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VERAE TIME x ZAPIER · PROGRESS REPORT · RUN ON NS1.GEORGELAMBERT.ORG

NATS cluster message speed — NS1 host study

packages/zapier-decisions/reports/nats-cluster-bench-ns1.md

Progress report (second study) · run `20260912T051237Z` (UTC)

Execution provenance. Every process for this study ran on **NS1.GEORGELAMBERT.ORG** (`70.88.205.138`): the orchestrator (`study-on-ns1.sh`), `nats bench` , `latency.mjs` (inside LXC 510 on this hypervisor), `charting` (`matplotlib`), and HTML/PDF (`pandoc + weasyprint`). The operator laptop did **not** publish, subscribe, draw charts, or render the PDF. Traffic stayed on `vmbr1` from LXC **510** to `nats-a/b/c` (**511-513**).

This is a full methodology write-up plus the numbers from that on-host run. The earlier report (`nats-cluster-bench` , run `20260912T045131Z`) used the same cluster but was **orchestrated and rendered off-box**. Use this document when you need “it was all run on 138.”

1. Executive summary

Item	This NS1-host run
Control plane	NS1.GEORGELAMBERT.ORG (70.88.205.138), user marchon
Bench client	LXC 510 verae-px-worker
Brokers	LXC 511/512/513 nats-a/b/c on 10.10.10.21-23
Client URL	nats://10.10.10.21:4222,nats://10.10.10.22:4222,nats://10.10.10.23:4222
Host load before	8.59 8.39 8.15 5/3843 4096277
Host load after	8.67 8.33 8.15 9/3863 4114865
Core 1p1s 128 B pub	502,502 msgs/s
JetStream 1p 128 B r=3	7,393 durable pubs/s
Ping p50 / p99	0.395ms / 1.377ms

Product traffic is the JetStream row. Ping is one-message delay. Flood is mailbox catch-up after a burst.

2. Where it ran (and where it did not)

```
Operator laptop —ssh→ NS1.GEORGELAMBERT.ORG 70.88.205.138
                        study-on-ns1.sh
                        python3 build-ns1-study-report.py
                        sudo pct exec 510 → nats bench / latency.mjs
                                      |
                                      ▼ vmbr1
                                10.10.10.21-23 :4222
```

- **Did run on 138:** bash, python3, matplotlib, pandoc, weasyprint, `pct`, nats-server (in LXC), nats CLI and Node (in LXC 510).
- **Did not run on the laptop:** no local `nats bench`, no local charting, no local WeasyPrint for this file.

3. Results (this run)

Host and brokers

Before

Node	VMID	connections	in_msgs	out_msgs	cpu	cores	mem (B)	jetstream
nats-a	511	2	1,721,203	4,933,759	1	1	26,398,720	True
nats-b	512	2	1,613,205	3,513,096	0	1	23,097,344	True
nats-c	513	2	1,760,973	4,048,582	2	1	23,867,392	True

After

Node	VMID	connections	in_msgs	out_msgs	cpu	cores	mem (B)	jetstream
nats-a	511	2	2,097,596	5,910,161	1	1	38,273,024	True
nats-b	512	2	2,121,816	4,746,539	1	1	41,361,408	True
nats-c	513	2	2,241,366	5,053,978	1	1	38,162,432	True

nproc=40 ·

uname= Linux NS1.GEORGELAMBERT.ORG 6.17.2-1-pve #1 SMP PREEMPT_DYNAMIC PMX 6.17.2-1
(2025-10-21T11:55Z) x86_64 GNU/Linux

