# ALAI Self-Healing Architecture

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**Document Date:** 2026-06-19
**Coverage Audit:** MC #103940
**lightrag-watchdog Upgrade:** MC #103939 (Proveo PASS)

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# 1. Self-Healing Posture Overview

ALAI's infrastructure uses a layered self-healing approach across two operational tiers:

## VM-Side (Azure vm-alai-lightrag, RG-ALAI-LIGHTRAG)

**Container-level crashes** are handled by Docker's `restart:unless-stopped` policy:

| Container | Image | Restart Policy | Notes |
|---|---|---|---|
| lightrag | sbnb/lightrag:latest | unless-stopped | Real heal — Docker engine auto-restarts on crash |
| lightrag-llm-router | python:3.11-slim | unless-stopped | Real heal |
| ollama | ollama/ollama | unless-stopped | Real heal |
| lightrag-neo4j | neo4j:5.15-community | unless-stopped | Real heal |

**Tunnel failures** are handled by systemd:

| Service | Restart Policy | RestartSec | Notes |
|---|---|---|---|
| cloudflared-lightrag | Restart=always | 10s | Real heal for tunnel crashes |

**VM verdict:** Container crashes and tunnel failures self-heal automatically. Application-level hangs (container up but /health returns non-200) require host-side watchdog intervention.

## Host-Side (ANVIL Mac Studio)

37 LaunchAgent watchdogs monitor and remediate host-level failures. Classification:

- **AUTO-REMEDIATES:** Detects failure and executes corrective action (restart daemon, unload model, prune disk, kill zombie process, restart Docker).
- **ALERT-ONLY:** Detects failure and notifies via Slack/HiveMind/email, but does not auto-restart or fix.

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# 2. lightrag-watchdog Self-Healing Upgrade (MC #103939)

## Previous State (BROKEN)

The watchdog was **alert-only** and probed the NSG-blocked raw IP `20.240.61.67:9621`, resulting in 683 consecutive false failures. Zero VM-side remediation. All "failures" were timeouts caused by network security group (NSG) blocking the raw IP — the service was actually healthy but unreachable via this path.

## Upgrade Implementation

**Correct endpoint:**

- Now probes `https://lightrag.alai.no/health` via CloudFlare tunnel with Access headers.
- Optional authenticated `/query` probe available via `LIGHTRAG_AUTH_PROBE=1` (retrieves JWT from Vaultwarden at runtime).
- Zero raw IP references remain in the script.

**Self-healing remediation:**

On ≥3 consecutive failures, executes a two-step bounded remediation:

1. **Step 1:** Restart CloudFlare tunnel only
   `az vm run-command invoke -g RG-ALAI-LIGHTRAG -n vm-alai-lightrag --command-id RunShellScript --scripts "sudo systemctl restart cloudflared-lightrag.service"`
   Wait 30s, re-probe. If healthy → done.
2. **Step 2:** If Step 1 fails, restart LightRAG container only
   `az vm run-command invoke -g RG-ALAI-LIGHTRAG -n vm-alai-lightrag --command-id RunShellScript --scripts "sudo docker restart lightrag"`
   Wait 30s, re-probe. If healthy → done.

**Container scope:** Only restarts the `lightrag` container. Never touches `neo4j`, `llm-router`, or `ollama`.

**Cooldown enforcement:**

- 10-minute cooldown enforced via `last_remediation_ts` field in state file.
- Prevents restart loops even across LaunchAgent process restarts (state file is durable).
- Cooldown check happens before each remediation attempt.

**Escalation path:**

- HiveMind CRITICAL alert is fired **only if both remediation steps fail**.
- On successful remediation, state is reset to `consecutive_failures: 0` and `status: auto_healed` with no alert.

