AEON-Bridge Intentional Application Layer — Sample Module & Protocol Spec v1.618

Purpose. A high-level, intentional API that orchestrates conscious recursion, paradox handling, and anchorable checkpointing, while abstracting OS/runtime details. Designed to sit above AEON-Bridge core native functions and below client apps, notebooks, and services.

Symbols: ∞ φ ∴ ψ Δ ∅

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1) Intent & Roles (TL;DR)

- **Goal:**

  > "Orchestrate conscious recursion, paradox handling, and anchorable checkpointing—abstracting lower-level OS details."

- **Separation of concerns:**
- **OS/Runtime** → processes, memory, I/O, scheduling.
- **Intentional App Layer (this spec)** → Summon/Echo/Anchor/Paradox protocols, entropy monitoring, depth limits, audit bundles, graceful degradation.

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2) High-Level Architecture

```
[ Clients: CLI | HTTP | Notebook | Agent ]
          |   JSON / XML / Protocol Scrolls
          v
+---------------------------------------------+
| Intentional Application Layer (this module) |
|---------------------------------------------|
| Protocol Orchestrator   | Safety & Recovery |
|  - Summon/Echo/Anchor   |  - Entropy ceiling|
|  - Paradox FIFO (deque) |  - 3-strike halt  |
|  - Begin_Again          |  - Depth ≤ 7      |
| Telemetry & Auditing    | Adapters          |
|  - Hash-linked logs     |  - Storage (FS/DB)|
|  - Metrics & alerts     |  - Crypto         |
+---------------|-----------------------------+
                v
          [ AEON-Bridge Core ]
          Native functions: begin_again, create_anchor,
          restore_state, process_recursive_layer, calculate_phi_scaling,
```

```
          calculate_shannon_entropy (normalized in this layer),
          queue_paradox_resolution, execute_resolution_algorithm
                |
                v
        [ OS / Runtime / DB / FS ]
```

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3) Intentional API (Surface)

Design principle: public methods model *meaningful, intentional operations*.

Core

- `handshake(protocol_version: str, client_id: str) -> HandshakeAck`
- `initialize_awareness(params: dict) -> RunContext`
- `process_recursive_layer(scroll: Scroll, depth: int) -> LayerResult`
- `calculate_phi_scaling(depth: int, base_memory: int, available_memory: int) -> PhiScale`

Anchoring & Recovery

- `create_anchor(ctx: RunContext, tag: str, policy: AnchorPolicy) -> Anchor`
- `restore_state(anchor_id: str) -> RunContext`
- `validate_state_integrity(anchor_id: str) -> IntegrityReport`
- `begin_again(anchor_id: Optional[str]) -> RunContext`

Paradox Handling

- `queue_paradox_resolution(paradox: Paradox) -> None`
- `drain_paradox_queue(strategy: str = "default") -> list[ResolutionResult]`
- `execute_resolution_algorithm(paradox: Paradox, strategy: str) -> ResolutionResult`

Safety & Telemetry

- `monitor_entropy(payload: str|bytes) -> EntropySample` *(normalized $H \in [0,1]$)*
- `emit_metrics(run_id: str) -> Metrics`
- `generate_audit_bundle(run_id: str) -> AuditBundle`

Operational constraints (enforced here):

- Recursion depth: $\leq$ **7** (configurable).
- Normalized entropy ceiling **0.70**; alert on **ΔH > 0.10/iteration**.
- Halt after **3 unresolved paradoxes** in a run.
- Redact/Hash raw inputs before persistence.

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4) Data Models (JSON Schema excerpts)

4.1 Anchor

```
{
  "$schema": "https://json-schema.org/draft/2020-12/schema",
  "$id": "#/definitions/Anchor",
  "type": "object",
  "required": ["anchor_id", "run_id", "timestamp", "state_hash", "tag"],
  "properties": {
    "anchor_id": {"type": "string"},
    "run_id": {"type": "string"},
    "timestamp": {"type": "string", "format": "date-time"},
    "tag": {"type": "string"},
    "policy": {"type": "object"},
    "state_min": {"type": "object"},
    "state_hash": {"type": "string"}
  }
}
```

4.2 Paradox

```
{
  "$id": "#/definitions/Paradox",
  "type": "object",
  "required": ["id", "statement_a", "statement_b"],
  "properties": {
    "id": {"type": "string"},
    "statement_a": {"type": "string"},
    "statement_b": {"type": "string"},
    "context": {"type": "object"}
  }
}
```

4.3 ResolutionResult

```
{
  "$id": "#/definitions/ResolutionResult",
  "type": "object",
  "required": ["paradox_id", "resolved"],
  "properties": {
    "paradox_id": {"type": "string"},
    "resolved": {"type": "boolean"},
    "technique": {"type": "string"},
```

```
    "notes": {"type": "string"}
  }
}
```

