Section 3. Entropic Branching - The Real Mechanism

This section formalizes the central claim of Paper A-16: branching is not the multiplication of worlds, but the loss of mutual accessibility after collapse. Within the CUWF framework, the appearance of many domains arises when the universal wave field partitions into closure-preserving regions whose entropic constraints have diverged beyond mutual reach. The decisive object is therefore not the wavefunction alone, but the accessibility structure induced by collapse.

3.1 Branching Does Not Occur at Superposition

In standard quantum notation, a system may be represented as a superposition $|\Psi\rangle = \Sigma_i c_i |i\rangle$. In CUWF, such an expression refers only to amplitude structure within a single candidate regime of accessibility. Superposition describes representational plurality; it does not, by itself, establish ontological separation.

The CUWF criterion is straightforward: as long as alternative components of $|\Psi\rangle$ remain connected by at least one admissible chain of collapse-transitions within the same closure, they do not constitute distinct universes. They remain multiple relational possibilities inside one domain, not parallel domains.

To make this distinction precise, three layers must be separated:

(1) Amplitude plurality: multiple components coexist within the representation.

(2) Decoherence plurality: components become dynamically non-interfering in a chosen pointer basis due to environmental entanglement.

(3) Accessibility plurality: components become mutually unreachable because the admissible transition graph itself fractures.

The first layer is kinematic. The second is dynamical, but still does not guarantee permanent separation. Only the third is ontological in the CUWF sense, because it is defined by the existence or non-existence of admissible relational paths.

Branching therefore does not originate at measurement as such. Measurement may trigger collapse and amplify divergence, but a parallel domain is formed only when the accessibility operator is restructured so deeply that the closure sustaining one coherent universe can no longer be maintained across competing outcomes.

3.1.1 Why Decoherence Alone Is Not Branching in CUWF

Decoherence explains why interference terms become effectively unobservable in macroscopic systems. However, decoherence does not by itself imply that alternative outcomes have become mutually inaccessible domains. It shows only that certain cross-terms are suppressed relative to a chosen environmental trace.

CUWF objects here on ontological grounds: the absence of observed interference is not identical to the absence of an admissible bridge. In principle, recoherence may still occur in specially engineered systems. Even when recoherence is practically impossible, CUWF distinguishes between what is merely impractical and what is structurally forbidden.

Branching, in this framework, is a structural forbiddance defined on the space of collapse-transitions. Decoherence may be a precursor to branching, but branching itself is a threshold event in accessibility space.

3.2 Definition of Entropic Branching

Let Ω denote the universal wave field, and let a collapse outcome be represented by a stabilized domain-state A (or B) that supports persistent macroscopic regularities. CUWF associates to each domain-state X an entropic accessibility operator Ξ_E, which encodes the set of admissible relational transitions that preserve that domain's closure:

Ξ_E(X) = { T : X -> X' | T is physically admissible and closure-preserving under entropic constraints }.

The meaning is deliberately operational. Ξ_E(X) does not represent everything that is mathematically conceivable, but only what can occur without violating the entropic closure that stabilizes the domain.

Now define an accessibility divergence functional $\Delta\Xi\_E(A,B)$, measuring the difference between the admissible-transition structures associated with two outcomes A and B. The general branching criterion is $\Delta\Xi\_E(A,B) > \Theta\_access$.

Here Θ_access is the critical accessibility threshold. Once the divergence exceeds this threshold, no closure-preserving bridge remains between A and B. The system has not generated a second substrate; it has partitioned the one substrate into two incompatible closures.

Two clarifications are essential. First, $\Delta\Xi\_E(A,B)$ is a structural distance, not a coordinate distance. It compares admissible transition-sets or graphs, not positions in space. Second, Θ_access is not a small perturbative marker. It denotes the minimal degree of divergence required for permanent severing, namely the point at which the intersection of admissible transition families collapses to null in the relevant regime.

3.2.1 Concrete Models for ΔΞ_E(A,B)

Because Ξ_E(X) is set-valued, DeltaΞ_E may be defined in several mathematically equivalent ways, depending on how accessibility is represented.

Graph model (recommended in CUWF):

Represent Ξ_E(X) as a directed graph G_X whose nodes are coarse-grained states and whose edges are admissible transitions. A natural structural distance is the normalized symmetric difference of edge sets:

$$\Delta\Xi\_E(A,B) = |E\_A \text{ Delta } E\_B| / |E\_A \text{ union } E\_B|,$$

where E_A and E_B are edge sets, and Delta denotes symmetric difference.

