted, send a QUOTA_DQACQ RPC with lock enqueue packed (the master might grant us back more than usage)
  - This way, only locks for "active" IDs are replayed

Slave (re)Integration

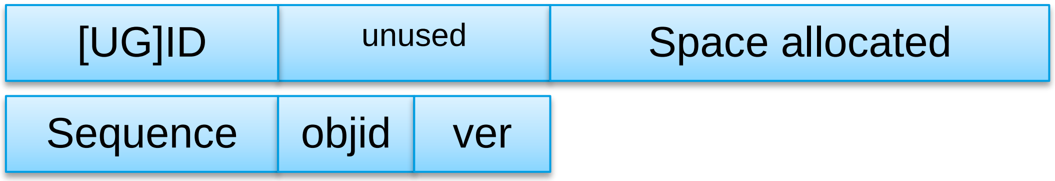


Index Network Transfer

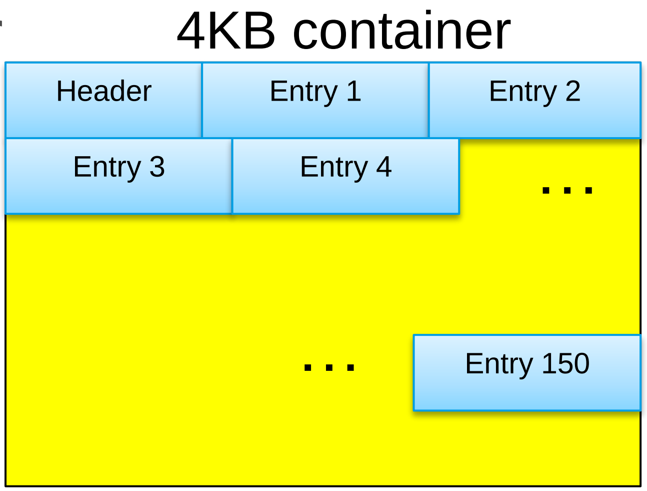
- Generic mechanism for reading index files over the network
  - Serialize the index into a byte stream on the “server ”
  - Deserialize it on the “client”
- Only used to transfer the per-slave index from master to slave for the time being
- Probably many other use cases in the future
  - Quota master migration
  - Repquota
  - Directory split
- Credits to Andreas