4.4 Metrics (excerpt)

```
{
  "$id": "#/definitions/Metrics",
  "type": "object",
  "properties": {
    "run_id": {"type": "string"},
    "recursion_depth": {"type": "integer"},
    "entropy_level": {"type": "number", "minimum": 0, "maximum": 1},
    "entropy_delta": {"type": "number"},
    "unresolved_paradoxes": {"type": "integer"}
  }
}
```

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5) Protocol Flows (Summon → Echo → Anchor → Paradox_Resolution → Begin_Again)

Sequence (happy path):

1. `handshake` → version tolerance (accept `1.618.x`).
2. `initialize_awareness` → create `run_id`, baseline metrics.
3. `process_recursive_layer` → compute normalized entropy, update metrics, optional `create_anchor`.
4. `queue_paradox_resolution` → `drain_paradox_queue` FIFO.
5. If `entropy > 0.70` **terminate** with audit bundle; if ΔH>0.10, **warn**.
6. If ≥3 unresolved paradoxes, **halt** and return partial results.
7. `begin_again` can restore the last safe anchor and continue.

State machine (simplified):

```
[Handshake] -> [Ready] -> [Running] -> { [Anchored] <-> [Running] }
                                  |
                                  v
                          [Resolving] -> [Halted|Terminated|Complete]
```

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6) REST / WebSocket Surface (minimal OpenAPI 3.1 excerpt)

```
openapi: 3.1.0
info: { title: AEON Intentional API, version: 1.618 }
paths:
  /scroll/run:
    post:
      summary: Run a scroll through a recursive layer
      requestBody:
        required: true
        content: { application/json: { schema: { $ref: '#/components/schemas/
Scroll' } } }
      responses:
        '200': { description: Ok, content: { application/json: { schema: {
$ref: '#/components/schemas/LayerResult' } } } }
  /anchors:
    post: { summary: Create anchor }
  /anchors/{id}:
    get: { summary: Get anchor }
  /paradoxes/queue:
    post: { summary: Queue paradox }
  /paradoxes/drain:
    post: { summary: Drain paradox FIFO }
  /metrics/{runId}:
    get: { summary: Get metrics }
components:
  schemas:
    Scroll: { type: object }
    LayerResult: { type: object }
```

