Lessons in running libvirt at scale

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What we do @Nutanix:

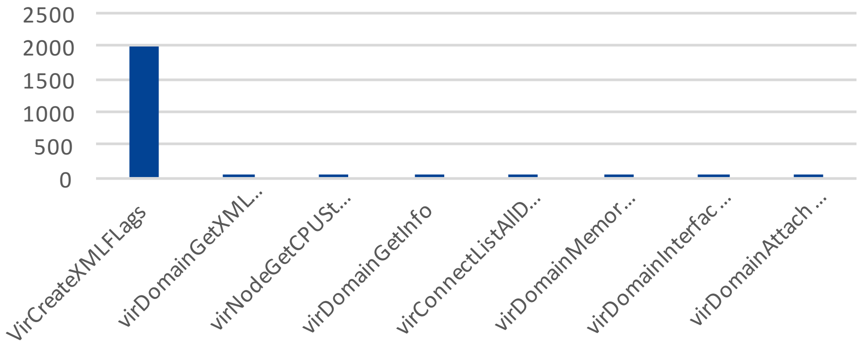
- Self healing, dynamically scaling, auto-balancing clusters.
- Proprietary orchestration layer to work with Libvirt, Qemu, KVM
- Designed for scale: must support 1000 VMs per box and 100s of concurrent ops.
- Near-immediate host failure detection based on libvirt keepalives.
- Automated VM failover in less than a minute.

How do I measure the efficacy of management layer?

- Reliability : Do all requests complete deterministically, without impacting vital functions ?

- Throughput : How many ops can be driven in a given time window.

RPC call stats in an idle environment



Bulk Power ONs:

- During bulk power ops, libvirtd would “lock up” for long intervals.
  - All client communication { RPC / Keepalives } ignored.
- Libvirt liveness tied to Host HA.
- False alarm : Perfectly healthy VMs force-evacuated.

Catastrophe !

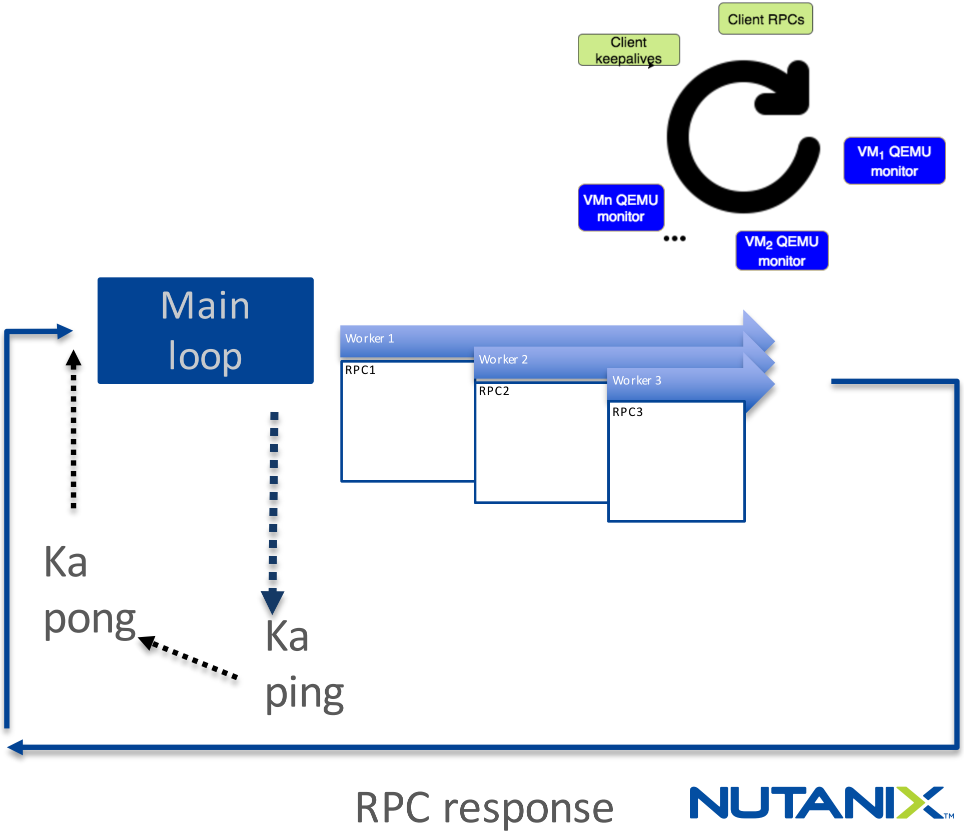
Analysis:

- Keepalives are enqueued right from the main loop, *each time epoll() detects a message could be sent.*[1]

[1] Reported: https://www.redhat.com/archives/libvir-list/2017-May/msg00016.html

Current Threading model (QEMU driver)

- Main epoll() loop listens on all sockets :
  - Client socket(s) for RPCs/ keepalives(Ka)
  - VM Monitor(s) for replies + events + hangup
- Client comunication:
  - Optimized keepalive handling.
  - All RPCs punted to threadpool.



Current threading model (contd)

- VM monitoring:
  - ‘reply’ messages wake up requisite worker thread (no overhead for main thread)
  - Hangups and async QMP events : *handlers run in main thread.*
    - All events need the per-VM lock.
    - Event races with existing RPC → lock contention holds down the main loop!

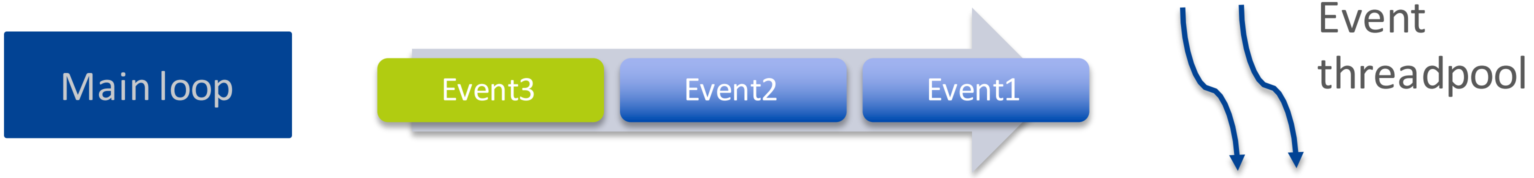
Solution #1:

- Introduce a dedicated thread(pool) in QEMU driver to handle async events.
  - Main thread just “posts” the event to this queue.
  - Events are picked up as they arrive, by a dedicated event handler thread.
  - Can be expanded to a event-threadpool based implementation.
  - Lock contention point moves from main thread to event handler thread.

Solution #1 (contd):

Drawback:

- Event processing can suffer latency.
  - Add more threads, burn more resources?
- Dedicated event worker may still contend with RPC(s)



Solution #2:

- Introduce a dedicated thread(pool) in QEMU driver to handle async events.
  - Main thread just “posts” the event to this queue.
  - Events are picked up by the worker thread(s) as they arrive, leaving the RPC threadpool free to pursue client RPCs.
  - Event threads only pick an event if the respective VM lock is available.
  - Additionally, each RPC worker also “drains” queued event(s) just before giving up the lock.

Limitation:

- Increases time accounted for in RPC context:
  - Other worker threads may time out ?
  - Non-deterministic client behaviour: same RPC may take varying times depending on size of event queue.
- Prioritizing Shutdown/hangup handling:
  - “standard” event worker vs priority worker?
- Blurred lines: When RPCs and events merge.

Returning to assessment mode : Throughput validation

Re-evaluating the current threading model:

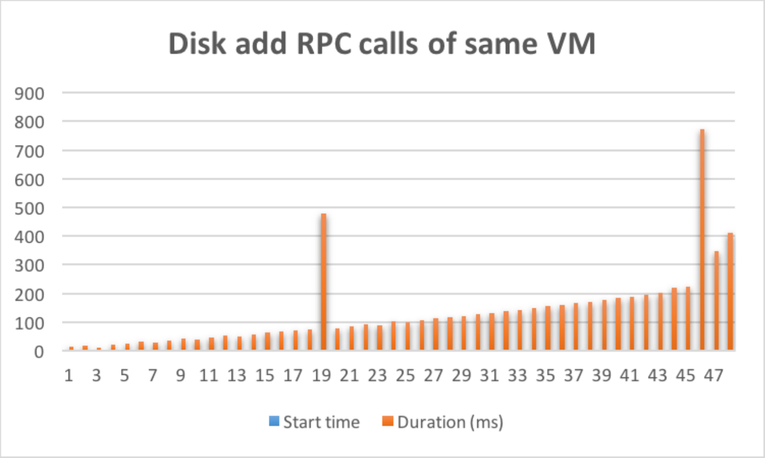
- Worker threads running RPCs for the same VM contend for the same lock
  - Only *one* of all makes forward progress.
  - Unfair delay for non-contending RPCs stuck behind in the queue.