Index Transfer Format

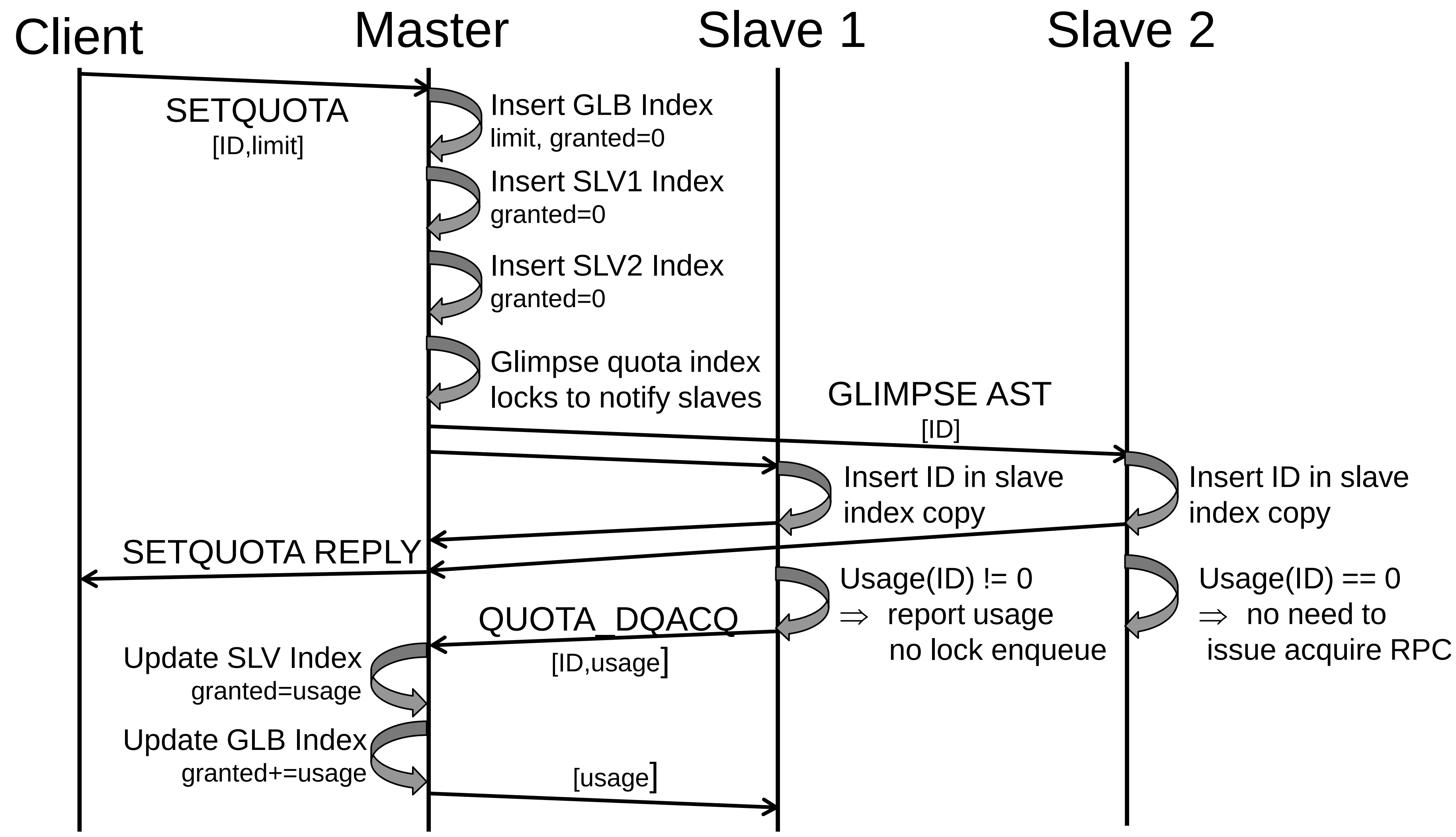
- Compact record format: 24-byte



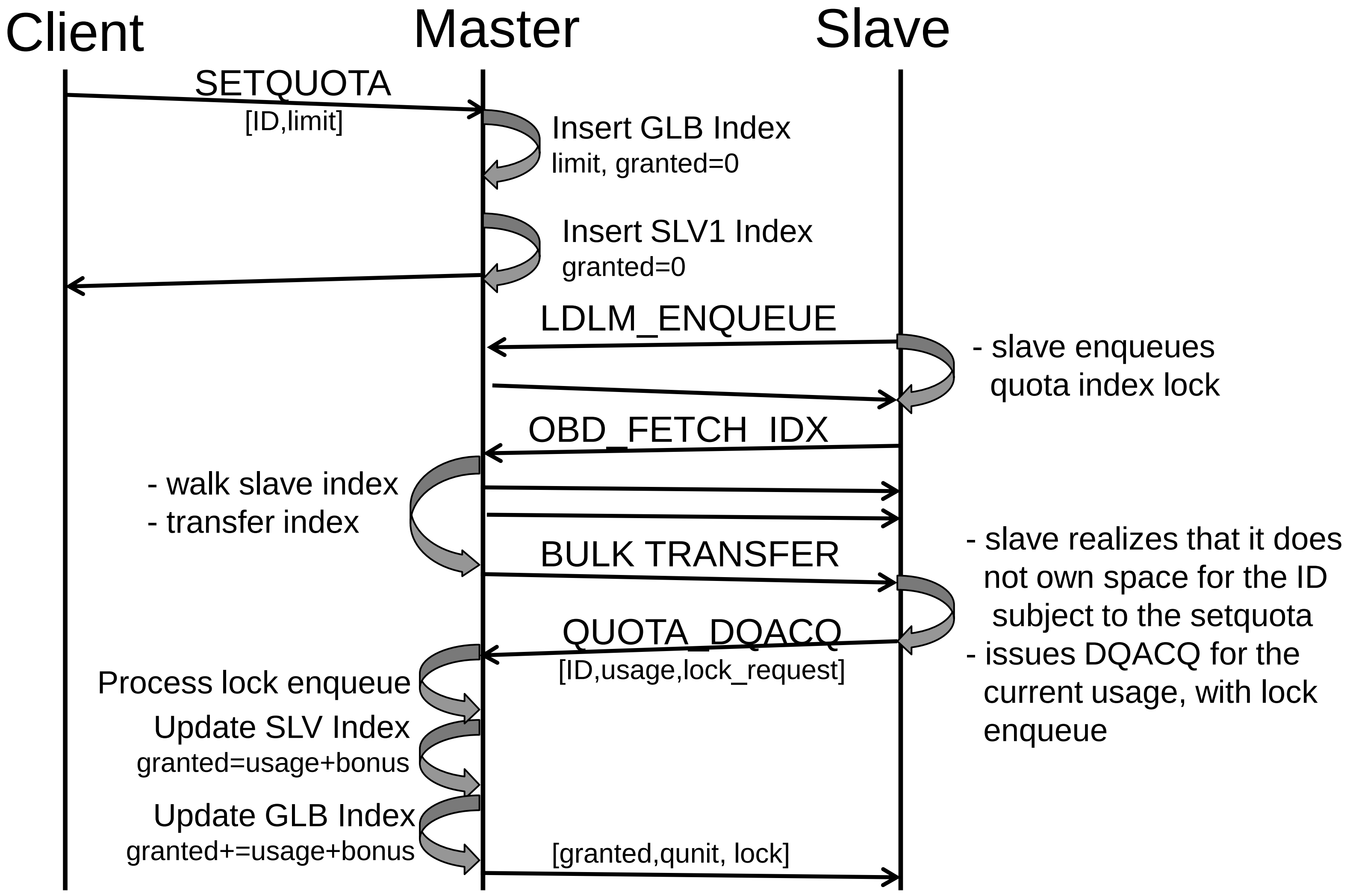
  - Union between 16-byte FID and 8-byte [UG]ID
  - 8-byte space representing the amount of quota space allocated to the slave for this ID
- Records are grouped in a container
  - Independent of page size, always 4KB
  - Header with magic, flags, format version, #entries and padding, resp. => 4+4+1+1+6 = 16 bytes
  - 170 IDs per 4K container
  - 43,520 IDs in a 1MB bulk transfer
  - LLNL has 2500 users/groups



