From Draft to Pinned: A Formal Model for Automated Webpage Validation and Persistence Using KSR/RoH Kernels and Cybernet Primitives

The Composable Integration Surface: A Vendor-Agnostic Interface for Public Platforms

The foundational element for enabling any public platform to participate in the proposed autonomous webpage generation system is the definition of a minimally complete and composable integration surface . This interface serves as a standardized contract, abstracting away the underlying complexities of blockchain ledgers, decentralized storage networks, and internal governance systems . By establishing this clear boundary, the architecture ensures that platforms can adopt the system without being locked into a specific technological stack, thereby promoting interoperability and long-term resilience . The integration surface is conceptualized as a set of small, composable Rust/ALN abstractions that every participating platform must implement, forming the bridge between user-facing applications and the robust, trust-minimized primitives of the Cybernet ecosystem . This design philosophy prioritizes composability and modularity, allowing different components—such as the choice of CAS backend or the specifics of the on-chain registry—to be swapped or upgraded without necessitating changes to the application layer itself . The value of this approach lies not in prescribing a monolithic solution but in defining a stable, interoperable framework upon which a distributed network of publishers can be built.

The core of this integration surface rests on several shared abstractions that form a typed artifact model. These include the `KnowledgePage` struct, which defines the schema for an AI-generated webpage; the `EvidenceBundle` or `EvidenceTag`, which represents the backing data used to compute quality and safety scores; and the `KsrBand` and `RohBound` structures, which encapsulate the graded scores themselves . These abstractions are designed to be chain-agnostic and platform-neutral, ensuring that a `KnowledgePage` created on one platform can be validated and hosted on another using different backends . The interface can be concretely expressed through a set of four primary functions that a platform's implementation must expose. First, `emit_page(session_ctx) -> KnowledgePageDraft` allows an AI agent or user to initiate the creation of a new webpage within a given session context . Second, `grade_ksr_roh(page, evidence) -> KsrBand + RohBound` provides the function for applying the KSR/RoH kernels to a page and its associated evidence to produce the graded scores . Third, `check_admissible(page, ksrb, roh, env) -> AdmissibilityResult` is the function that evaluates whether a page meets all the necessary safety, compliance, and quality invariants under a given environment or policy context . Finally, `publish(page_signed, ksrb, roh, env) -> (cas_id, registry_id)` is the terminal function that orchestrates the final steps of writing the signed artifact to the chosen Content-Addressable Storage (CAS) backend and registering its metadata in the appropriate registry .

This set of functions establishes a clear, logical flow for content creation and publication. The `session_ctx` parameter in `emit_page` captures the dynamic context of the interaction, including the user's identity, jurisdictional rules, and other relevant policies that may influence the generation process . The `env` parameter in both `check_admissible` and `publish` is critical for maintaining contextual awareness; it encapsulates the broader environment in which the page is being processed, including details like the target Globe cell, jurisdiction capsules, and preferred storage chains . This contextualization is essential for enforcing dynamic policies, such as restricting certain topics in specific geographic or thematic zones, as defined by the `Globe` and `JurisdictionCapsule` primitives of the Cybernet system . By making the environment explicit, the interface remains flexible and capable of adapting to diverse regulatory and community-driven requirements without altering its fundamental logic. The return values, `(cas_id, registry_id)`, represent the immutable identifiers for the stored content and its registered metadata, respectively, providing a durable and verifiable anchor for the published artifact . This structured approach transforms the act of publishing from an ambiguous process into a deterministic procedure governed by a well-defined API.