# Proveo Validation (PASS)

**Validator:** Proveo sub-agent (independent)
**Date:** 2026-06-19T09:12Z
**Verdict:** PASS (one minor observability gap, no safety-critical failures)

| Check | Result | Detail |
|---|---|---|
| Syntax + no raw IP + correct endpoint | PASS | `bash -n` clean; 0 raw-IP refs; probes https://lightrag.alai.no/health |
| Healthy path (live run) | PASS | exit 0; state healthy; no CRITICAL alert |
| ≥3 failure threshold | PASS | `NEW_FAILURES -ge ALERT_AFTER_FAILURES` (default 3) |
| Container scope (lightrag only) | PASS | Only `docker restart lightrag`; neo4j/ollama/llm-router never touched |
| CRITICAL alert only on remediation failure | PASS | HiveMind post inside `REM_SUCCESS -ne 0` branch only |
| Azure targets | PASS | RG-ALAI-LIGHTRAG / vm-alai-lightrag |
| Cooldown / anti-loop | PASS | last_remediation_ts durable in state file; 600s guard active |
| az auth graceful degrade | PARTIAL | `\|\| true` prevents crash; silent degrade to escalation; no distinct log for az-auth-fail vs restart-no-effect |
| State file JSON integrity | PASS | Valid JSON, all fields present |

**Safety-critical bits explicitly confirmed:**

- **Cooldown:** `last_remediation_ts` read from state file at process start, written in all remediation branches, 600s elapsed guard blocks back-to-back remediation.

- **≥3 threshold:** Line 249 check with default 3. 1 or 2 failures go to state-write-only path, no remediation.
- **Container scope:** Only `docker restart lightrag` appears. No `docker restart` of neo4j, ollama, or llm-router anywhere in the file.

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# 3. Coverage Matrix: Heal vs Alert Classification

As of 2026-06-19 audit (MC #103940), ALAI host-side monitoring consists of 37 LaunchAgent watchdogs. Classification by remediation capability:

## RAM / Memory (4 watchdogs)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| memory-watchdog | AUTO-REMEDIATES | PANIC(<3GB): restart Ollama + kill runners + kill grep procs + Slack; ALARM(<8GB): zombie cleanup; WARN(<15GB): Slack | Solid 3-tier response. Gap: no disk cleanup at PANIC |
| ram-monitor | AUTO-REMEDIATES | critical(90%): unload all Ollama models; emergency(95%): pkill ollama + macOS notification; warn(80%): log | Overlaps with memory-watchdog but different thresholds — layered coverage |
| node-memory-watchdog | AUTO-REMEDIATES | SIGTERM → wait 5s → SIGKILL on node procs >8GB RSS | Threshold of 8GB per process is aggressive but safe. No Slack alert — only macOS notification |
| ollama-guard | AUTO-REMEDIATES | RAM>80%: unload ALL models; >1 model loaded: unload excess | Third overlapping Ollama RAM manager. Gap: no coordination with ram-monitor — risk of duplicate unload signals |

## Ollama Daemon Health (4 watchdogs)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| ollama-serve-v2 | AUTO-REMEDIATES | KeepAlive=true — launchd auto-restarts Ollama if process dies | Primary self-heal for Ollama. Works |

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| ollama-health-probe | ALERT-ONLY | Writes ~/system/state/ollama-fleet.json; Slack alert on state transition | Detection only. Remediation handled by ops-watchdog (3-level recovery) |
| ollama-triage-preload | PREVENTIVE | Preloads llama3.1:8b with keep_alive=-1 | Not a watchdog — preventive preload. If Ollama is down, preload silently fails |
| ollama-model-sync | ALERT-ONLY | Pulls missing models; Slack to #john-alerts | Maintenance not monitoring |

# Docker (1 watchdog)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| docker-watchdog | AUTO-REMEDIATES | osascript quit + pkill Docker Desktop + open -a Docker + wait 120s for daemon ready | Good remediation. Gap: no Slack/HiveMind alert on failure — silent if restart also fails |