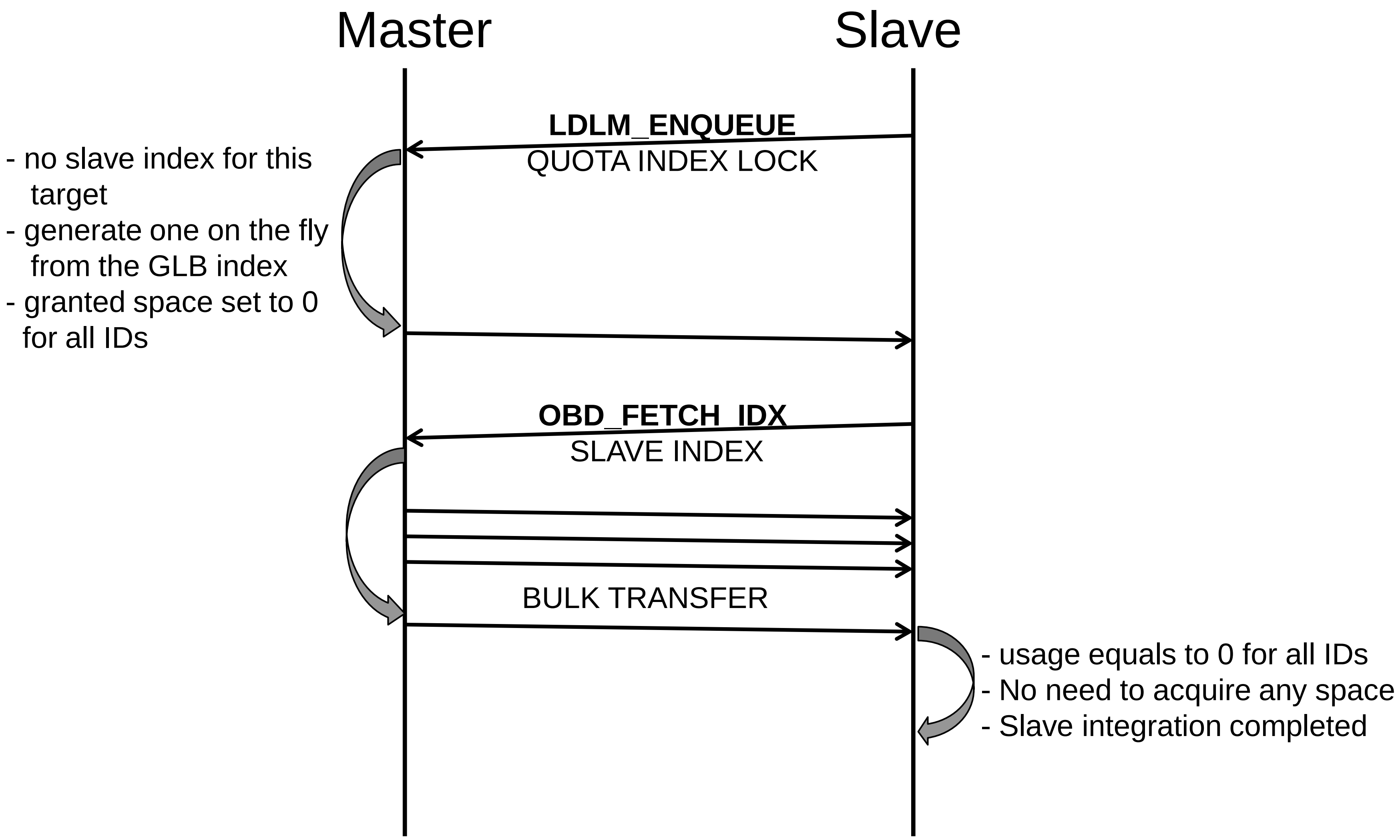
Setquota with slaves connected



Setquota with disconnected slaves



Online OST/MDT Addition


Master
Slave
LDLM_ENQUEUE
QUOTA INDEX LOCK
- no slave index for this target
- generate one on the fly from the GLB index
- granted space set to 0 for all IDs
OBD_FETCH_IDX
SLAVE INDEX
BULK TRANSFER
- usage equals to 0 for all IDs
- No need to acquire any space
- Slave integration completed

Granting more to Slaves

- Quota space allocated to slave on first write/create
- Huge fraction of the quota space is granted
  - Less DQACQ RPCs
  - More autonomy to slaves
  - Mitigate space overestimation issue with ZFS
- Possible thanks to a reliable quota space revocation mechanism based on the LDLM
- Connected slaves that potentially owned unused quota space for a given ID must have a per-ID quota lock
- Master issues glimpse or blocking callbacks on the per-ID quota locks
- The master can now be more selective since it is aware of the quota space distribution

Quota Space Rebalancing

- **Glimpse callbacks** sent on the per-ID locks to ask slaves to release a fraction of the unused quota space, if any
  - Replace the blind qunit broadcast
  - OST_QUOTA_ADJUST_QUNIT RPC not used any more
- Slaves release space in glimpse reply
  - Information packed in a new quota LVB
- **Blocking callbacks** sent as a last resort to claim all unused quota space back

New layering

- MDD/obdfilter don’t deal with quota any more
- Space estimated in OSD layer
- Routines handling enforcement called directly from OSD layer
- Quota space acquired in ->declare
  - DQACQ sent while transaction isn’t started
- Released at transaction stop time