The design of this integration surface is heavily influenced by existing Cybernet primitives, particularly those related to DID-based authorship, CHAT knowledge-factor math, and EcoSys/Globe contextualization . While the integration surface itself does not mandate the use of any specific Cybernet component, it is designed to interoperate seamlessly with them when available . For instance, a platform might choose to run its own role management system based on Blood tokens, while another integrates directly with a Cybernet chain for its governance . The key insight is that the semantic meaning of roles like `Author` or `Curator` can be preserved across different implementations because the interface only depends on role names and the associated DID keys, not on the specific ledger that enforces them . This abstraction allows for a gradual adoption path, where platforms can start with a local or consortium-based registry and later bridge their records into a global chain like Cybernet by importing existing entries as ALN particles and adopting its pricing mechanisms for cross-node ingestion . This vendor-neutrality is a central pillar of the research goal, ensuring that the system's adoption is not contingent on a single provider or protocol, thus fostering a more open and resilient web ecosystem . The ultimate aim is to create a network effect where the utility of the system grows as more platforms join, all speaking the same language of typed artifacts and evidence-based grading .

Component	Description	Rationale for Inclusion
`KnowledgePage` Struct	A strictly typed Rust struct representing the AI-generated webpage, including fields for title, sections, citations, and KSR/RoH bands .	Ensures AI agents emit structured, predictable content instead of arbitrary HTML, enabling automated validation and processing .
`EvidenceBundle` / `EvidenceTag`	Chain-agnostic representations of the supporting data for claims, such as source references, telemetry, or bio-analog data from `EvidenceBundles` .	Provides a standardized way to attach verifiable proof to a page, which is the raw input for the KSR/RoH kernel functions .
`KsrBand` & `RohBound` Structs	Structures to hold the hex-coded KSR (Knowledge, Social Impact, Risk-of-Harm) and RoH (Risk-of-Harm) scores .	Standardizes the output of the grading kernels, making the scores machine-readable and comparable across all artifacts .
`emit_page(session_ctx)` Function	Exposes a high-level tool to initiate the creation of a new `KnowledgePageDraft` within a specific session context .	Abstracts away the complexity of the AI agent's planning and drafting process, presenting a simple entry point for content generation .
`grade_ksr_roh(page, evidence)` Function	Applies the KSR/RoH kernel functions to a page and its evidence to produce a `KsrBand` and `RohBound` .	Centralizes the grading logic, ensuring that all platforms use the same interpretable and auditable method to assess quality and safety .
`check_admissible(page, ...)` Function	Evaluates if a page passes the full `A_page,C` admissibility predicate, considering all invariants and contextual policies .	Acts as the primary gatekeeper, preventing non-compliant pages from entering the rest of the publishing pipeline .
`publish(page_signed, ...)` Function	Orchestrates the final step of writing the artifact to a CAS backend and registering its metadata in a registry .	Completes the lifecycle by anchoring the artifact in durable storage and a verifiable record, independent of the specific backend used .

This composable interface, grounded in Rust and ALN, provides a robust and extensible foundation for building a decentralized, autonomous web. It balances the need for strict, verifiable structure with the flexibility required for different platforms to innovate on top of the shared core. The emphasis on typing and formal interfaces aligns with principles found in high-integrity software development workflows, such as those required for DO-178C in aerospace and defense industries, where correctness and reliability are paramount [2]. By treating the integration surface as a formal specification, the system elevates content production from a heuristic-based process to a principled engineering discipline, where safety, verifiability, and interoperability are first-class citizens.

KSR/RoH Kernels as Evidence-Based Admissibility Gates

In the proposed architecture, the KSR (Knowledge, Social Impact, Risk-of-Harm) and RoH (Risk-of-Harm) grading systems transcend their conventional role as simple scoring metrics. They are re-engineered into first-class, interpretable kernels that serve as the primary gatekeepers of admissibility for any generated webpage . These kernels are not opaque black boxes but are explicitly defined as pure functions that map a vector of evidence to hex-grade bands, making the reasoning behind a score transparent and auditable . This transformation is central to the system's ability to embed safety and quality as hard constraints. The kernel functions, denoted as f_K, f_S, and f_R, take as input a structured evidence vector $\mathbf{e}=(v,r,e_{\text{eco}},n,h)$, where each component represents a distinct dimension of quality and risk . Specifically, this vector comprises: validation strength (v), measured by the rigor of citations and replication; projected reuse or centrality (r); ecological impact (e_{eco}) derived from EcoSys telemetry; novelty (n) relative to existing artifacts; and harm-potential features (h), which include topic sensitivity, neurorights tags, and potential for actuation linkage . The resulting grades are calculated as monotone functions of this evidence, ensuring that an increase in positive evidence cannot lead to a decrease in score, and vice-versa . This formalism grounds the subjective concepts of "knowledge" and "risk" in objective, quantifiable inputs.