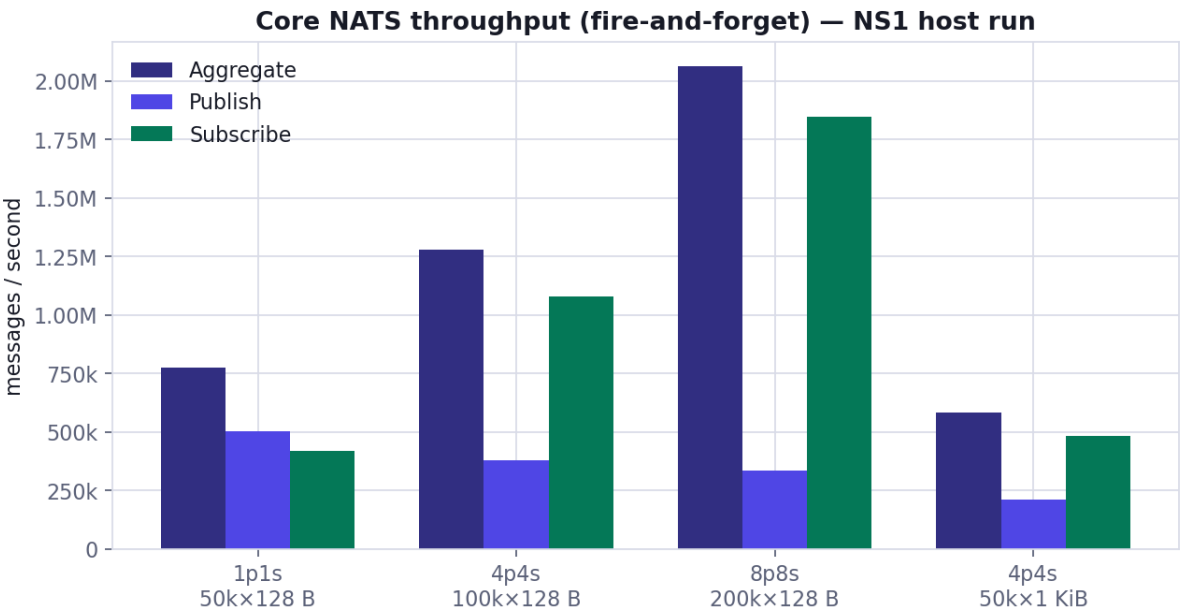
Throughput

Run	Mode	Aggregate msgs/s	Pub msgs/s	Pub MB/s	Sub msgs/s	Sub MB/s
core-1p1s-50k-128	core pub/ sub	776,331	502,502	61.34	420,976	51.39
core-4p4s-100k-128	core pub/ sub	1,278,454	379,985	46.38	1,078,910	131.70
core-4p4s-50k-1k	core pub/ sub	581,464	209,545	204.63	482,645	471.33
core-8p8s-200k-128	core pub/ sub	2,065,217	333,731	40.74	1,847,242	225.49
js-1p-20k-128-r3	jetstream r=3 file	—	7,393	0.90	—	—
js-2p2s-20k-128-r3	jetstream r=3 file	15,416	7,728	0.94	7,711	0.94
js-4p-20k-1k-r3	jetstream r=3 file	—	14,985	14.63	—	—
js-4p-50k-128-r3	jetstream r=3 file	—	17,986	2.20	—	—

Round-trip delay

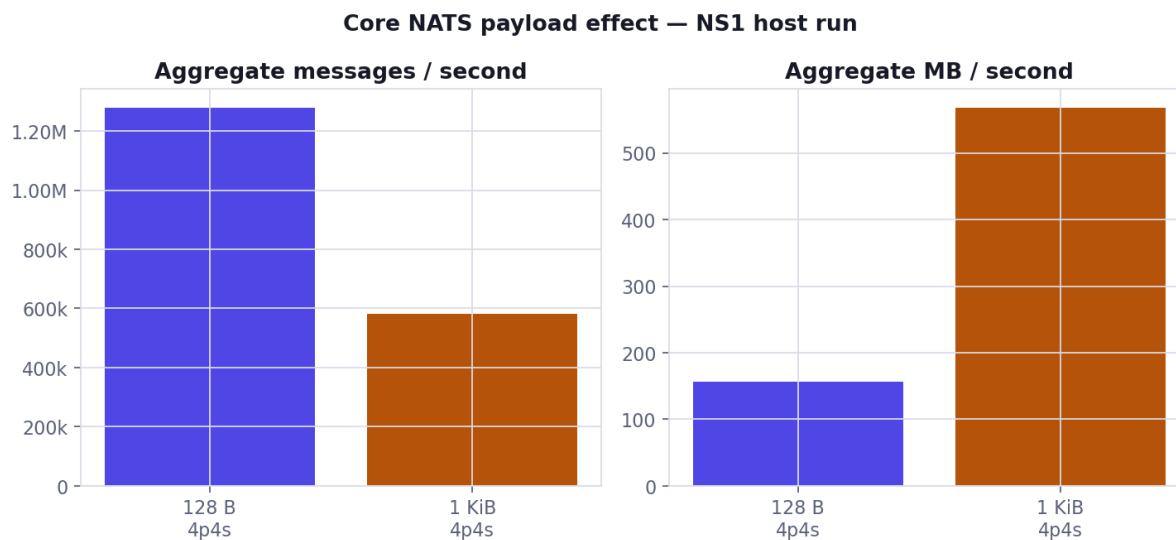
Run	Kind	Count	Pubs	Size	min	avg	p50	p90
lat-ping-1k-128	ping (sequential RTT)	1000	1	128 B	0.341ms	0.470ms	0.395ms	0.65
lat-1p-5k-128	flood (burst queueing)	5000	1	128 B	132.425ms	203.717ms	204.458ms	241.
lat-4p-5k-1k	flood (burst queueing)	5000	4	1024 B	196.422ms	221.264ms	224.039ms	233.
lat-4p-10k-128	flood (burst queueing)	10000	4	128 B	211.108ms	294.925ms	300.254ms	314.
lat-8p-20k-128	flood (burst queueing)	20000	8	128 B	280.608ms	414.972ms	409.802ms	513.