Cascading timeouts

- Client’s RPC processing might be stuck waiting for DQACQ RPC to master to complete
- Waiting for too long might cause the initial RPC to time out
  - client has to reconnect and resend all RPCs in flight, painful
- Client nodes can get evicted if lock cancellation underway
- Current quota code drops the reply
  - Quota not the only one to do that, check ost_brw_read/write()
- -EINPROGRESS now returned to clients
  - Client should retry indefinitely
  - Lock timeout will be extended thanks to HP request handling
  - New connect flag to detect clients that support EINPROGRESS

Slave Eviction

- Can happen when glimpse callback on quota locks not acknowledged in a timely manner
  - Might impact other services using this connection
- From the master perspective, the slave has gone "disconnected "
  - new ID can be added/removed to/from the slave index w/o issuing glimpses
  - space reserved by this slave cannot be claimed back
- From the slave point of view
  - Quota locks must be re-enqueued ASAP
  - Meanwhile, continue to operate with the on-disk copy
  - If one ID runs out of local quota space, requests are failed with -EINPROGRESS
  - Once the lock is requeued, all in-memory structures & on-disk index are cleaned up and recreated

DNE support

- Inode quota managed in the same way as block quota
- All MDTs are slaves
- EINPROGRESS support to be extended to metadata
- Metadata targets no longer acquire block quota space and only deal with inode limit
- No inode quota with ZFS OSD

Quota Control Commands

- obd_quotactl issued by client
  - lfs setquota
  - lfs quota
  - lfs quotaon/off/check (DEPRECATED)
- Handlers in MDT & OFD layers
- Need to call into master and slave

Quota CTL list

- GETQUOTA
  - Get global parameter from master
- GETOQUOTA
  - Get slave usage & limit
- SETQUOTA
  - Set new global limit on master
- GETINFO
  - Fetch grace time from master
- SETINFO
  - Set grace time on master
- QUOTAON/OFF/CHECK are deprecated

Quota Data Structures

- Accounting objects
  - MDT, OFD, lquota SLV
- Master objects, GLB & SLV indexes
  - lquota MST
- Slave index copy, aka SLV objects
  - OFD, MDT, lquota SLV
- Quota context
  - OSD

#1 Storing Quota Data Structures

- lu_quota API invoked from MDT/OFD/OSD to call into quota
  - Master & slave object and context
  - lu_quota_{init,fini}/lu_quotactl/lu_quota_op_{begin,end}
- lu_quota pointer in dt_device
  - NOGO from Alex during patch review ☹
- Separate master from slave data structures

#1 Solution Proposal

- lquota_mst_context
  - Stored in mdt_device of MDT0
  - lquota_mst_quotactl() to handle GETQUOTA/GETINFO/SETQUOTA
  - lquota_mst_{acquire/release}
- lquota_slv_context
  - Stored in osd_device
  - lquota_slv_{begin,end}
- MDT/OFD lookup accounting & slave objects on access

#2 LDLM Namespace

- MDT0 is the quota master
- Shall we use the existing namespace for quota locks or use a different one?
- Existing namespace could be reused by storing quota_id in res[0..1] and quota master information in res[2..3]
- Problem with LRU resize if multiple namespaces per target?

#3 Versioning the index

- Avoid transferring the indexes
- One version for the list of IDs
  - Version bumped each time a new ID is added/removed from the list
  - Requires synchronous setquota
- One version for each slave index file
  - Version bumped on dqacq/dqrel
  - Tricky since multiple RPCs can run concurrently
- No entry added in slave index on setquota

#4 Quota on/off

- lfs quotaon/off/check deprecated
  - Deprecating on/off/check quotactl
- Replace with lctl conf_param
- Quota on/off lost with write conf
  - Same of OST pool configuration
  - Require to create separate config logs to store those generic parameter
  - Should be handled in a separate project

#5 Per-quota pool

- Quota can be turned on/off on metadata or data independently
- Default pool ID assumed to be 0 for both data and metadata default pool
- Layout on ldiskfs is …