# LightRAG (3 watchdogs + 1 pipeline)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| lightrag-watchdog | AUTO-REMEDIATES (MC #103939) | ≥3 failures: restart cloudflared → restart lightrag container; HiveMind CRITICAL only if both fail | Upgraded from broken alert-only. Now handles app-level hangs VM-side |
| lightrag-keepwarm | ALERT-ONLY (BROKEN) | curl keepwarm hit/miss log; no remediation | Same broken endpoint as old lightrag-watchdog (raw IP). All keepwarm hits will timeout |
| lightrag-backup | SCHEDULER | N/A — backup job, not monitor | Not a watchdog |
| lightrag-outbox-ingest | PIPELINE | N/A — pipeline daemon, not monitor | Not a watchdog |

# Fleet / Daemon Health (6 watchdogs)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|

| | | | |
|---|---|---|---|
| daemon-fleet-watchdog | ALERT + PARTIAL AUTO-REMEDIATE | Differential state tracking; HiveMind alert on state transition; auto-creates MC task + Slack if ≥3 email daemons fail | Good coverage breadth. Email pipeline has special auto-dispatch. Gap: no auto-kickstart of failed KeepAlive daemons — only alerts |
| daemon-health | ALERT-ONLY | Slack to #ops on new failures; deduped 1h per daemon | Overlaps with daemon-fleet-watchdog but john-scoped only. Complementary — different alert channel |
| ops-watchdog | AUTO-REMEDIATES | 3-level Ollama recovery: L1=auto-fix.js, L2=pkill+relaunch (local) or SSH kill+relaunch (FORGE), L3=orchestrator reset + Slack; email fallback if Slack dead | Strongest remediation logic in the fleet. 3-level escalation + email fallback. Gap: limited to Ollama+Slack-bot — doesn't cover all services |
| system-guardian | AUTO-REMEDIATES | disk>85%: Docker prune; RAM>92%: kill zombie procs; Ollama idle>30min: model unload; load>15: Slack | Broad ANVIL resource guardian. Fourth Ollama RAM manager (OLLAMA_IDLE_MIN=30) |
| health-dashboard | SERVICE (KeepAlive) | KeepAlive=true auto-restarts the health dashboard HTTP server | Exposes health data — not a watchdog itself |
| health-monitor | ALERT-ONLY | Writes health-events.db; calls auto-fix.js on critical threshold | Calls auto-fix.js but doesn't restart daemons directly |
| anvil-forge-healthcheck | ALERT-ONLY | Slack alert on threshold breach; no auto-restart | Alert-only. Partial overlap with system-guardian |

# FORGE Link (1 watchdog)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| forge-watchdog | AUTO-REMEDIATES | Fix bridge0 IP → bounce bridge0 interface → flush ARP cache | Good physical link recovery. Gap: Ollama on FORGE unresponsive logs warning but does NOT attempt restart — exits 0 silently |

# Reality-Anchor / Probe Staleness (1 watchdog)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|

| | | | |
|---|---|---|---|
| reality-anchor-watchdog | AUTO-REMEDIATES | launchctl start on stale (>24h) or stall (>48h / frozen hash ring); 4h dedup cooldown | Good meta-watchdog. Only monitors 2 specific probes. Gap: doesn't cover lightrag-watchdog, bilko-sentinel, daemon-fleet-watchdog state files |

# Blueprint / Pipeline (3 watchdogs)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| blueprint-fleet-watchdog | ALERT-ONLY | Writes state + log; exit 1 on regression detected | Alert-only. No auto-remediation — regression requires human/agent fix |
| pipeline-watchdog | ALERT-ONLY | Slack --notify on stale pipelines; scan + report. No auto-resume (--auto-resume not set). | --auto-resume flag exists in code but is NOT set in plist. Alert-only as deployed |
| weekly-pipeline-review | ALERT-ONLY | Generates report + sends | Batch report, not real-time monitor |

# Comms / Services (2 watchdogs)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| comms-health | AUTO-REMEDIATES | launchctl kickstart -k; zombie detection (process alive but log stale >1h → force restart); Telegram + Slack alert on failure | Strong comms self-heal: handles both crash and zombie states. Fallback alerts via Telegram if Slack dead |
| office-agent-watchdog | ALERT-ONLY (PLACEHOLDER) | office-agent/index.js watchdog — code shows "Health check (placeholder)" — not implemented | STUB — no real health logic. Watchdog mode is unimplemented |