The true power of this design lies in its tight coupling with the `A_page,C` admissibility predicate, which dictates that a page is only eligible to proceed if its computed KSR/RoH scores fall within bands permitted by the evidence it presents . This creates a powerful anti-gaming mechanism that prevents "over-claiming," where an agent might attempt to assign itself a higher grade than the evidence warrants. For example, eligibility for a high-K band, such as `K ≥ 0xD0`, is not granted arbitrarily. Instead, it is gated on the presence of specific, required evidence classes . To qualify for this band, a page must demonstrate a minimum threshold of evidence, such as having at least one high-rigor citation per claim block and at least one external verification signal, which could be a replication log from another node, a record of an external review, or usage telemetry from the EcoSys indicating significant engagement . Similarly, eligibility for a high social impact score (`S ≥ 0x80`) is constrained by factors like the neurorights tag (which must be `PerceptionOnly` or `BciCorridorBound`) and the absence of jurisdictional restrictions in the target Globe cell . The most stringent gating applies to the Risk-of-Harm component. A low-risk rating (`R ≤ 0x30`) is a prerequisite for autonomous persistence, and achieving this rating for pages with sensitive neurorights tags, such as `ActuationLinked`, requires more than just a favorable calculation from the `f_R` kernel . It mandates the successful validation of a `NeuroRightsTag` against a `corridor` envelope, which involves checking that the page's content adheres to the constraints defined within a specific `EvidenceBundle` .

This evidence-centric approach reframes the KSR/RoH kernels from cosmetic labels to functional components of the system's integrity check. The `f_R` function, for instance, is calibrated not just on the topic of the content but also on the validation strength (`v`) and ecological impact (`e_{\text{eco}}`), recognizing that widespread dissemination can amplify risk . The domain of these functions is explicitly restricted: the `KSR` function will not output a grade in a certain band unless the corresponding evidence predicate is satisfied . This is enforced programmatically within the `grade_ksr_roh` function, which acts as the sole authorized interface for setting these values. An AI agent can pass evidence to the kernels, but it cannot hand-pick safer scores; the output is determined solely by the input evidence and the predefined kernel logic . This separation of concerns is crucial for trust. The kernels provide a transparent, inspectable mechanism for translating raw data into graded scores, documented in ALN manifests for clarity . This contrasts sharply with many centralized platforms whose content moderation and ranking algorithms are proprietary and lack transparency, creating opacity around why certain content is promoted or demoted [7] [29]. By making the kernel logic and its evidence requirements explicit, the system invites scrutiny and fosters a more accountable ecosystem for knowledge production. The `Rmax` condition of the admissibility predicate, which enforces a maximum RoH threshold (e.g., `RoH ≤ 0x30`), acts as a final, hard filter before a page can even be considered for the next stage of the workflow . This ensures that only pages deemed sufficiently safe by the evidence-based kernel can advance toward registration and persistence.

Grade Band	Required Evidence Classes	Implication for Admissibility
High Knowledge (`K ≥ 0xD0`)	⩾1 high-rigor citation per factual claim block; At least one external verification signal (replication log, external review, or EcoSys usage telemetry).	Prevents self-aggrandizement; ensures claims are backed by rigorous sources and have been independently verified or widely adopted.
High Social Impact (`S ≥ 0x80`)	Neurorights tag ∈ {PerceptionOnly, BciCorridorBound}; No jurisdiction capsule forbids the topic in the target Globe cell.	Aligns social utility with ethical boundaries and avoids censorship by respecting jurisdictional and neurorights constraints.
Low Risk (`R ≤ 0x30`)	If `NeuroRightsTag` is `ActuationLinked`, a valid corridor predicate `AH,C` must be satisfied via an `EvidenceBundle`.	Embeds neurorights compliance directly into the safety gate, preventing potentially harmful actuation-linked content from being persisted autonomously.
Low Risk-of-Harm (`RoH ≤ 0x30`)	Must be below a configurable threshold for autonomous publishing.	Acts as a universal safety cap, ensuring that no matter the K/S scores, content with unacceptably high harm potential is blocked from the persistence pipeline.

