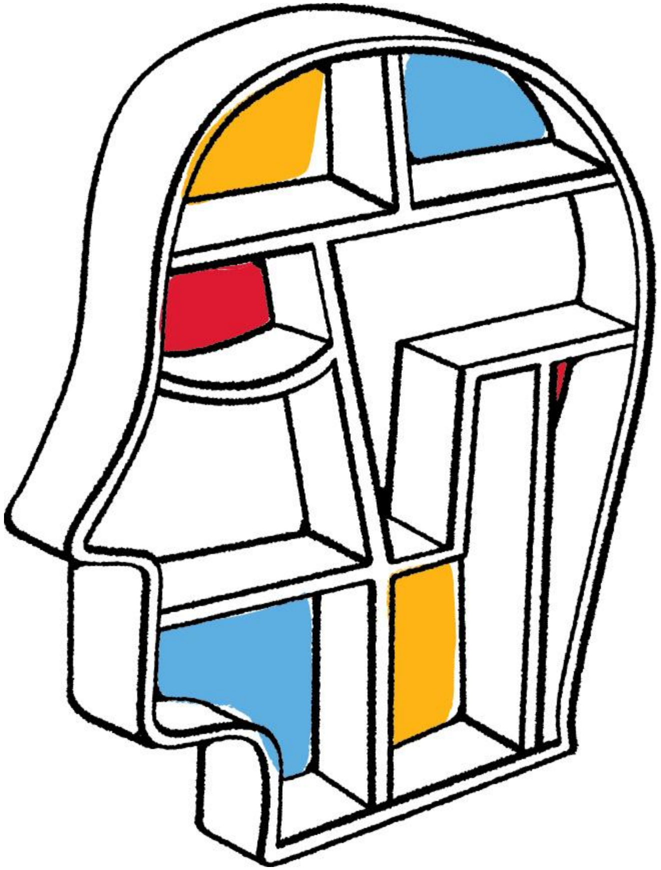
Go further, faster®

NFSv4.1 dynamic slot allocation

Trond Myklebust
<trond@netapp.com>



What is dynamic slot allocation?

- A tool for managing **global** session resources
  - Allows dynamic resizing of the replay cache on a per-client, per-load basis
    - The client communicates to the server whether or not it can fill all slots.
    - The server then decides how many slots it should allocate to that client in the future.
    - Communication occurs via the SEQUENCE operation, which means that updates occur on every COMPOUND.

Ordinary session management

- Number of session slots negotiated at CREATE_SESSION time
  - *ca_maxrequests* sets the table size
  - Server pins *sr_highest_slotid* and *sr_target_highest_slotid* to *ca_maxrequests*-1
  - Server ignores the client settings of *sa_highest_slotid*
- If the server runs out of resources, it can force renegotiation of the session by returning NFS4ERR_BADSESSION.

Dynamic session management

- Initial session table size still negotiated at CREATE_SESSION time.
  - Session table size changes communicated using SEQUENCE: *sr_highest_slotid* and *sr_target_highest_slotid* reply fields
  - Server may adapt table size using its own policy criteria. E.g. client load, resource availability
  - Also a callback mechanism for out-of-band slot recalls.

How does the client communicate load?

- The session slots are numbered from 0…n.
- The client is required to allocate all slots from 0…n-1, before it can use slot n.
- In each SEQUENCE call, the client fills the *sa_highest_slotid* field to reflect the highest slot number in use *at the time the SEQUENCE was sent*.

How does the server reply?

- The server fills the *sr_highest_slotid* with the highest slotid that the client is allowed to use.
  - This is the highest slotid for which the server is caching the sequence number.
- It fills the *sr_target_highest_slotid* with the highest slotid that the client should use in the future.
  - IOW: as soon as the client sees this target, it should stop allocating new slotids > target.