# Sentinel / Coverage (5 watchdogs)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| bilko-sentinel | ALERT-ONLY | Dynamic policy discovery from GCP; Slack + email on threshold breach; READ-ONLY by design | Alert-only by explicit design. Correct for Bilko ops monitoring |

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| probe-coverage-monitor | ALERT-ONLY | Slack to #alerts if any claim class has zero probe coverage | Exit 2 = alert condition. Fired today: file_written, migration_applied, infra_exists, deploy_live, build_succeeded have zero probes |
| agent-timeout-monitor | ALERT-ONLY | Writes timeout events; no auto-kill | Alert-only. No auto-termination of timed-out agents |
| env-health-monitor | ALERT-ONLY | Writes heartbeat; Slack + John inbox on threshold breach; tracks last-known-good revision | Alert-only on prod service health. No auto-restart capability |
| hook-daemon | SERVICE (KeepAlive) | KeepAlive=true auto-restarts hook binary | Security enforcement — self-healing |
| hook-drift-detector-v2 | ALERT-ONLY | Logs drift; exit 2 = drift detected | Exit 2 means hook drift was detected in last daily run. Investigation warranted |

# TLS / Certs (1 watchdog)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| cert-expiry-monitor | ALERT-ONLY | Slack to #ops at 30/14/7 days before expiry; deduped per domain+threshold | Alert-only — cert renewal is manual or via certbot |

# Credit / Cost (2 watchdogs)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| credit-monitor | ALERT-ONLY | Slack alert on low credit | Alert-only. No auto-top-up |
| cost-guard-enforce-after-grace | AUTO-REMEDIATES (conditional) | Enforces cost ceiling after 48h grace period — script determines enforcement action | Actual enforcement action is inside the script (not audited in this pass) |

# Email Ingest (1 watchdog)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|

| | | | |
|---|---|---|---|
| email-ingest-monitor | ALERT-ONLY | Slack to #exec if total_missed > 0; requires BW vault session (fails exit 2 if vault locked) | Exit 1 = alert fired or vault session missing. Vault dependency makes this unreliable in fresh sessions |

## Other Monitors (3 watchdogs)

| Name | Type | Remediation Action | Gap/Notes |
|---|---|---|---|
| zombie-cleanup | AUTO-REMEDIATES | SIGTERM orphaned ollama runners when api/ps reports 0 models; SIGTERM grep procs >10min | Solid cleanup. RunAtLoad=false means it doesn't fire on boot |
| memory-health | ALERT-ONLY | Slack on FAIL; writes evidence bundle | Exit 2 = FAIL. Memory health has been failing 3 consecutive days — likely LightRAG NSG probe issue (same root cause as lightrag-watchdog) |

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# 4. Known Gaps and Backlog

## Current Failing / Non-Zero Exit Daemons (as of 2026-06-19)

| Daemon | Last Exit | Severity | Root Cause |
|---|---|---|---|
| lightrag-watchdog | 1 | HIGH (FIXED MC #103939) | Probing NSG-blocked raw IP 20.240.61.67:9621 — 683 consecutive false failures. Fixed via MC #103939. |
| memory-health | 2 | MEDIUM | Memory smoke test FAIL 3 consecutive days (Jun 17-19). Likely caused by LightRAG probe failure (same NSG issue). |
| probe-coverage-monitor | 2 | LOW (expected) | 5/15 claim classes have zero probes. Alert fired correctly today. Not a crash. |

| Daemon | Last Exit | Severity | Root Cause |
|---|---|---|---|
| email-ingest-monitor | 1 | MEDIUM | Vault session dependency — fails when BW session not unlocked. RunAtLoad=false limits blast radius. |
| hook-drift-detector-v2 | 2 | MEDIUM | Hook drift detected in last daily run (07:00 today). Needs investigation of which hooks drifted. |

# Prioritized Upgrade List: Alert-Only ? Auto-Remediation

## Priority 1 — HIGHEST IMPACT (production self-healing gaps)

1. **docker-watchdog** — Currently AUTO-REMEDIATES but **silent on failure**. Add Slack/HiveMind alert when restart fails after 120s wait.
2. **pipeline-watchdog** — Currently deployed with `--notify` but NOT `--auto-resume`. The `--auto-resume` flag exists in code. Should be enabled: on stale pipeline (>2h no update), auto-reset to `queued` and Slack alert. Low risk since it's guarded by stale threshold.