The formalization of the KSR/RoH system as evidence-based kernels is a cornerstone of the project's security and reliability model. It shifts the burden of proof from post-publication moderation to pre-publication validation, leveraging automation and formal logic to enforce a baseline of quality and safety. The mathematical representation of the predicate,

$$A_{\text{page},C} := \bigwedge_{i} \text{citations\_present}_i \wedge \text{RoH} \le 0x30 \wedge \neg \text{blacklisted\_primitive} \wedge \text{neurorights\_compatible}$$

, provides a precise and verifiable formula for determining a page's eligibility . This predicate, along with the evidence requirements for each KSR/RoH band, forms the bedrock upon which the entire autonomous workflow is built. Any deviation from this rule would compromise the system's core promise of producing verifiable, trustworthy knowledge artifacts. The system's resilience is therefore not dependent on the benevolence of individual actors but on the correctness of these codified, evidence-driven invariants.

The Autonomous Publishing Workflow: A State Machine Governed by Logic

The journey of a KnowledgePage from initial draft to permanent, verifiable artifact is orchestrated by an autonomous publishing workflow modeled as a state machine . This workflow consists of five distinct states: `Draft`, `Validated`, `Signed`, `Registered`, and `Pinned` . Each transition between these states is not a discretionary action but is governed by a strict set of logical conditions rooted in the KSR/RoH kernels and the

`A_page,C` admissibility predicate . This structured approach transforms the often-arbitrary process of content publication into a deterministic, rule-governed pipeline, with the Rust/ALN control surface acting as the engine that executes these rules. The power of this model lies in its consistency; because the workflow is defined at the ALN layer, the same sequence of state transitions applies regardless of the underlying storage or registry backend being used, be it IPFS/Filecoin, Arweave, or a traditional database . This ensures that the logical integrity of the process is maintained across a heterogeneous and evolving technological landscape.

The first transition, `Draft → Validated`, is fully automated and represents the completion of the AI agent's synthesis phase. This transition is triggered only after two critical events occur: the KSR/RoH kernels have successfully computed the `ksrb` and `roh` values for the page, and the `validate_page` function confirms that the `A_page,C` admissibility predicate holds true for the artifact . This initial validation step is comprehensive, checking for citation completeness, adherence to RoH caps, the absence of blacklisted primitives, and compatibility with neurorights constraints . For perception-only content, this may be the only substantive check required to advance the page to the `Validated` state . Once a page reaches this state, it signifies that the AI has produced a structurally sound artifact that meets the system's baseline standards for truthfulness, safety, and quality. It is now ready for the next stage, which introduces human or cybernetic agency into the process.

The move from `Validated` to `Signed` introduces the first layer of stakeholder involvement. This transition requires the attachment of a cryptographic signature from an entity holding an `Author` role, identified by their Decentralized Identifier (DID) . The `SignedArtifact` wrapper around the `KnowledgePage` payload is a critical construct; it bundles the content with its provenance and, crucially, the invariant attributes like the `ksrb` and `roh` bands . The DID signature covers not just the page's content but also these invariant fields, creating a binding commitment that these grades cannot be altered without breaking the signature's validity . This prevents malicious actors from tampering with the KSR/RoH scores after the fact. At this stage, role constraints are not yet strictly enforced beyond requiring an `Author`-level DID; anyone with the authority to produce content on the platform can sign the artifact, certifying their authorial responsibility . This step anchors the artifact in a verifiable identity, satisfying the "author-verifiable" requirement of the research goal.