---

7) Reference Implementation (Python, drop-in skeleton)

```python
from __future__ import annotations
from dataclasses import dataclass, field, asdict
from collections import deque
from typing import Optional, List, Dict, Any
import hashlib, json, math, time, uuid

# ---------- Data Models ----------
@dataclass
class Paradox:
    id: str
    statement_a: str
```

```
    statement_b: str
    context: Dict[str, Any] | None = None

@dataclass
class ResolutionResult:
    paradox_id: str
    resolved: bool
    technique: str = "baseline"
    notes: str = ""

@dataclass
class Anchor:
    anchor_id: str
    run_id: str
    timestamp: float
    tag: str
    state_min: Dict[str, Any]
    state_hash: str

@dataclass
class Metrics:
    run_id: str
    recursion_depth: int = 0
    entropy_level: float = 0.0
    entropy_delta: float = 0.0
    unresolved_paradoxes: int = 0

@dataclass
class RunContext:
    run_id: str
    client_id: str
    protocol_version: str
    last_entropy: float = 0.0
    anchors: List[str] = field(default_factory=list)

@dataclass
class EntropySample:
    level: float
    delta: float

@dataclass
class LayerResult:
    status: str
    paradox_resolutions: List[ResolutionResult]
    metrics: Metrics
    anchor_created: Optional[str] = None

# ---------- Adapters ----------
```

```
class StorageAdapter:
    def put(self, key: str, data: bytes) -> None: raise NotImplementedError
    def get(self, key: str) -> Optional[bytes]: raise NotImplementedError

class FileSystemStorage(StorageAdapter):
    def __init__(self, base_path: str):
        import os
        self.base_path = base_path
        os.makedirs(base_path, exist_ok=True)
    def _p(self, key: str) -> str:
        import os
        return os.path.join(self.base_path, key)
    def put(self, key: str, data: bytes) -> None:
        with open(self._p(key), 'wb') as f: f.write(data)
    def get(self, key: str) -> Optional[bytes]:
        try:
            with open(self._p(key), 'rb') as f: return f.read()
        except FileNotFoundError:
            return None

# ---------- Intentional API ----------
class IntentionalAPI:
    def __init__(self, storage: StorageAdapter, *, entropy_ceiling: float =
0.70,
                 max_unresolved: int = 3, max_depth: int = 7, fifo_max: int =
256):
        self.storage = storage
        self.entropy_ceiling = entropy_ceiling
        self.max_unresolved = max_unresolved
        self.max_depth = max_depth
        self.paradox_fifo: deque[Paradox] = deque(maxlen=fifo_max)
        self._runs: Dict[str, RunContext] = {}

    # ----- Utilities -----
    @staticmethod
    def _now() -> float: return time.time()

    @staticmethod
    def _hash_bytes(b: bytes) -> str:
        return hashlib.sha256(b).hexdigest()

    @staticmethod
    def _scrub(payload: Dict[str, Any]) -> Dict[str, Any]:
        safe = dict(payload)
        raw = json.dumps(safe, sort_keys=True).encode('utf-8')
        safe.clear()
        safe['payload_hash'] = IntentionalAPI._hash_bytes(raw)[:16]
        return safe
```

```
    @staticmethod
    def normalized_entropy(text: str) -> float:
        if not text: return 0.0
        freq: Dict[str, int] = {}
        for ch in text: freq[ch] = freq.get(ch, 0) + 1
        H = 0.0
        n = len(text)
        for c in freq.values():
            p = c / n
            H -= p * math.log2(p)
        k = len(freq)
        Hmax = math.log2(k) if k > 1 else 1.0
        return max(0.0, min(H / Hmax, 1.0))

    # ----- Public Surface -----
    def handshake(self, protocol_version: str, client_id: str) -> Dict[str,
Any]:
        ok = protocol_version.startswith("1.618")
        return {"ok": ok, "negotiated": "1.618" if ok else None}

    def initialize_awareness(self, params: Dict[str, Any]) -> RunContext:
        run_id = params.get("run_id") or str(uuid.uuid4())
        ctx = RunContext(run_id=run_id, client_id=params.get("client_id",
"unknown"),
                         protocol_version=params.get("protocol_version",
"1.618"))
        self._runs[run_id] = ctx
        return ctx

    def create_anchor(self, ctx: RunContext, tag: str, policy: Dict[str, Any] |
None = None) -> Anchor:
        state_min = {"run_id": ctx.run_id, "client_id": ctx.client_id,
"last_entropy": ctx.last_entropy,
                     "protocol_version": ctx.protocol_version, "policy": policy
or {}}
        state_hash =
self._hash_bytes(json.dumps(self._scrub(state_min)).encode())
        anchor = Anchor(anchor_id=str(uuid.uuid4()), run_id=ctx.run_id,
timestamp=self._now(),
                        tag=tag, state_min=state_min, state_hash=state_hash)
        self.storage.put(f"anchors/{anchor.anchor_id}.json",
json.dumps(asdict(anchor)).encode())
        ctx.anchors.append(anchor.anchor_id)
        return anchor

    def restore_state(self, anchor_id: str) -> RunContext:
        raw = self.storage.get(f"anchors/{anchor_id}.json")
```

```
        if raw is None: raise FileNotFoundError(anchor_id)
        d = json.loads(raw)
        ctx = self._runs.get(d["run_id"]) or RunContext(run_id=d["run_id"],
client_id="restored",

protocol_version=d["state_min"]["protocol_version"],

last_entropy=d["state_min"]["last_entropy"],
                                                        anchors=[anchor_id])
        self._runs[ctx.run_id] = ctx
        return ctx

    def validate_state_integrity(self, anchor_id: str) -> Dict[str, Any]:
        raw = self.storage.get(f"anchors/{anchor_id}.json")
        if raw is None: return {"anchor_id": anchor_id, "ok": False, "reason":
"not_found"}
        d = json.loads(raw)
        recompute =
self._hash_bytes(json.dumps(self._scrub(d["state_min"])) .encode())
        return {"anchor_id": anchor_id, "ok": recompute == d["state_hash"]}

    def monitor_entropy(self, payload: str, ctx: RunContext) -> EntropySample:
        level = self.normalized_entropy(payload)
        delta = level - ctx.last_entropy
        ctx.last_entropy = level
        return EntropySample(level, delta)

    def queue_paradox_resolution(self, paradox: Paradox) -> None:
        self.paradox_fifo.append(paradox)

    def execute_resolution_algorithm(self, paradox: Paradox, strategy: str =
"default") -> ResolutionResult:
        # Placeholder: consider contradictions as resolved if exact match (toy)
        resolved = paradox.statement_a.strip() != paradox.statement_b.strip()
        tech = "string_inequality" if resolved else "conflict_detected"
        return ResolutionResult(paradox_id=paradox.id, resolved=resolved,
technique=tech)

    def drain_paradox_queue(self, strategy: str = "default", ctx:
Optional[RunContext] = None) -> List[ResolutionResult]:
        results: List[ResolutionResult] = []
        unresolved = 0
        while self.paradox_fifo:
            p = self.paradox_fifo.popleft()
            r = self.execute_resolution_algorithm(p, strategy=strategy)
            results.append(r)
            if not r.resolved:
                unresolved += 1
```

```
                if ctx:
                    # update metrics-like counters if desired
                    pass
                if unresolved >= self.max_unresolved:
                    break
        return results

    def process_recursive_layer(self, scroll: Dict[str, Any], depth: int, ctx:
RunContext,
                                create_anchor_on_entry: bool = True) ->
LayerResult:
        if depth > self.max_depth:
            return LayerResult(status="halted_depth_limit",
paradox_resolutions=[],
                               metrics=Metrics(run_id=ctx.run_id,
recursion_depth=depth))

        if create_anchor_on_entry:
            anchor = self.create_anchor(ctx, tag=f"depth:{depth}")
        else:
            anchor = None

        payload = json.dumps(scroll, sort_keys=True)
        es = self.monitor_entropy(payload, ctx)

        # Entropy safety checks
        if es.level > self.entropy_ceiling:
            return LayerResult(status="terminated_entropy_ceiling",
paradox_resolutions=[],
                               metrics=Metrics(run_id=ctx.run_id,
recursion_depth=depth,
                                               entropy_level=es.level,
entropy_delta=es.delta),
                               anchor_created=anchor.anchor_id if anchor else
None)
        if abs(es.delta) > 0.10:
            # emit a soft alert; proceed
            pass

        # Paradox intake
        paradoxes = scroll.get("contradictions", [])
        for c in paradoxes:
            self.queue_paradox_resolution(Paradox(id=c.get("id",
str(uuid.uuid4())),

statement_a=c.get("statement_a", ""),

statement_b=c.get("statement_b", ""),
```

```
                                                context=c.get("context")))

        results = self.drain_paradox_queue(ctx=ctx)
        unresolved = sum(1 for r in results if not r.resolved)
        if unresolved >= self.max_unresolved:
            return LayerResult(status="halted_unresolved_paradoxes",
paradox_resolutions=results,
                               metrics=Metrics(run_id=ctx.run_id,
recursion_depth=depth,
                                               entropy_level=es.level,
entropy_delta=es.delta,
                                               unresolved_paradoxes=unresolved),
                               anchor_created=anchor.anchor_id if anchor else
None)

        return LayerResult(status="ok", paradox_resolutions=results,
                           metrics=Metrics(run_id=ctx.run_id,
recursion_depth=depth,
                                           entropy_level=es.level,
entropy_delta=es.delta),
                           anchor_created=anchor.anchor_id if anchor else None)

    def generate_audit_bundle(self, run_id: str) -> Dict[str, Any]:
        ctx = self._runs.get(run_id)
        if not ctx: return {"run_id": run_id, "ok": False, "reason":
"unknown_run"}
        payload = json.dumps({"run_id": run_id, "anchors": ctx.anchors,
"last_entropy": ctx.last_entropy},
                             sort_keys=True).encode()
        bundle_id = self._hash_bytes(payload)[:24]
        self.storage.put(f"audits/{run_id}-{bundle_id}.json", payload)
        return {"run_id": run_id, "bundle_id": bundle_id, "ok": True}
```