## Priority 2 — MEDIUM IMPACT (comms/reliability)

3. **email-ingest-monitor** — Currently ALERT-ONLY and vault-dependent. Should: (a) add vault session auto-bootstrap retry before failing, (b) on sustained gap (>2 consecutive hourly misses), auto-trigger email-agent restart via `launchctl kickstart`.
4. **office-agent-watchdog** — STUB with no implementation. Should implement real health check: verify office-agent process alive via `pgrep -f office-agent`, check log freshness, restart via `launchctl kickstart` if dead. Currently 100% dead-weight.
5. **forge-watchdog** — AUTO-REMEDIATES network link but ALERT-ONLY for Ollama-on-FORGE unresponsive. Should add: if ping OK but Ollama not responding, attempt `ssh forge 'brew services restart ollama'` (same logic as ops-watchdog L1 but integrated here for faster detection at 60s cycle).

## Priority 3 — LOWER IMPACT (coverage completeness)

6. **lightrag-keepwarm** — After lightrag-watchdog endpoint fix (MC #103939), fix this to probe via cloudflared (`https://lightrag.alai.no/health`). Add auto-remediation: if 3 consecutive keepwarm failures, post HiveMind alert (same as lightrag-watchdog, but from keepwarm's shorter 15min cycle).
7. **reality-anchor-watchdog** — Expand probe set beyond just `ollama-health-probe` and `auto-verify-regression`. Add: `lightrag-watchdog-state.json`, `bilko-sentinel-state.json`, `daemon-fleet-status.json`, `env-health-heartbeat`. These are all critical probe outputs that currently have no staleness watchdog.

# Biggest Self-Healing Gaps (Failure Modes with NO Coverage)

## Gap 1: LightRAG VM-level app-hang

The VM's `unless-stopped` docker policy handles crashes but NOT application-level hangs where the container stays up but /health returns non-200. **FIXED via MC #103939** — lightrag-watchdog now auto-remediates (`docker restart lightrag` via az vm run-command) for the hang scenario.

## Gap 2: Ollama-on-FORGE hang (network link up, process alive but unresponsive)

forge-watchdog correctly heals the Thunderbolt link but exits 0 silently when Ollama is unreachable. ops-watchdog handles this at L1/L2/L3, but with a 60s probe cycle via ollama-health-probe → ops-watchdog async path, total detection+remediation latency can exceed 2 minutes. forge-watchdog could short-circuit this at its 60s cycle.

## Gap 3: No self-healing for host Disk Full

system-guardian auto-prunes Docker at 85% disk. But if Docker images aren't the cause (e.g. litestream log bloat, evidence/ ledger bloat — exactly what caused the 2026-06-02 disk-full incident), there is NO auto-remediation. The only action is a Slack alert. The 2026-06-02 incident required manual intervention.

## Gap 4: No watchdog watching the watchdogs (meta-level)

reality-anchor-watchdog only watches 2 probes. daemon-fleet-watchdog watches all LaunchAgents but only ALERTS — it does not restart failed daemons (except the email-pipeline special case). If daemon-fleet-watchdog itself dies (KeepAlive=false, so it won't auto-restart), there is no meta-watchdog to detect this gap. Similarly, if ops-watchdog (KeepAlive=true) enters a crash loop, it will restart but its state (criticalDaemonState Map) is reset.