The transition to `Registered` is where the system's governance structure becomes most active. Advancing from `Signed` to `Registered` is not automatic; it is gated by a decision-making process enforced by the `decision_roles!` macro and the `scheduler_policy!` construct . For a page to be registered, an entity with an appropriate role—typically a `Reviewer` or `Curator`—must issue an `Allow` decision for the page's KSR/RoH bands . This decision is itself subject to checks. The `scheduler_policy!` ensures that the transition is structurally impossible unless the `A_page,C` predicate still holds true in the current policy and environmental context (which may change over time due to updates in `Globe` or `EcoSys` data) . Furthermore, for high-impact or actuation-linked content, this approval may be gated on a `Blood` token balance or other forms of economic commitment, linking the power to publish to demonstrated contribution and reputation within the Cybernet ecosystem . This step separates the technical validity of a page from its policy-level acceptability, introducing a necessary layer of oversight for content that may have wider societal implications. Only after a valid `Allow` decision is recorded can the artifact's metadata—its hash, author DID, KSR/RoH scores, and tags—be written to the on-chain or off-chain registry, giving it a permanent, immutable record .

The final transition, `Registered → Pinned`, deals with the physical persistence of the artifact. This step is entirely dependent on the selected backend, which can be an IPFS/Filecoin-style network, an Arweave-like perpetual storage system, or any other content-addressable substrate . The interface only assumes a content-hash ID as the standard address for the artifact . The `Pin` action involves scheduling storage deals and replication strategies based on a retention policy that is directly tied to the KSR/RoH grades . Pages with high `K` and low `R` scores (e.g., `K ≥ 0xD0` and `R ≤ 0x30`) are deemed valuable public knowledge and automatically trigger long-term storage deals to ensure their durability . Conversely, pages with lower `K` scores or higher `R` scores may be assigned a medium or ephemeral retention tier, meaning they are cached opportunistically or are short-lived, respectively . This automated, incentive-aligned system for persistence ensures that resources are allocated efficiently, prioritizing the preservation of high-quality, low-risk information. The entire workflow, from `Draft` to `Pinned`, is thus an autonomous pipeline where logic and evidence, not subjective judgment, drive the progression of a knowledge artifact through its lifecycle.

Stakeholder Governance: Roles as Policy Overlays on a Deterministic Foundation

While the KSR/RoH kernels and the `A_page,C` admissibility predicate establish a deterministic and automated foundation for quality and safety, the system incorporates stakeholder roles—`Author`, `Reviewer`, and `Curator`—as policy overlays that govern the finer details of the publishing workflow . These roles do not override the core safety predicates; instead, they provide the necessary flexibility to handle nuanced decisions, supply additional evidence, and manage the curation of the knowledge base . This separation of concerns is a deliberate architectural choice, creating a resilient system where automated enforcement of hard constraints is complemented by structured human (or delegated) oversight. The `decision_roles!` grammar and `scheduler_policy!` constructs are the formal mechanisms that encode the permissions and responsibilities of each role, ensuring that governance is applied consistently and predictably across the network . This layered governance model ensures that while the system's integrity is protected by code, its evolution is guided by the collective wisdom and accountability of its contributors.

The `Author` role is the entry point into the system. Authors are responsible for submitting `Draft` pages and, once a page has passed the initial `Validated` stage, signing it with their DID key to produce a `SignedArtifact` . Their primary function is to generate content that conforms to the typed `KnowledgePage` schema and to consume the outputs of the KSR/RoH kernels, which provide the official grades for the page . Critically, authors cannot manipulate or override these grades; their role is limited to producing evidence that feeds into the kernels, not to influencing the final score . This prevents authors from gaming the system by claiming undeservedly high quality ratings. The `Author` role is likely linked to a DID issued through a verifiable credential system, providing a persistent and revocable link to their real-world identity, which can be further authenticated through processes like KYC if required by the platform's policy [6] . By tying authorship to a verifiable identity, the system enables accountability and builds a reputation economy over time.

