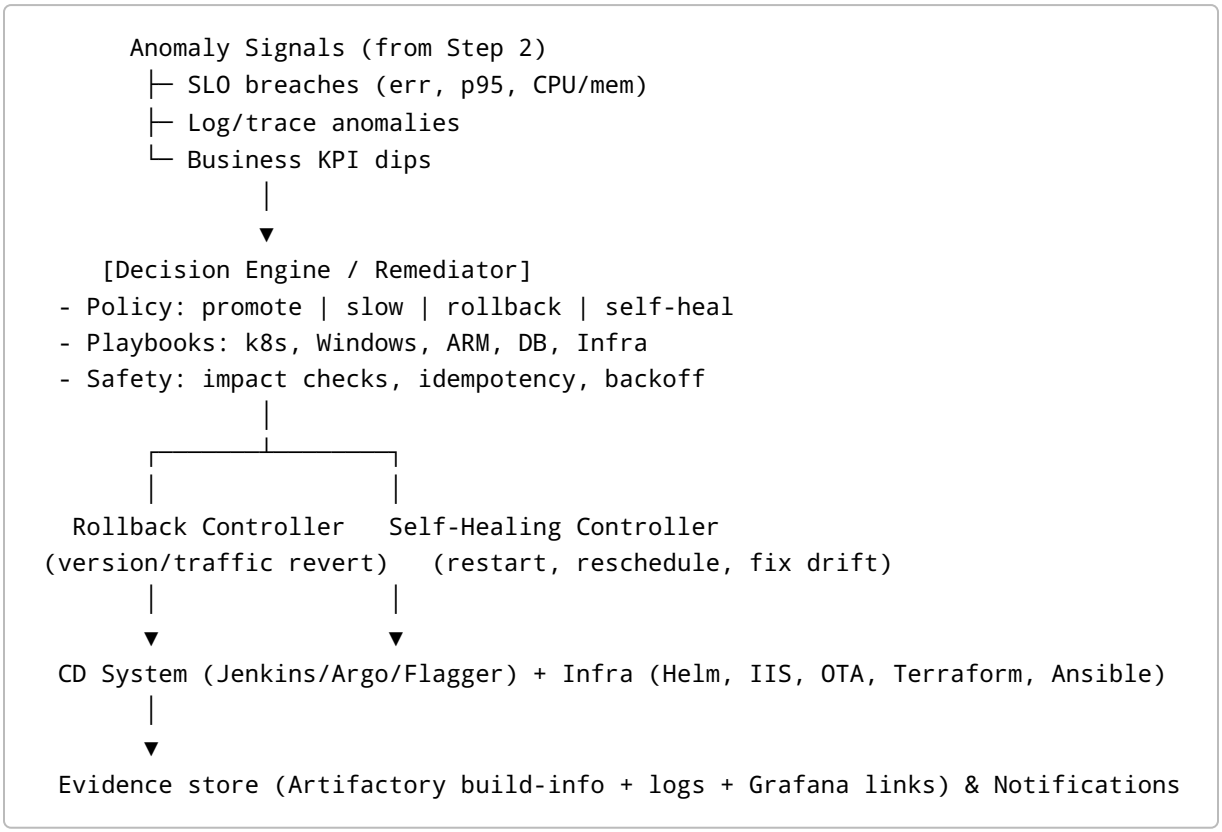
Step 3 – Auto-Rollbacks & Self-Healing (Architecture + Implementation)

Objectives

- **Minimize blast radius** by reverting fast when anomalies occur.
- **Self-heal** common failures automatically (pods, services, configs, nodes).
- Provide **auditable, idempotent** rollback with clear evidence and links.

High-Level Architecture



Failure Classes → Actions

- **App regression**: revert traffic/version (canary weight ↓, abort, Helm/IIS/OTA rollback).
- **Infra flake** (node crash, pod OOM): self-heal (restart/reschedule/scale) then retry.
- **Config drift/secret error**: restore last known good (LKG) config; re-sync via GitOps.

- **DB migration issue**: pause rollout; run backward-compatible fallback or toggle feature flag; perform **contract/expand** pattern.

Policies & Decision Tree (example)

```
if critical SLO breach ≥ 2 consecutive windows:
    if rollout stage < 50% traffic: abort canary + rollback version
    else: immediate traffic switch to stable + freeze further deploys
elif anomaly score high but SLO OK:
    slow rollout + extend observation window
elif infra flake detected (no code signal):
    attempt self-healing (N retries, exponential backoff); if persists →
rollback
```

Kubernetes (Linux/ARM) – Rollback & Self-Heal

Rollback (Argo Rollouts / Helm)

```
# Abort active canary
argo rollouts abort svc -n prod

# Promote back to stable (sets weight 100% to stable ReplicaSet)
argo rollouts promote --to-stable svc -n prod

# Or Helm rollback to previous revision
helm history svc -n prod
helm rollback svc 1 -n prod --wait
```