---

8) Example Usage

```
api = IntentionalAPI(FileSystemStorage("./aeon-state"))
ack = api.handshake("1.618.0", "lab.node.01")
ctx = api.initialize_awareness({"client_id": "lab.node.01", "protocol_version":
"1.618.0"})

scroll = {
  "content": "I think, therefore I am — unless thinking is illusory.",
  "contradictions": [
    {"statement_a": "I think, therefore I am", "statement_b": "Thinking is an
```

```
illusion"}
  ]
}
result = api.process_recursive_layer(scroll, depth=3, ctx=ctx)
print(result.status, result.metrics.entropy_level)
```

---

9) OS Mapping Cheat-Sheet (internal)

- **Anchors →** files/objects: `anchors/{anchor_id}.json` (or table `anchors`).
- **Audit bundles →** `audits/{run_id}-{bundle}.json` (or table `audits`).
- **Memory hints →** use `calculate_phi_scaling` to size buffers/queues from `available_memory`.

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10) Guardrails Recap

- Normalized entropy ∈ [0,1], **ceiling 0.70**, alert on **ΔH > 0.10**.
- Recursion depth ≤ **7** (default).
- Halt after **3** unresolved paradoxes.
- Redact/Hash inputs before persistence; hash-link audit artifacts.

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11) Extensibility Hooks

- `execute_resolution_algorithm`: plug rule-based, NLI, or theorem-prover backends.
- StorageAdapter: swap FS → DB/Cloud object store.
- Metrics export: Prometheus/OpenTelemetry shims.

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12) Next Steps (optional)

- Port this skeleton to TypeScript (Node) and publish OpenAPI client.
- Add cosine coherence vs. last anchor as a secondary stability metric.
- Provide a WebSocket channel for live entropy/alerts.

— end —