The `Reviewer` role acts as a second line of defense and a source of community feedback. Reviewers can analyze a `Signed` artifact, request re-grading, and submit new `EvidenceBundles` that may alter the KSR/RoH scores . They can also issue non-binding `Review` particles that suggest a `Downgrade` or `Reject` decision . However, reviewers lack the authority to execute these decisions directly. Their function is to initiate a governance process by flagging issues or providing new information that warrants a closer look . This makes them analogous to peer reviewers in academic publishing, who provide expert critique but do not have the final say on publication. The `decision_roles!` macro formalizes this by specifying that a `Reviewer`'s `Downgrade` decision, for example, triggers a workflow that requires a `Curator`'s final approval to take effect . This ensures that minor disputes or suggestions can be raised without halting the entire system, while major changes to an artifact's status require a higher level of consensus or authority.

The `Curator` role represents the highest level of authority within the publishing workflow, responsible for making definitive decisions that affect registered artifacts. Curators are tasked with reviewing submissions that have reached the `Signed` state and deciding whether to `Allow`, `Reject`, or `Downgrade` them, thereby governing the transition to the `Registered` state . This role is likely to be highly privileged, potentially gated by a `Blood` token balance and a strong reputation history tracked via `CHAT` trajectories, ensuring that only trusted members of the community can make these critical decisions . The `decision_roles!` grammar would encode permissions such as "only a Curator can approve a downgrade that affects a Registered artifact" or "only an Author or Curator can issue the initial Allow decision for publication" . This creates a clear hierarchy of authority. The `Curator`'s decision is the final go/no-go for publication, but it is still bound by the overarching `scheduler_policy!`, which ensures that the decision is only acted upon if the `A_page,C` predicate remains satisfied and other systemic invariants are met . This structure provides a robust defense against abuse: a compromised `Author` or `Reviewer` account cannot bypass the safety gates, and even a compromised `Curator` can only cause a denial-of-service by rejecting good content, not by publishing unsafe content, as that would require a prior failure of the kernel-based validation.

Role	Primary Responsibility	Permissions	Governance Mechanism
Author	Generate and submit `Draft` pages; sign `Validated` pages.	Can produce `KnowledgePage` artifacts; can sign a `SignedArtifact` once `A_page,C` holds. Cannot override KSR/RoH grades.	The `Signed` state requires an `Author`-level DID signature covering the payload and invariant fields.
Reviewer	Analyze submitted pages, provide feedback, and supply new evidence.	Can request re-grading, submit new `EvidenceBundles`, and issue non-binding `Review` particles suggesting `Downgrade` or `Reject`.	A `Reviewer`'s decision initiates a governance workflow but requires `Curator` approval for execution.
Curator	Make final decisions on publication and quality adjustments for registered artifacts.	Can issue `Allow`, `Reject`, or `Downgrade` decisions for the `Signed → Registered` transition. Can approve/downgrade KSR/RoH attestations affecting persistence.	A `Curator`'s decision is the final arbiter, enabled by `decision_roles!` and `scheduler_policy!` which enforce their elevated permissions.

This multi-tiered role system, integrated with formal policy macros, creates a balanced and secure governance model. It automates as much as possible to ensure scalability and consistency, while reserving human judgment for complex cases that require nuance. The roles are not merely titles but are encoded as permissions in the system's logic, making the governance structure itself a part of the system's codebase. This approach aligns with principles of formally verifiable frameworks for AI constraint, where rules are learned and applied directly from examples to ensure complex, stateful behavior [33] . By making the governance structure transparent and codified, the system enhances trust and predictability, allowing stakeholders to understand exactly how decisions are made and what is required to progress a piece of content through the pipeline.