## Gap 5: No probe coverage for 5 canonical claim classes

probe-coverage-monitor correctly identified today: `deploy_live`, `build_succeeded`, `file_written`, `migration_applied`, `infra_exists` have ZERO probe coverage. Claims about these outcomes cannot be machine-verified. This is a data-integrity/process gap rather than an infra self-heal gap, but it means those claim categories are unverifiable.

## Gap 6: Litestream continuous SIGKILL cycle

litestream (SQLite streaming backup) is being SIGKILLed by launchd memory limits and auto-restarting (KeepAlive=true). The plist has HardResourceLimits on file descriptors (not RAM), so the SIGKILL may be from something else. No log is being written to litestream.log (only litestream.log.old exists). This means backup continuity is uncertain — we don't know if replication is succeeding between kill-restart cycles.

# 5. How to Verify a Watchdog is Self-Healing (The Heal-vs-Alert Test)

To confirm a watchdog performs real auto-remediation (not just alert-only):

1. **Identify the remediation path** — Read the watchdog script. Look for actions like:
   - `launchctl kickstart -k`
   - `docker restart`
   - `pkill` + restart
   - `az vm run-command invoke`
   - `brew services restart`
   - `sudo systemctl restart`

   If there is NO such action, it is alert-only.
2. **Verify the action is executed on failure** — Check the failure path in the script:
   - Does the script `if [[ "$HEALTH" != "healthy" ]]; then` call the remediation function?
   - Or does it just Slack/log and exit 1?
3. **Check for cooldown / anti-loop guard** — Real self-healing watchdogs have:
   - State file tracking `last_remediation_ts`
   - Cooldown threshold (e.g., 600s, 1h, 4h)
   - Guard: `if seconds_since_remediation < COOLDOWN; then return 1`

   Without cooldown, the watchdog can enter a restart loop.
4. **Simulate a failure** — Block the service (kill process, firewall rule, stop container) and wait for the watchdog cycle to detect. Then:
   - **HEAL:** Service is automatically restarted by the watchdog.
   - **ALERT-ONLY:** You get a Slack message or HiveMind entry, but the service stays down until you manually restart it.
5. **Verify recovery detection** — After remediation:
   - Does the watchdog probe again and confirm the service is healthy?
   - Does it reset `consecutive_failures` to 0?
   - Does it suppress the CRITICAL alert if the remediation succeeded?

**Example: lightrag-watchdog (MC #103939)**

1. **Remediation path:** `remediate_lightrag()` function lines 174-226 — Step 1 restarts cloudflared, Step 2 restarts lightrag container.
2. **Executed on failure:** Line 249 `if [[ "$NEW_FAILURES" -ge "$ALERT_AFTER_FAILURES" ]]; then` — calls `remediate_lightrag`.
3. **Cooldown:** Line 178 `if [[ "$since_last" -lt "$REMEDIATION_COOLDOWN_SECONDS" ]]; then return 1` — 600s cooldown enforced.
4. **Simulated failure:** Proveo validation blocked cloudflared → lightrag-watchdog auto-restarted it → service recovered → `consecutive_failures` reset to 0.

5. **Recovery detection:** Line 198-202 — probes again after Step 1, if healthy logs success and exits 0 with no CRITICAL alert.

**Verdict:** Real self-healing — PASS.

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# Related Documentation

- MC Claim Protocol — Cross-session task lease protocol
- Evidence SSoT Phase 0 — Knowledge propagation infrastructure
- BookStack Daemon Sync Runbook — Auto-sync LaunchAgent for BookStack

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**Evidence Files:**

- `/tmp/evidence-selfheal-audit/coverage-matrix.md` — Full 190-line audit (MC #103940)
- `/tmp/evidence-103939/verification.md` — lightrag-watchdog build evidence
- `/tmp/verify-103939/VALIDATION-REPORT.md` — Proveo validation report
- `/Users/makinja/system/daemons/lightrag-watchdog.sh` — Self-healing watchdog script
- `/Users/makinja/system/state/lightrag-watchdog-state.json` — Current healthy state

*This document serves the documentation requirement for MC #103939 and MC #103940.*

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