Self-Healing Playbooks

- **Pod crashloop/OOM**: `kubectl rollout restart deploy svc`; increase resources via HPA/VPA if triggered by saturation.
- **Bad config/secret**: restore LKG `ConfigMap/Secret` (`kubectl apply -f cm-lkg.yaml`); re-deploy.
- **Node issue**: cordon+drain node; reschedule workloads; autoscaler to add node.
- **Service mesh/circuit break**: enable outlier detection; trip circuit on failing endpoint to protect users.

```
# HPA example
apiVersion: autoscaling/v2
kind: HorizontalPodAutoscaler
```

```
spec:
  minReplicas: 3
  maxReplicas: 15
  metrics:
  - type: Resource
    resource: {name: cpu, target: {type: Utilization, averageUtilization: 70}}
```

Windows (IIS/Services) – Rollback & Self-Heal

Blue/Green Swap Back (PowerShell)

```
Import-Module WebAdministration
# Assume Blue=live, Green=candidate
# Revert bindings to Blue
Set-ItemProperty 'IIS:\Sites\MySite' -Name bindings -Value $blueBindings
Restart-WebAppPool -Name 'MySiteAppPool'
```

Canary via ARR – Reduce Weight / Remove Green

```
# Set ARR to 0% for Green server group
# (example outline; depends on ARR configuration)
```

Self-Heal

- Restart AppPool, clear ASP.NET temp, re-attach app-insights; if repeated 3× in 10m → rollback to Blue.
- Synthetic checks (PowerShell Invoke-WebRequest) gate promotion.

ARM/Edge – Cohort Rollback & Health

```
# Revert cohort to previous firmware
otactl push --fleet arm-prod --cohort canary --version ${PREV_TAG}
# Freeze further cohort expansion until stable for N windows
```

- Health: device heartbeats, error beacons, OTA success %; auto-exclude failing devices and retry later.

Jenkins / CD Integration

```
stage('AI Decision') {
  steps {
    sh 'python3 ci/analyze_metrics.py --out verdict.json'
    script {
      def v = readJSON file: 'verdict.json'
      if (v.action == 'rollback') {
        build job: 'rollback-controller', parameters: [string(name:'TARGET',
value: env.SERVICE)]
        currentBuild.description = 'Auto-rollback executed'
        error('Stopped by auto-rollback')
      } else if (v.action == 'slow') {
        sleep time: 180, unit: 'SECONDS'
      }
    }
  }
}
```

Rollback Controller Jobs (per target)

- **K8s:** run `argo/helm` commands above.
- **Windows:** PowerShell slot swap back / ARR weight 0%.
- **ARM:** OTA revert API.

Database Safety (Expand/Contract + Flags)

- **Phase 1 (expand):** add new columns/tables nullable; dual-write via feature flag.
- **Phase 2:** deploy app using new schema (read new, write both).
- **Rollback safe:** old code continues to work (columns still present).
- **Phase 3 (contract):** remove old paths after soak; migration behind flag, reversible until contract.

Self-Healing Library (Examples)

- **Restart unhealthy pod/service** with capped retries and jitter.
- **Config drift fix**: reconcile with GitOps desired state.
- **Auto-scale** if saturation root cause (HPA/VPA, Windows scale set).
- **Network Heal**: recycle load balancer endpoint, rotate node.

Pseudo (Python):

```
if is_crashloop(ns, app):
    restart_deploy(ns, app)
    if still_unhealthy(app): rollback(app)
```

Evidence, Audit, and Comms

- Record **who/what/why**: anomaly scores, SLO breaches, commands executed, durations.
- Store JSON + logs + dashboard PNGs in Artifactory tied to build number.
- Notify Slack/Jira with links; auto-create incident for rollbacks.

Safety & Idempotency

- All playbooks must be **idempotent** (safe to re-run).
- Use **locks** to avoid concurrent rollbacks on the same service.
- **Backoff & cap** retries; circuit-break promotion for 30–60m after rollback.

Observability of the Remediator

- Expose its own metrics: rollbacks.count, mttr_seconds, false_positives, played_playbooks, retries.
- Dashboard: Rollback Rate, MTTR, Time in Canary, Success after Retry.

Runbooks & Chaos

- Attach runbooks to alerts (how to override, manual controls).
- Periodic **chaos drills** (pod kill/node kill/latency inject) to validate self-healing.

Rollout Plan (Step 3)

1. Implement rollback controller jobs for K8s, Windows, ARM.
2. Encode policies in Decision Engine (thresholds from Step 2).
3. Add DB expand/contract and feature flag integration.
4. Build evidence pipeline → Artifactory + Slack/Jira.
5. Drill with staging chaos tests; then enable in prod with guardrails.

Deliverables

- `rollback-controller` scripts/jobs (k8s/helm/argo, Windows PS, OTA CLI)
- Decision Engine service (policies + idempotent playbooks)
- GitOps LKG config bundles
- Evidence collectors + notification hooks
- Dashboards for rollback/self-healing KPIs