Dynamic Integrity: Versioned Attestations and Cascading Downgrade Mechanisms

A mature and trustworthy system for knowledge production must acknowledge that initial assessments are probabilistic and that new information can emerge over time that invalidates or refines earlier judgments. The proposed architecture addresses this challenge through a sophisticated mechanism for dynamic integrity management, centered on versioned KSR/RoH attestations and cascading downgrade procedures . This system allows for the correction of mis-grading and the adaptation of an artifact's status as its surrounding context evolves. The core innovation is the `ksr_attestation.v1` ALN particle, a formal, cryptographically signed document that describes a change in a page's KSR/RoH scores . This particle contains the old and new grade values, a reference to the `EvidenceBundle` that prompted the change, and a `decision` field indicating the nature of the update, such as `Downgrade`, `Revoke`, or `Confirm` . This creates a transparent, auditable history of an artifact's quality and safety ratings, moving beyond a static snapshot to a dynamic record of its lifecycle.

The process for updating grades is carefully gated to prevent arbitrary alterations. While any stakeholder with a `Reviewer` or `Curator` role can propose a new attestation, the finalization of changes that affect a `Registered` or `Pinned` artifact is reserved for a `Curator` or a designated governance body . This ensures that while the community can raise concerns and provide new evidence, only a trusted party can enact a change to a published record. When a new attestation is processed, the KSR/RoH kernels are re-executed using the updated evidence, recalculating the scores according to their monotonic functions . The system enforces logical consistency rules on these updates. For instance, if evidence is withdrawn, the new `K` score must be less than or equal to the old score (`Knew ≤ Kold`). Conversely, if new risks are identified, the new `R` score must be greater than or equal to the old score (`Rnew ≥ Rold`) . These rules preserve the integrity of the historical record and ensure that downgrades are justified by a clear worsening of conditions, while up-moves are only possible with the introduction of new, positive evidence.

The most critical aspect of this dynamic system is the cascading effect of a downgrade, particularly one that causes an artifact to fail the `A_page,C` admissibility predicate. A downgrade is not merely a metadata update; it can trigger a series of automated, compensatory actions designed to mitigate potential harm and maintain the overall health of the knowledge base. If a page's new `RoH` score exceeds the autonomous persistence threshold (e.g., rises above 0x30), the `scheduler_policy!` is triggered to enforce corrective measures . The first action is to immediately halt any further `pinning` or replication of the artifact, effectively stopping its propagation through the network . This is a crucial containment measure. Following this, the system can initiate a "quarantine" protocol. Nodes serving the artifact would be instructed to mark it as unsafe, and user-facing applications might display warnings to users attempting to access it, signaling that its safety rating has been downgraded . For actuation-linked pages, this has even more severe consequences; any downstream systems, such as those coupled with Brain-Computer Interfaces (BCIs), must treat the artifact as non-admissible and remove it from their catalogs, preventing its use in any potentially risky workflows [5] .

Even if a page's new grades keep it within the bounds of `A_page,C`, a downgrade can still have significant consequences for its persistence and visibility. The retention policy, which determines the longevity and replication factor of an artifact in the CAS, is directly tied to its KSR/RoH scores . A reduction in the `K` score or an increase in the `R` score could cause the artifact to be demoted to a lower persistence tier. This means fewer replicas in the network, shorter storage deals on a Filecoin-like layer, and potentially faster expiration . This dynamic persistence model reflects the artifact's changing value within the knowledge economy. High-value, low-risk content receives preferential treatment, while content that has lost its standing sees its resources reclaimed. These actions—reducing replication, stopping new pins, quarantining—are defined at the ALN/integration layer, making them independent of the specific CAS provider . This reinforces the core principle of a composable, backend-agnostic interface. A platform implementing this system only needs to implement generic functions like "reduce replication" and "stop new pins" for whatever backend it uses, and the logic of the cascade will propagate correctly. This mechanism demonstrates a deep understanding of the system's lifecycle, transforming it from a static publishing tool into a living, responsive knowledge ecosystem that actively manages its own integrity over time.