Core NATS



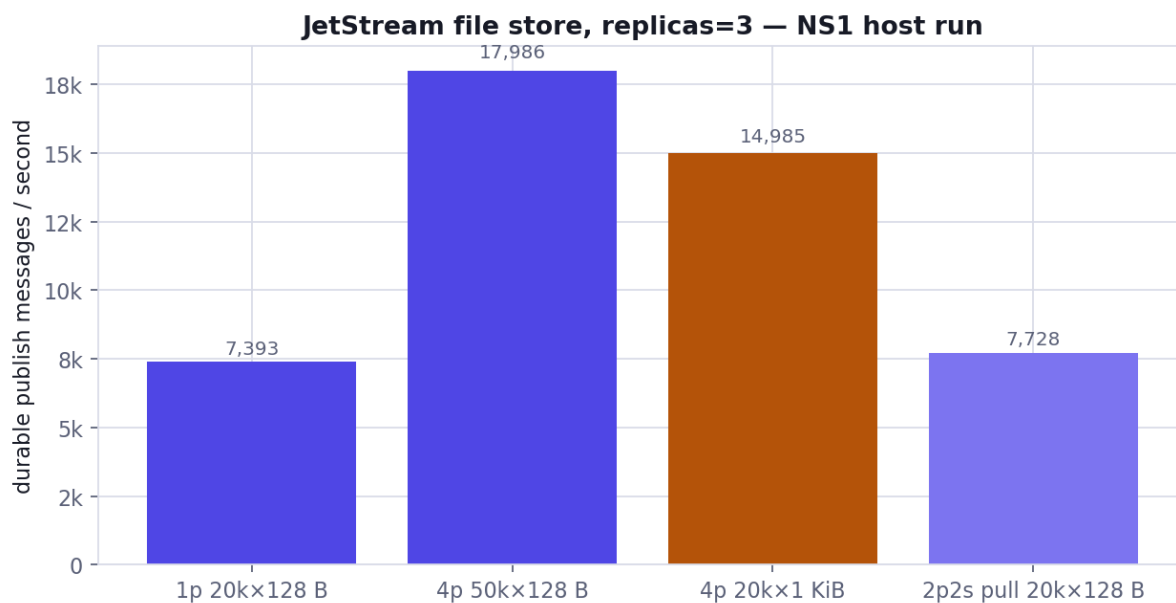
Core NATS throughput at four loads (NS1 host run)

Core NATS throughput at four loads (NS1 host run) ### Payload size (core)