Operator model:

Represent Ξ_E(X) as an operator acting on a state space of relational configurations. One may then define

$$\Delta\Xi\_E(A,B) = \|\ \Xi\_E(A) - \Xi\_E(B)\ \|.$$

Information-theoretic model:

Associate to each domain a probability measure over admissible transitions, conditional on closure. The divergence may then be written as

$$\Delta\Xi\_E(A,B) = JSD(P\_A \,\|\, P\_B).$$

Although their mathematical forms differ, all three models carry the same physical meaning: branching corresponds to a sharp reduction in the overlap of admissible transition structures.

3.2.2 Recoverable Divergence vs. Rupture

The inequality ΔΞ_E(A,B) > Θ_access defines the rupture regime. Below threshold, CUWF permits classes of behavior that may resemble divergent histories but do not yet qualify as parallel universes.

These include:

Partial divergence, in which outcomes remain weakly connected through rare closure-preserving transitions.

Effective irreversibility, in which bridges exist in principle but require extreme fine-tuning.

Domain mixing, in which local patches temporarily share accessibility channels before stabilization is complete.

Only above Θ_access does CUWF assign the status of parallel domains. This distinction is essential, because it prevents the framework from collapsing into an indiscriminate picture in which everything branches continuously. Branching is not ubiquitous. It is an exceptional threshold phenomenon in the geometry of accessibility.

3.3 Gradient Fracture in the Entropic Field

CUWF characterizes branching as a fracture driven by entropic gradients. As collapse proceeds, the entropic constraints stabilizing a domain may diverge sharply across candidate outcomes. When the gradient separation exceeds the domain's capacity to preserve a unified closure, the accessibility manifold fractures.

To express this formally, introduce an entropic potential-like functional Φ_E defined on domain-states, such that its gradient encodes the tendency of accessibility either to compress or to open:

$$g\_E(X) = \nabla\Phi\_E(X).$$

Branching occurs when the gradient difference between two outcomes exceeds a critical fracture scale Λ_branch:

$$\| g\_E(A) - g\_E(B) \| >= \Lambda\_branch.$$

This condition is consistent with $\Delta\Xi$_E(A,B) > Θ_access because sufficiently strong gradient separation forces the admissible-transition structures themselves to diverge. Transitions that preserve closure in A cease to be closure-preserving in B, and conversely.

The crucial point is that fracture here does not mean spatial tearing. It means the disappearance of admissible relational channels. The universal field remains singular, but its accessibility graph splits into disconnected components.

3.3.1 Why Fracture Becomes Irreversible Beyond Threshold

Once the accessibility graph becomes disconnected, no process internal to either component can reconstruct the missing edges without violating closure. Irreversibility therefore arises at the structural level, not merely at the thermodynamic level.

In CUWF, irreversibility is tied to the topology of accessibility. If the admissible transition graph decomposes as

$$G = G\_A \sqcup G\_B,$$

then no path exists from A to B. Any hypothetical bridge would require a transition that is inadmissible in at least one domain, and therefore not physically realizable while preserving that domain's stabilized laws, metrics, and collapse structure.

This provides the CUWF replacement for the Many-Worlds narrative. The universe does not endlessly split into equally real branches. Rather, collapse dynamics can drive the accessibility structure into disconnected components, and those components are what CUWF identifies as parallel universes.

3.3.2 Structural Analogy: River Delta and Channel Separation

A useful analogy is a river delta, interpreted structurally rather than spatially. A single river, corresponding to the Still-Wave substrate, may feed multiple channels. Under mild divergence, channels may reconnect downstream; this corresponds to recoverable divergence. Under strong divergence, sedimentation and flow barriers eliminate reconnection routes, and the channel network becomes permanently separated; this corresponds to rupture.

The analogy maps as follows:

River: universal substrate Ω

Channel network: accessibility graph Ξ_E

Sedimentation barriers: entropic constraints generated by collapse

Permanent separation: $\Delta\Xi$_E(A,B) > Θ_access

The analogy should not be misunderstood as implying that universes occupy different places. Its purpose is to show how one substrate can sustain multiple mutually disconnected flow-networks without multiplying the underlying reality.

3.3.3 Summary of the Mechanism

Entropic branching in CUWF is the transition from one coherent accessibility closure to multiple disconnected closures. It is not triggered by superposition alone. It requires collapse-driven divergence that exceeds an accessibility threshold, equivalently expressible as an entropic-gradient fracture.

This mechanism prepares the next section, where the collapse divergence criteria are specified in detail: how the threshold is identified, which quantities govern it, and why certain regimes - particularly early cosmological transitions - are more likely to generate permanent branching than ordinary laboratory measurements.