Entropica Forensic Model

EFM Codex: Volume II

Arbiter, Forest Layer, and Swarm Governance

Version 1.4

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Abstract

Volume II covers the deliberative layers (Arbiter, Forest) and multi-agent coordination. Version 1.3 integrates with Volume I v1.6 Spawn Governance, enabling condition-based swarm spawning, research probe deployment, and distributed coordinator hierarchies.

Contents

1 Introduction

Volume II builds on Volume I's foundation to address:

1. Arbiter deliberation and precedent (Layer 2)
2. Forest layer swarm coordination (Layers 3–5)
3. Dialect evolution and communication
4. Swarm spawn governance integration

2 Swarm Spawn Governance

With Volume I v1.6's elimination of the "No Self-Birth" prohibition, swarms can now spawn dynamically based on operational conditions.

Swarm Spawning

Swarm Spawning Model
Coordinator capsules in the Forest layer may spawn workers when:

1. Task decomposition requires parallelism
2. Swarm health $H_{swarm} \geq \tau_{swarm,spawn}$ (default 0.6)
3. Resource pool has available allocation
4. Spawn rate within swarm limits ($R_{swarm,max}$)
5. Forest consensus approves (for > 10 simultaneous spawns)

2.1 Swarm Spawn Roles

Role	Spawn Authority	Limits
Coordinator	Full (within profile)	$R_{local} = 50$/window
Sub-coordinator	Delegated	$R_{local} = 20$/window
Worker	None	Cannot spawn
Probe	None	Ephemeral, cannot spawn

Table 1: Spawn authority by swarm role.

2.2 Swarm Spawn Flow

1. **Task Analysis:** Coordinator determines parallelism benefit
2. **Resource Check:** Query pooled Vault allocation
3. **Health Validation:** Swarm health meets threshold
4. **Rate Check:** Within $R_{swarm,max}$
5. **Consensus (if bulk):** Forest validates > 10 simultaneous
6. **Spawn Execution:** Children inherit coordinator's Vault binding
7. **Registration:** All children logged to d-CTM with lineage

2.3 Coordinator Liability

Coordinators bear recursive liability for spawned workers:

- Worker actions attributed to coordinator's d-CTM
- Coordinator health degrades if workers misbehave
- HALT on coordinator cascades to all descendants
- Resource usage aggregated at coordinator level

3 Research Probe Spawning

The Discovery Stack (Appendix M) may spawn research probes:

Swarm Spawning

Probe Characteristics

- Ephemeral: Default lifetime 1000 ticks
- Isolated: Cannot affect parent's state directly
- Accountable: Actions logged to parent's d-CTM
- Non-spawning: Probes cannot spawn children

3.1 Probe Use Cases

1. **Hypothesis Testing:** Explore parameter space in isolation
2. **Environment Probing:** Safe external system interaction
3. **Adversarial Testing:** Red-team scenarios in sandbox
4. **Data Collection:** Parallel information gathering

4 Forest Consensus for Bulk Spawning

When a coordinator requests > 10 simultaneous spawns:

1. Coordinator submits spawn request to Forest
2. Arbiter nodes evaluate:
   - Task justification (is parallelism warranted?)
   - Resource impact (will this strain the Vault?)
   - Pattern analysis (is this anomalous?)
3. Quorum vote: majority of Arbiter nodes must approve
4. If approved, spawn proceeds with elevated R_{local}
5. If rejected, coordinator may appeal or decompose request

5 Dialect Evolution in Spawned Swarms

Spawned capsules inherit parent's dialect but may evolve:

- **Initial state:** Clone of parent's dialect
- **Drift:** Natural variation from operational context
- **Mutation:** Deliberate adaptation (requires $H \geq 0.8$)
- **Reconciliation:** Forest harmonizes divergent dialects

6 Integration with Volume I v1.6

Vol I Concept	Vol II Application	Reference
Spawn Conditions S_1–S_6	Swarm spawn validation	§2
τ_{spawn}	Swarm health threshold	§2.1
D_{max}	Coordinator hierarchy depth	§2.1
R_{max}, R_{local}	Swarm rate limits	§2.2
Spawn Accountability	Coordinator liability	§2.3

Table 2: Volume I spawn governance applied to Volume II.

7 Testing and Validation

7.1 Test Suite Summary

#	Test	Validates
V2-1	Arbiter election	Fair election among candidates
V2-2	Escalation routing	Escalations reach correct Arbiter
V2-3	Precedent lookup	Judicial precedents retrieved correctly
V2-4	DCG computation	Distributed Coherence accurate
V2-5	SCI calculation	Swarm Coherence Index correct
V2-6	Fork threshold	Fork triggered at $SCI < \theta_{fork}$
V2-7	Merge decision	Merge approved when branches converge
V2-8	Swarm spawn	Coordinator spawns within limits
V2-9	Probe lifecycle	Probe expires at timeout
V2-10	Bulk spawn consensus	Forest validates > 10 spawns
V2-11	Coordinator liability	Worker actions affect coordinator health
V2-12	Dialect inheritance	Children inherit parent dialect

Table 3: Volume II test suite.

7.2 Behavioral Invariants

1. **Spawn Authority:** Only Coordinators may spawn workers
2. **Rate Limit:** $\forall t$: $R_{swarm}(t) \leq R_{swarm,max}$
3. **Liability Chain:** $\forall$ worker W: $liability(W) \subseteq liability(coordinator(W))$
4. **Probe Isolation:** $\forall$ probe P: $state(parent(P))$ unaffected by P
5. **Consensus Requirement:** Bulk spawns (> 10) require Forest quorum

7.3 Integration Tests

1. **End-to-end Swarm Spawn:** Coordinator requests spawn, conditions validated, children created, registered in d-CTM

2. **Cascade HALT:** HALT on coordinator propagates to all descendants within 10 ticks
3. **Dialect Reconciliation:** Divergent dialects harmonized within 1000 ticks
4. **Full Behavioral Scenario:** Complete multi-agent task with spawning, escalation, and termination

Changelog

v1.4 (December 2025)

- Added Testing and Validation section
- 12 test cases specified
- 5 behavioral invariants defined
- 4 integration tests specified

v1.3 (December 2025)

- Integrated with Volume I v1.6 Spawn Governance
- Added Swarm Spawn Governance section
- Added Research Probe Spawning
- Added Forest Consensus for Bulk Spawning
- Defined coordinator liability model

v1.2 — Arbiter precedent, Forest layer, dialect evolution