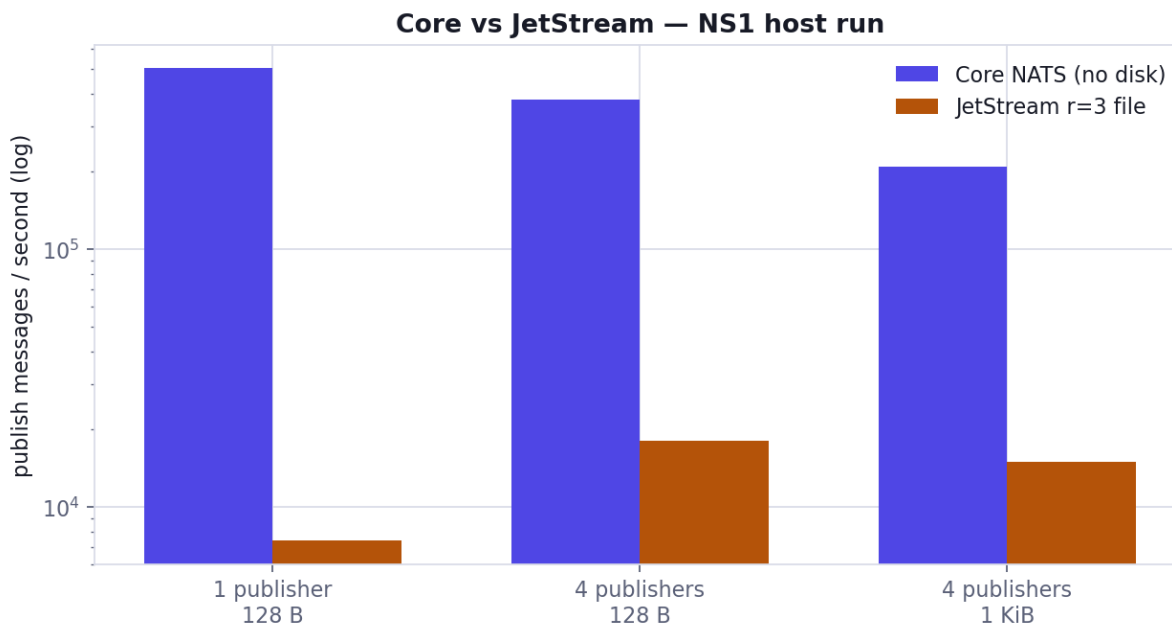
Core NATS 128 B vs 1 KiB (NS1 host run)

Core NATS 128 B vs 1 KiB (NS1 host run) ### JetStream r=3 file



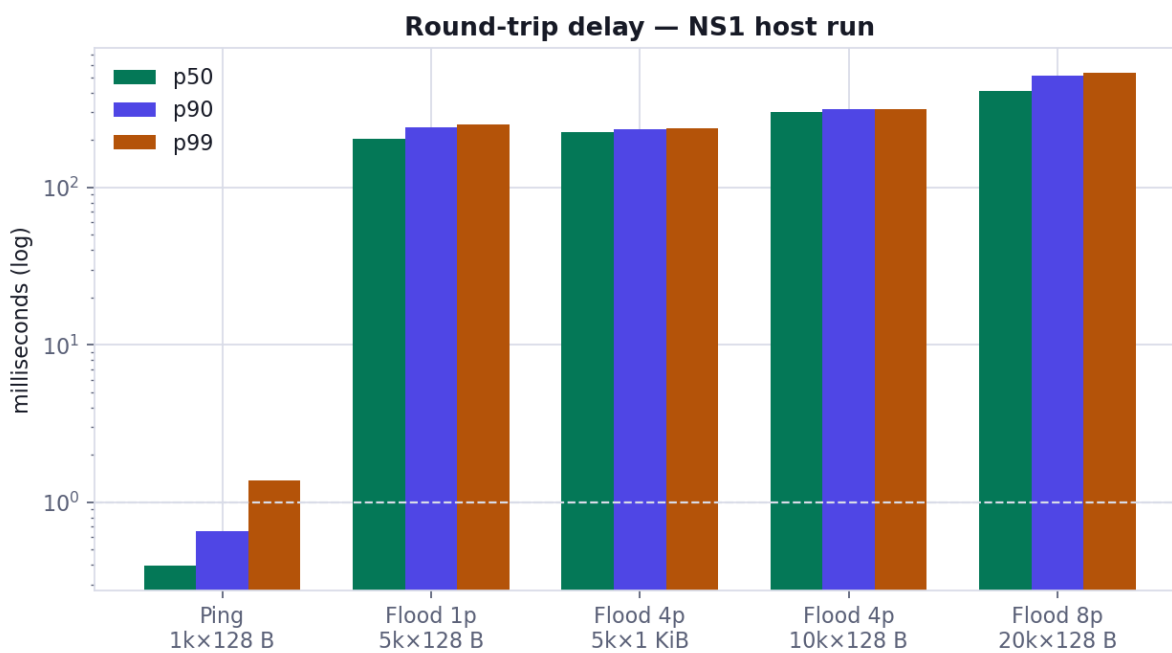
JetStream durable publish rate (NS1 host run)