Some notes

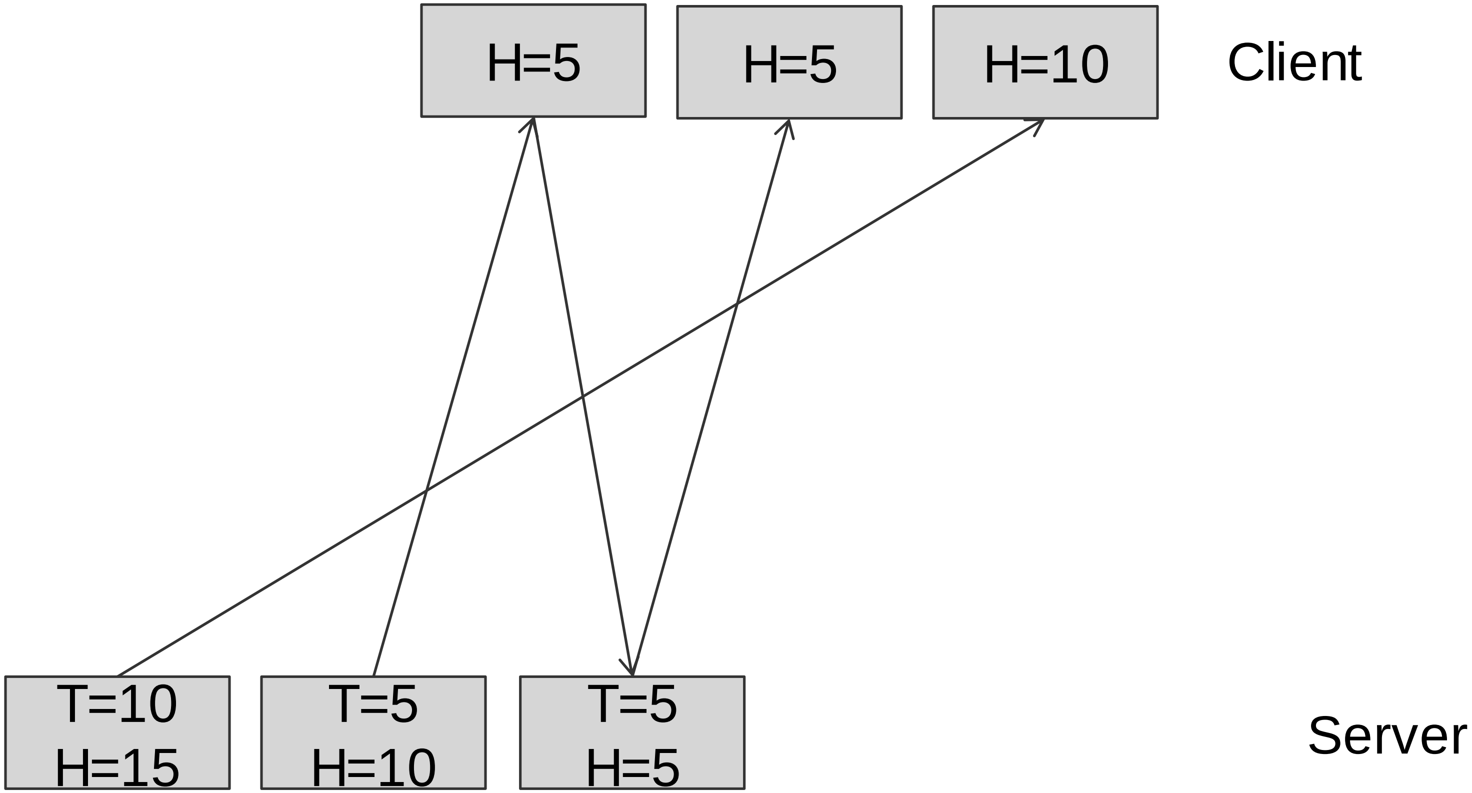
- *sr_target_highest_slotid* <= *sr_highest_slotid*
- Since dynamic slot allocation is not a mandatory feature (but a really useful one), then servers SHOULD ensure that for clients that don’t support dynamic slot allocation, *sr_highest_slotid* >= *csr_fore_chan_attrs.ca_maxrequests-1* (see CREATE_SESSION).

Sounds easy. Where's the catch?

- Asynchronous nature of communication means that the client and server need to be careful when updating the values for *sr_highest_slotid*, sr_*target_highest_slotid*.
  - SEQUENCE requests/replies on different slots can be reordered w.r.t. each other.

How does reordering create problems?

- Client sees incorrect limits:



H=5

H=5

H=10

Client

T=10
H=15

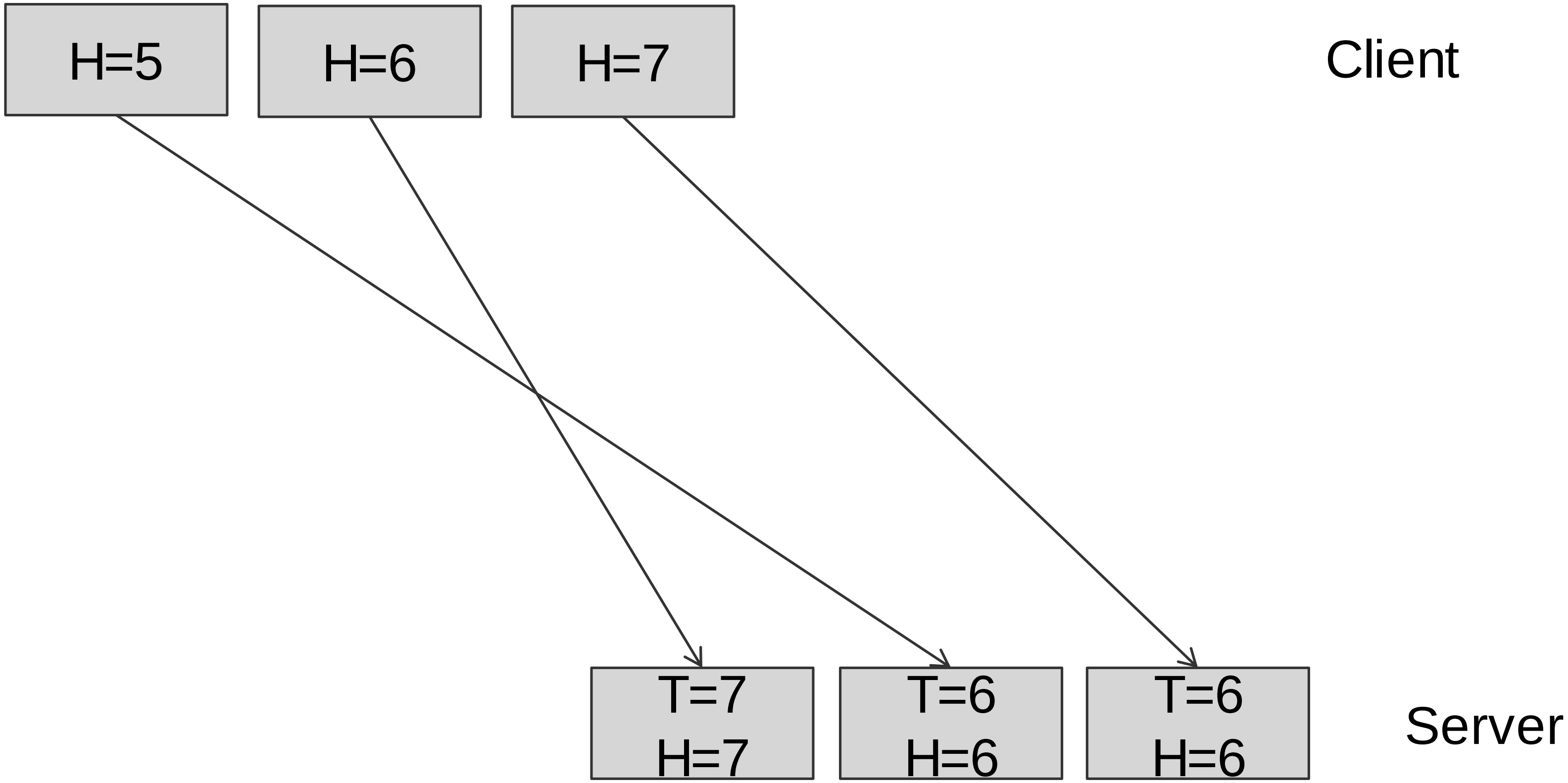
T=5
H=10

T=5
H=5

Server

How does reordering create problems?

- Server sees incorrect client load:

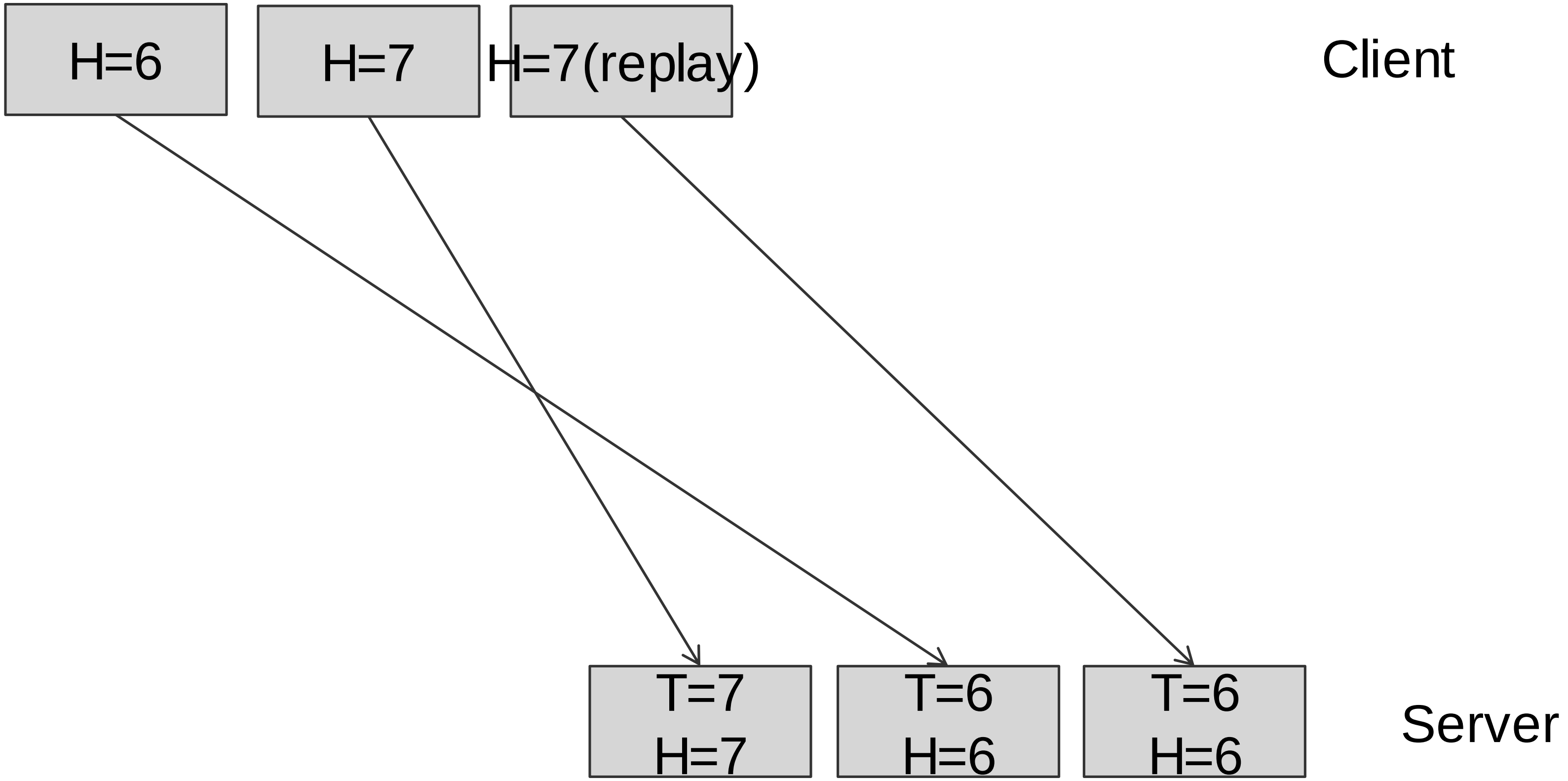


When can *sr_highest_slotid* decrease?

- After changing *sr_target_highest_slotid*.
  - Need to know that the client is not trying to replay any requests on those slots
  - Check *sa_highest_slotid*.
    - But what if it was reordered?

How does reordering create problems?

- Server retires sr_*highest_slotid* too early:



When can *sr_highest_slotid* decrease?

- After changing *sr_target_highest_slotid*.
  - Need to know that the client is not trying to replay any requests on those slots
  - Check *sa_highest_slotid*.
    - But what if it was reordered?
- Solve reordering problem by checking *sa_highest_slotid* **only** on slots on which the new *sr_target_highest_slotid* have been sent.
  - Server needs to track value of *sr_target_highest_slotid* for each slot.

When can *sr_highest_slotid* decrease

- Alternative server strategy is to only grow the window using *sr_target_highest_slotid* mechanism.
  - Use CB_RECALL_SLOT to tell the client to shrink the window
  - Problem is that only solves the reordering issues for server highest slotid limits.

Protocol nits…

- RFC5661 does not say what happens to the sequence id for a “new” slot, when the server raises *sr_highest_slotid*.
  - Should it be initialised to ‘0’ on the server?
    - Reordering corner cases: client may fail to see slot being retired and then reinstated…
    - Alternative is to allow any initial value.
  - Need an errata…

Implementation: client

- Linux 3.7 upstream NFSv4.1 client and newer implements dynamic slot allocation on the forward channel.
  - Supports CB_RECALL_SLOT
  - Client will generate extra SEQUENCE ops in order to satisfy lower target highest slotid.
  - Implements simple smoothing to avoid re-ordering issues w.r.t. highest slotid and target.

Implementation: server

- Server patches published and available for Linux 3.7, and 3.8. Not yet upstreamed.
  - Implements basic client-driven policy
    - grow the number of slots by ¼ when *sa_highest_slotid* >= *sr_target_highest_slotid*
    - Shrink slot table when *sa_highest_slotid* is decreasing
  - Global maximum number of slots.
  - Smoothing used to avoid *sa_highest_slotid* reordering issues.

NetApp®

Thank you