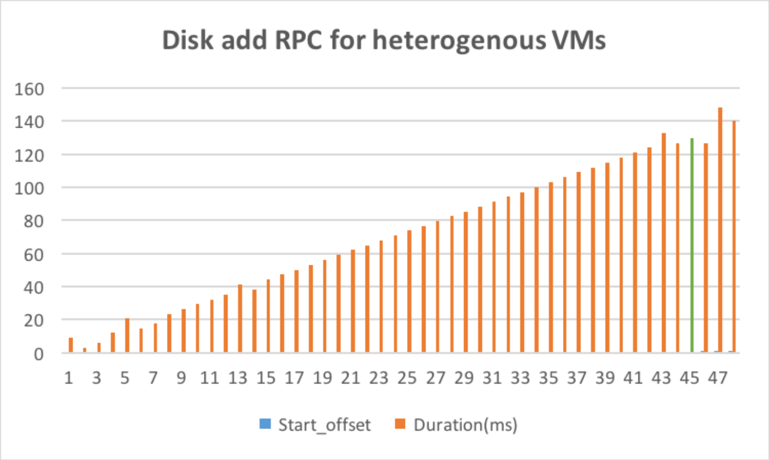
Evaluating libvirt throughput:

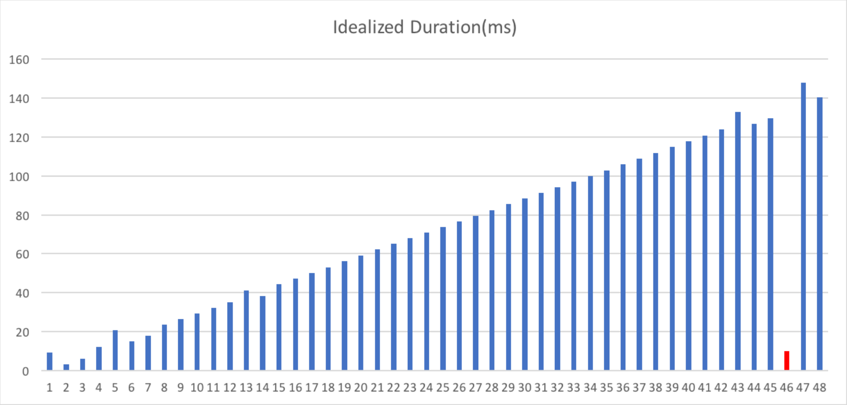
Test setup:

- Libvirtd configured with min, max workers of {2,10}
- Multithreaded C program used to drive >3x RPCs :
  - *for the same VM.*
    - As expected, RPCs exhibit sequential execution.
  - *Behavior with heterogenous VM RPCs*

Results:


Disk add RPC calls of same VM
900
800
700
600
500
400
300
200
100
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47
🟦 Start time
🟧 Duration (ms)


Disk add RPC for heterogenous VMs
160
140
120
100
80
60
40
20
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47
🟦 Start_offset
🟧 Duration(ms)


Idealized Duration(ms)
160
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

Analysis:

- Impact:
  - Adversely hits a multi-tenant environment

Proposed solution :

Can we carve out per-VM queues ?

- Better throughput.
- Easier to bake in event infrastructure.

Other good-to-have(s), while we discuss..

- Libvirt daemon interacts with client in perfect async fashion, using serial numbers to tie requests to responses.
- Client translates API calls into async messages, but sends them using `virNetClientSendWithReply()`
- An application linked to the client has to work with blocking calls ☹
- Might need changes to the current multi-threaded dispatch model..

Questions ??

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