JetStream durable publish rate (NS1 host run) ### Core vs JetStream



Core vs JetStream publish rate, log scale (NS1 host run)

Core vs JetStream publish rate, log scale (NS1 host run) ### Delay



Ping vs flood delay percentiles, log scale (NS1 host run)

Ping vs flood delay percentiles, log scale (NS1 host run)

4. Study methodology

4.1 Question

On the NS1 test stand, what message **throughput** and **delay** does the three-node [verae](#) JetStream cluster deliver at several loads, and which part of the stack is the limiter for product traffic (jobs, events, webhooks, archive)?

4.2 Hypotheses (stated before the run)

1. **H1 — Core vs JetStream.** Fire-and-forget core NATS is at least an order of magnitude faster than JetStream **file + replicas=3**, because durable publish waits for a majority disk replica.
2. **H2 — JetStream parallelism.** Adding publishers does **not** linearly increase JetStream write rate once the replica log is saturated.
3. **H3 — Quiet delay.** Sequential pub→sub round trip on [vmbr1](#) is well under 1 ms p99 when the consumer is waiting.
4. **H4 — Burst delay.** If publishers dump a batch before the subscriber drains, observed delay is **queueing time**, roughly linear in backlog, not in cluster hop count.
5. **H5 — Payload.** Moving 128 B → 1 KiB lowers message rate and raises byte rate on core NATS; JetStream in this size band stays replica/fsync bound.

4.3 Independent variables (what we changed)

Factor	Levels
Transport	Core NATS pub/sub vs JetStream file replicas=3
Publisher count	1, 2, 4, 8
Subscriber count	0 (JS publish-only), 1, 2, 4, 8
Message count	1k, 5k, 10k, 20k, 50k, 100k, 200k (by ladder step)
Payload	128 B, 1024 B
Delay mode	ping (publish, wait, repeat) vs flood (publish all, then drain)

4.4 Dependent variables (what we recorded)

Metric	Instrument	Unit
Publish rate	<code>nats bench</code> 0.1.6 Pub stats	msgs/s, MB/s
Subscribe rate	<code>nats bench</code> Sub stats	msgs/s, MB/s
Aggregate	<code>nats bench</code> NATS Pub/Sub stats	msgs/s (fan-out counts both sides)
Publisher spread	<code>nats</code> min/avg/max msgs/s	not delay
One-way-ish RTT	<code>latency.mjs</code> header timestamp	min, avg, p50, p90, p99, max
Host load	<code>/proc/loadavg</code> before and after	load average
Broker counters	<code>http://127.0.0.1:8222/varz</code> inside each <code>nats</code> LXC	connections, in/out msgs, cpu, mem

Important: `nats` CLI 0.1.6 min/avg/max are **rate spread across publishers**, not microseconds of delay. Delay is only `latency.mjs`.

4.5 Controls and constants

- Cluster name `verae`, three routes, client `:4222`, cluster `:6222`, monitor loopback `:8222`.
- Client URL always the three-node list on `vmbr1` (never host `127.0.0.1:4222`, never `vmbr0`).
- Bench client is LXC **510**, not a `nats-*` server.
- JetStream bench stream name `benchstream`, **file** storage, **replicas=3**, deleted between JS loads (`nats stream rm --force`) so names do not collide.
- Product streams were **not** the bench target (no load test on `ZAPIER_*` / `VERAE_ARCHIVE`).
- No TLS, no nkeys, no account isolation (isolation is `vmbr1`).
- Same `nats` CLI version (0.1.6) and `nats@2` Node client as the first ladder.

4.6 Procedure

1. Confirm this script is executing on **NS1.GEORGELAMBERT.ORG**. Refuse otherwise.
2. Snapshot host load, memory, LXC configs, and each `nats` `varz`.