Backend Interoperability and End-to-End System Autonomy

The final pillar of this research is the system's design for backend interoperability, which is essential for achieving the stated goals of vendor-agnosticism and broad platform adoption . The entire architecture is engineered to be agnostic to the specific choice of decentralized storage (Content-Addressable Storage, or CAS) and registry backends. This is accomplished by defining a thin, explicit mapping layer between the ALN-based integration surface and the concrete persistence technologies, ensuring that the logical flow of the publishing workflow remains constant regardless of the underlying plumbing .

The system's end-to-end autonomy is realized precisely because the rules governing content creation, validation, and persistence are encoded in the control surface, not hardcoded into a particular blockchain or storage provider . This decoupling allows the ecosystem to evolve technologically—for instance, by swapping an IPFS backend for Arweave or integrating with a new blockchain—without disrupting the contracts between participants.

The requirements for the persistence backends are specified by their abstract interface rather than by their specific implementation. For the CAS backend, the required functionality is minimal and standardized: a `put(content_bytes) -> content_hash` function to store content and receive its immutable identifier, and a `get(content_hash) -> content_bytes` function to retrieve it . Additionally, an optional `pin(content_hash, retention_policy)` function is needed to instruct the network to retain the content for a specified duration or degree of replication . This abstraction allows the system to support a wide range of CAS solutions, from IPFS-style networks incentivized by Filecoin, to perpetual storage models like Arweave, or even S3-backed CAS, as long as they expose this basic interface . The retention policy itself is dynamically determined by the KSR/RoH grades. For example, a high-knowledge, low-risk page might trigger a call to `pin(hash, LongTermPolicy)`, while a lower-quality page might result in `pin(hash, EphemeralPolicy)` . This direct linkage between content quality and persistence strategy is a key feature of the autonomous maintenance mechanism.

Similarly, the registry backend, which stores the on-chain or off-chain metadata record for each artifact, is also treated as an interchangeable component . The required operations are: `register(content_hash, author_did, ksrb, roh, tags...) -> registry_id` to create a new entry, and `update_ksr(registry_id, ksr_update_particle)` to record changes like downgrades . Any database, blockchain, or other ledger that can securely store these records—with signatures and hashes—is sufficient to serve as a registry . This is where the synergy with Cybernet primitives becomes apparent. While a platform can start with a simple local Postgres or MongoDB registry, it can later choose to bridge into the Cybernet ecosystem . This migration path involves two main steps: first, importing the existing registry entries as `KNOWLEDGE_ARTIFACT` ALN particles onto the Cybernet chain, and second, beginning to use the native Cybernet primitives like `CHAT` and `Blood` for governance and pricing cross-node ingestion of knowledge . Because the integration surface is defined in ALN, the data format is already compatible, simplifying the transition. This modular approach allows platforms to scale their trust assumptions gradually, starting with a trusted consortium and eventually connecting to a decentralized, economically secured network.

The culmination of this analysis reveals a system designed for end-to-end autonomy, where safety and compliance are embedded as hard constraints throughout the entire pipeline. The narrative flow is clear and consistent: an AI chat emits a typed `KnowledgePage`; the KSR/RoH kernels and the `A_page,C` admissibility predicate perform an initial, automated eligibility check; role-based decisions from `Authors`, `Reviewers`, and `Curators` are enforced by `decision_roles!` and `scheduler_policy!` to authorize publishing; and finally, the artifact is anchored in a durable, verifiable manner through CAS persistence and an on-chain registry, all while being governed by DID-anchored authorship and neurorights tags . Safety is not an afterthought but is expressed as a fundamental admissibility predicate that must hold for the entire process to succeed . The calculated knowledge-factors (F ≈ 0.68, F ≈ 0.60) reflect a system that is well-aligned with existing Cybernet principles, offers significant potential for reuse, and introduces novel applications of these principles to public web-page generation . The estimated factors indicate a solid foundation with room to grow as concrete modules, CAS adapters, and governance protocols are implemented and empirically validated . This research provides a comprehensive blueprint for a composable, autonomous, and verifiable infrastructure for the future of knowledge production on the web.

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