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Reflections On Client Instance Uniqueness

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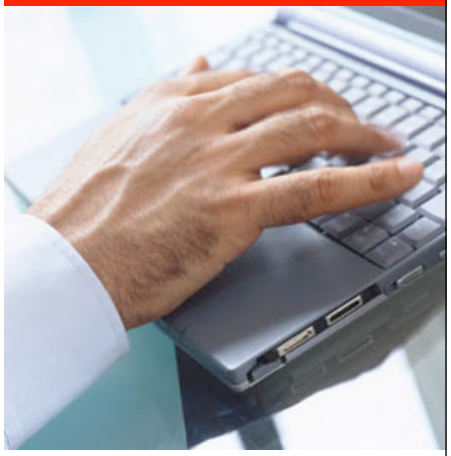
Constructing nfs_client_id4



- What is a client instance?
- RFC 3530bis recommendations
- Existing implementation practices
- Better choices

What Is A Client Instance?

- Boot verifier - `nfs_client_id4.verifier`
  - Unstructured 8-byte value
  - Changes across client reboot
  - Allows server to distinguish between client reboot and callback update
- Client string - `nfs_client_id4.id`
  - Opaque array of bytes chosen by client to be unique from all other clients
  - Fixed across client reboot
- Principal used for SETCLIENTID operation
  - Authentication flavor plus credential
  - Gray area

RFC 3530bis

- Section 9.1.1 covers client identification
- When boot verifier changes, server cancels client's leased state
- Id string
  - Unique across all clients
  - Fixed across client reboots
  - Different for each server address that client accesses
  - Don't assume client's address is fixed
- Security measure
  - Server can't cancel lease of a subsequent SETCLIENTID with same ID and new verifier uses a different principal

RFC 3530bis

- Founder's intent:
  - A client changes the boot verifier only when it reboots
  - Each distinct client has one and only one `id` string
  - A client always uses the same principal when sending SETCLIENTID

RFC 3530bis

- Recommended contents of `id` string
  - Server's network address
  - Client's network address
  - Possibly a UUID
  - Client host's serial number
  - A MAC address
  - A fixed timestamp
  - A true random number
- How has this worked out for us?

RFC 3530 Recommendations

Network Addresses

- Client network address in `id` string
  - Clients can share same address if behind a NAT router
  - Dynamically assigned client address can change over a reboot
  - Multi-homed client would generate a distinct lease for each of its network addresses
- Server network address in `id` string
  - Multi-homed server would create separate leases each server address through which the client accesses it
  - UCS clients must use the same string for all servers

RFC 3530 Recommendations

Authentication

- Server MUST NOT cancel lease if SETCLIENTID principal doesn't match original SETCLIENTID
  - NFS4ERR_CLID_INUSE is returned
  - Does this make principal part of client's identity?
- Authentication flavor in `id` string
  - Client generates separate lease for each flavor used
  - Linux added flavor name to `id` string until recently
- Using AUTH_SYS with SETCLIENTID
  - Most clients use { UID 0, GID 0 }
  - Server not likely to catch reuse by other clients
  - Server could examine machine name part of credential, but still no guarantee of uniqueness

RFC 3530 Recommendations

Hardware Serial Number

- MAC address in `id` string
  - Client with multiple NICs used serially (*e.g.* wifi, wired)
  - Client with multiple NICs used concurrently (*e.g.* multi-homed)
  - OS initialization order of NICs is indeterminant
  - Virtualized clients may get re-used MAC addresses
- Machine serial number
  - Aside from privacy concerns...
  - Most hardware platforms do not have a unique hardware identifier

RFC 3530 Recommendations

Additional Uniqueness

- UUID in `id` string
  - A Type 1 UUID is a MAC address and a time stamp
  - A random-variant UUID would have to be stored somewhere on the client, but is suitably unique
- Client hostname in `id` string
  - Nothing stops administrators from assigning same hostname
    - Especially challenging if non-FQDN are chosen
  - Hostnames often dynamically assigned, thus not fixed across reboots
  - Usually client hostname is “good enough,” until it isn’t

Good Practices

- Some servers use source address of SETCLIENTID or SETCLIENTID_CONFIRM to detect distinct clients using the same `id` string
  - Servers should use only the arguments of these operations, not transport addresses
  - Linux server is known to do this, fixed recently

Good Practices

- Some servers use `id` strings to keep leases sorted after a cluster take over
  - Allows an orderly give back, but
  - This design relies on clients using a distinct string for each server they access
  - Not compatible with UCS approach, needed to support Transparent State Migration
  - SunStorage is known to do this

Good Practices

- Some clients use a unique `id` string for each mount point
  - Servers must maintain more leases
  - Client must store these strings permanently to permit proper state recovery
  - Intent of RFC 3530 was for each client to use the same `id` string for all of its mount points
  - FreeBSD is known to do this

Good Practices

- Updating `nfs_client_id4.verifier`
  - RFC 3530 does not require a client's boot verifier to remain unchanged during a single client restart
  - Servers generally do not check for a verifier replay
  - Server uses boot verifier to prevent loss of leased state during a callback update
  - Some clients change the boot verifier on the next mount after the last mount of a server is gone
  - A client can use a boot verifier change to force a server to remove its leased state
  - Linux client is known to do these last two

Good Practices

- Virtualization
  - Virtualized NFSv4 clients running on the same physical host should use distinct `id` strings and boot verifiers
  - Virtualized NFSv4 servers running on the same physical host should behave as independent server instances
    - Maintain separate `clientid4` spaces
    - Maintain separate leases for a particular client

An Example: Linux Client

- Non-uniform
  - Traditional, now default for NFSv4.0
  - Allows compatibility with existing NFSv4.0 servers
  - Server IP address, client IP address, callback netid
- Uniform
  - Default for NFSv4.1, allowed for NFSv4.0 with migration
  - “Linux,” NFS version, then a uniquifier
    - uniquifier is normally client’s nodename
    - A replacement can be specified on boot command line
      - Can be stored by GRUB or provided via DHCP boot
      - Might be a UUID generated during client installation

An Example: Linux Client

- Traditional boot verifier
  - 64-bit time stamp stored in per-lease data structure
  - Regenerated on next mount when last mount of a server goes away
- New boot verifier
  - 64-bit time stamp stored per container
  - Regenerated when container is created (typically once per boot)
  - Special NFSv4.1 behavior when a STATE_REVOKED sequence flag is asserted
    - EXCHANGE_ID presents an impossible time stamp
    - Second EXCHANGE_ID presents original verifier