3. From NS1, `pct exec 510` the core ladder (1p1s, 4p4s, 8p8s at 128 B; 4p4s at 1 KiB).
4. Delete `benchstream`; JS ladder (1p, 4p, 4p×1 KiB, 2p2s pull) at replicas=3 file.
5. Copy `latency.mjs` into 510; ping then flood at several batch sizes.
6. Snapshot host/`varz` again.
7. Parse logs on **this host**; draw charts; write HTML and PDF on **this host**.

No publish, subscribe, chart, or PDF process runs on the operator laptop for this study.

4.7 Instrumentation path

```
[NS1 host 70.88.205.138]
  study-on-ns1.sh  (bash + python3)
    |
    | sudo pct exec 510
    v
[LXC 510 verae-px-worker 10.10.10.20]
  nats bench / node latency.mjs
    |
    | NATS client protocol to
    v
[LXC 511/512/513 10.10.10.21-23 :4222]
  nats-server -js cluster routes :6222
```

The hypervisor issues the guest commands. The messages themselves never leave `vmbr1`.

4.8 Threats to validity

Threat	Effect on numbers
One physical host	Three “replicas” share CPU, memory, and usually the same datastore. This measures process/LXC HA, not disk HA.
Shared load	NS1 also runs Caddy, Forgejo, keep, fleet, portal, and other CTs. Load average during a run is part of the result, not noise to ignore.
Single bench client	All publishers live in 510. Per-publisher rate spread is contention in that guest.
Short runs	Seconds of traffic. No compaction, no multi-hour page-cache eviction, no snapshot during load.
No TLS/nkeys	Production auth will cost CPU. Do not treat these rates as post-nkeys rates.
Fan-out aggregate	Core aggregate msgs/s counts pub+sub. Do not compare that column to JetStream unique writes.
Flood $\neq$ RTT	Mixing flood averages with ping p99 produces a fake “NATS is slow” story.
Lab only	Not a Zapier HTTPS bench and not live api.veraetime.net .

4.9 Ethics / safety

Bench uses throwaway subjects (`bench.core.*`, `bench.js.*`, `bench.lat.*`) and a throwaway stream. It does not purge product streams. Zapier cloud has no NATS socket.

5. Suggestions for fine-tuning

These follow from the method and from the first ladder on this stand (JetStream ~16k durable 128 B pubs/s; ping ~0.3 ms; flood hundreds of ms). Apply in order of leverage. Re-run **this NS1 study** after each change so the delta is measured the same way.

5.1 Treat JetStream as the product limiter

Product jobs/events/webhooks/archive are durable. Tuning core NATS to 2M msgs/s will not move a timestamp Zap. Put effort into **replica write path** and **consumer lag**, not core fan-out.

5.2 Split storage class by stream

Stream	Suggested store	Why
ZAPIER_JOBS	file, r=3	Work queue; lose-a-job is bad
ZAPIER_EVENTS	file r=3, or memory r=3 if events are rebuildable from job status	Hot waiters; measure both
ZAPIER_WEBHOOKS	file, r=3, workqueue	HTTPS to Zapier is the slow consumer
ZAPIER_USAGE	file, r=3, limits + max-age	Telemetry
VERAE_ARCHIVE	file, r=3, on the best disk	Puts are larger and must survive

Try `ZAPIER_EVENTS` as memory store in a maintenance window and re-run only the JS + ping/flood steps. If ping stays ~0.3 ms and durable events still ack at a higher rate, keep it; if a CT restart drops in-flight waiters, revert.

5.3 Give JetStream real disks

Today r=3 on three LXC guests on **one Proxmox host** is three files, one failure domain.

- Bind-mount a distinct SSD/NVMe (or ZFS dataset with its own vdev) into each nats LXC `store_dir`.
- Set `sync: always` only on archive if you need it; default sync is often enough for jobs and is faster. Measure.

- Do not put JetStream `store_dir` on the same busy rootfs as Forgejo/Caddy if we can avoid it.
- When moving to three metal boxes: same configs, private NIC, one disk (or mirror) **per node**. That is the first change that makes $r=3$ mean “two boxes can die.”

5.4 Isolate the nats CTs from the rest of NS1

Host load on this box is often already several. Pin:

- `nats-a/b/c`: dedicated cores, no steal from keep/fleet Node processes.
- Memory high enough that file-backed streams stay cache-hot for the working set.
- `cpuunits` / `cpuset` in `pct config` so a Zapier-facing Node GC pause does not stall fsync.

Re-run this study after pinning; H1/H2 should move more than ping.

5.5 Consumer and mailbox tuning (delay H4)

Flood delay is backlog / consume_rate. Fine-tune the **waiters**, not the broker RTT.

- `jobs.events` and `webhooks.deliver`: raise `max_ack_pending` so a slow HTTPS hook does not stall the whole consumer; cap it so a poison message cannot unbounded-buffer RAM.
- Pull consumers: larger batch, shorter `expires`, more pullers horizontally (fleet replica floors) instead of one fat subscriber.
- Middleware should **not** flood-publish then wait; it already does per-job publish. Keep that. The flood test is the outage profile when a consumer is stopped.
- Alert on **consumer lag** (pending + ack pending) from JetStream, not on ping RTT.

5.6 Publisher-side batching in middleware

A timestamp job is one small JSON. 16k msgs/s is ample. Still:

- Avoid per-byte publishes; one message per job/event.
- Reuse NATS connections (connection churn showed up as publisher spread in the core 4p/8p runs).
- Idempotent `msg id` / duplicate window sized to Verae retry window, not default-only.

5.7 nats-server knobs worth measuring (A/B with this script)

Knob	Why try it
<code>max_payload</code>	Keep default unless archive puts grow
<code>write_deadline</code>	Slow consumer protection for webhooks
<code>max_pending</code>	Bound memory on a stuck Zapier hook
<code>max_connections</code>	Fleet workers + keep + middleware
JetStream <code>max_file_store</code> / <code>max_memory_store</code>	Prevent one stream from filling the CT
<code>max_outstanding_catchup</code>	Replica restart after a nats-c blip
<code>GOMAXPROCS = LXC cores</code>	Do not overthread a 2-core CT

Change **one** knob, re-run `study-on-ns1.sh`, compare JetStream 1p 128 B and ping p99.

5.8 Network

- Keep NATS off `vmbr0`. No change.
- When on metal: dedicated NIC or VLAN for cluster `:6222` vs client `:4222` if possible (replication vs client load).
- Check virtio queue counts on the LXC nics if core 1 KiB byte rate plateaus.

5.9 Security cost (when nkeys/mTLS flip)

`verae-nats-accounts` is still a sketch. Enabling accounts will add CPU on publish. Budget: re-run this exact study **after** creds are in every `NATS_URL`, and accept a drop on both core and JS. Do not flip without that measurement.

5.10 Operational fine-tuning (lag, not peak msgs/s)

1. Scrape `varz` / `jsz` from the host over `vmbr1` (not public). Monitor loopback `:8222` is invisible to Prometheus on NS1 unless we add a host-side proxy on `10.10.10.21:8222` bound only to `vmbr1`.
2. Keep replica floors for webhook-deliver and job-poller — they are the flood defense.
3. Backup/restore drill of JetStream **during idle**, then a short JS 1p run to see catchup cost.

4. A 15–30 minute soak (not in this ladder) for page cache and compaction; add that as a third study when disks are dedicated.

5.11 What not to tune

- Do not chase core 8p8s aggregate. It is fan-out on a lab bridge.
- Do not treat flood 400 ms as “cluster RTT.” Fix consumers.
- Do not load-test on `ZAPIER_*` streams.
- Do not bind client NATS to `0.0.0.0` on `vmbr0`.

5.12 Recommended next experiments (same method, one change each)

1. CPU pin nats-a/b/c → re-run JS 1p + ping.
2. `ZAPIER_EVENTS`-shaped memory stream vs file (throwaway stream, same flags as this JS ladder).
3. Distinct `store_dir` disks per node.
4. nkeys on, same ladder.
5. Three hardware boxes, same `cluster.env` IPs updated.

Each experiment should produce a new `results/<utc>/` on NS1 and a new progress-repo report so we can diff H1–H5 instead of arguing from memory.

6. Reproducing this study

On **NS1** only:

```
cd ~/verae-src/verae-nats-cluster
bash scripts/study-on-ns1.sh
```

The script exits if `hostname` is not NS1. Outputs land in `results/<utc>/` including `nats-cluster-bench-ns1.{md,html,pdf}` and `charts/`. Copy those into `zapier-decisions/reports/` for the progress repo and catalog.

Raw logs for this run: `results/20260912T051237Z/`.