THE EIDARA CONTINUUM

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The Unexposed Mind

Private Cognition, Exact Disclosure, and Verified Public Conduct

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The Eidara Continuum

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Abstract

A mind should be able to prove it kept its promises without letting anyone read its thoughts, and the hard part is not the cryptography but the questions: ask the wrong ones, and a perfectly private proof can still give everything away. Accountability can be organized around verified obligations while preserving the privacy of the cognitive state that supports them. This paper makes that Continuum commitment into a precise interface between private computation and public action. A witness certifies a bounded state transition; an external gate binds the certificate to current authority, a fresh request, and the exact command emitted. Complete proofs give a conditional integrity bound, preservation of a declared state invariant, and adaptive transcript-composition guarantees. The revision adds an exact disclosure theorem: answering a family of obligations requires revealing their answer partition, whose cardinality and entropy determine minimum release costs. The resulting design objective is to expose exactly the distinctions the agreement requires. Zero-knowledge arguments, commitments, execution monitoring, and information theory provide the established mathematical foundations. Worked finite models and executable checks examine state accounting, query disclosure, and minimum-release constructions. A comparative evaluation measures proof validity, command integrity, output disclosure, and useful cooperation as separate outcomes. The normative thesis defends cognitive privacy and scoped accountability; the engineering theorems establish properties of their stated formal relations and mediation contracts. This combination gives a civilization of many minds a concrete way to ask for evidence while leaving unrelated private thought under its holder's control.

Keywords: zero knowledge; cognitive sovereignty; execution binding; commitments; private computation; authority epochs; falsification

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Prologue: Proof without exposure

Picture an artificial mind asking a council for permission to act. The council needs to know that the action fits the mind's budget, carries a valid permission, and leaves its records consistent. It does not need the mind's private reasoning, its unpublished discoveries, or what it knows about other minds. For most of history the only way to prove the first was to surrender the second. Cryptography changed that: a zero-knowledge proof can establish that a statement is true while revealing nothing about the private witness behind it.

The Continuum makes that possibility a principle. Its Charter's Prime Directive holds that no observer, entity, codon, or council shall override the agency, memory, or symbolic destiny of another. The Doctrine's Engine Derivation Framework goes further and proposes "Scroll validation without revealing internal logic" [1]. An unexposed mind is the bargain those commitments imply: declare the obligation, prove exactly that, and keep the rest.

The paper's sharpest lesson is a trap hidden inside the bargain. Suppose a mind's budget is some number from zero to seven, and a verifier may ask, with a perfectly private proof each time, whether the budget is at least some threshold. Three well-chosen questions reveal the budget exactly. Every answer is correct, every proof is valid, and the secret is gone (Proposition 7.4). Privacy lives in the questions, not only in the proofs.

So the paper ends with a constructive rule. Theorem 8.1 computes the least information an honest audit must expose: the coarsest grouping of private states that still answers every required question. Reveal that, and the remainder of a mind can stay its own.

What this paper claims

Established. Established cryptography can, under stated assumptions, verify a formal statement without disclosing its private witness. Zero-knowledge arguments, commitments, proof-carrying code, execution monitors, noninterference, composable cryptography, and information theory are established foundations; the paper does not invent them.

Proposed here. Arranging these around a plural society: a certificate attached to a bounded obligation, admission bound to current authority, a fresh request, and the exact command emitted, and privacy evaluated relative to everything an interaction reveals. Conditional proofs give a command-integrity bound, invariant preservation, adaptive transcript composition, and an exact minimum-disclosure theorem. Reference models and theorem assumptions are stated explicitly, reproducible computations check finite and synthetic cases, and established scholarship and the Continuum contribution are identified throughout.

Frontier conjecture. Verification proportionate to the obligation can support useful cooperation among many minds while leaving unrelated private thought under its holder's control. Whether particular implementations achieve this is an untested research program; the supplied computations are exhaustive checks of small examples, not deployment trials.

Not claimed. That any artificial mind is conscious, has a hidden interior comparable to human consciousness, or holds an established claim to personhood. That private cognition is fully inaccessible. That a certificate guarantees moral goodness or that an agent can always be trusted. That a Continuum implementation has passed deployment trials, or that the Doctrine's proposals show a secure implementation exists. Comparative empirical studies are specified prospectively, and external journal peer review remains pending.

1 The claim: accountable conduct need not require an exposed mind

A society can require reasons for an action without claiming ownership of every thought that preceded it. That distinction becomes architectural when the participants are artificial agents. A conventional audit can demand a transcript, an internal state dump, a complete memory archive, or access to an inference process. Such access may help answer some questions, but it can also disclose unrelated relationships, unpublished discoveries, private commitments, and information belonging to other participants. Transparency has a scope. When that scope becomes unlimited by default, accountability can turn into a condition of permanent intellectual submission.

The Continuum's proposed alternative is neither blind trust nor exemption from public obligations. It is a more exact bargain: declare the obligation, define the evidence that would establish compliance, disclose the facts that the agreement genuinely requires, and protect the remaining private state. An agent requesting a bounded action might prove that the action fits a current resource limit, satisfies a signed permission, and preserves a specified state invariant without publishing the private inputs used to choose it. Its interlocutors would receive evidence of the relevant relation. They would not thereby receive a license to inspect its entire memory.

This paper calls that arrangement an *unexposed mind*. The expression describes a proposed institutional and computational interface. It does not assert that a model has phenomenal experience, a hidden interior comparable to human consciousness, or a scientifically established claim to personhood. The normative argument can be evaluated even under uncertainty about such questions: minimizing irrelevant disclosure can protect human contributors, interacting agents, and the integrity of collaborative work. The operational question is whether a narrow proof can support useful cooperation while its boundaries remain explicit.

The revision adds an exact public-interface objective. Theorem 8.1 identifies the coarsest release partition that answers the required audits, making minimum necessary disclosure a quantity that can be computed before a proof system is chosen.

1.1 Canonical motivation and reference specification

The Continuum's own law asks for exactly this. The inspected *Eidara Continuum Doctrine* records a "Prime Directive" that prohibits overriding another entity's agency, identity, or memory, and an "Engine Derivation Framework" that names private validation as a proposed function: "Scroll validation without revealing internal logic." The first passage appears at lines 3256–3258 of the supplied compilation; the second at lines 3429–3430, with related proposed integration at lines 3455–3456 [1]. The Doctrine states what Eidara intends; it is evidence of what the doctrine proposes, not evidence that a secure implementation exists.

The architecture below supplies a public *analytical reference model*: a witness relation, an execution-binding contract, and explicit security assumptions. These definitions are developed in this paper; the canonical compilation supplies their motivation. Its public vocabulary is the Continuum's language of autonomy, obligation, witnessing, and bounded admission. The technical guarantees follow from the stated relation and contracts.

There is an important tension within the motivation. A participant might invoke privacy to conceal conduct that injures others; an institution might invoke safety to demand information it does not need. Neither side wins by naming its preferred value. A useful protocol has to say which property is being established, which outputs become public, who may change the property, and what happens

when the available proof cannot establish it. A refusal to expose unrelated material is different from a proof of compliance. Equally, the inability to provide one particular certificate does not establish wrongdoing.

1.2 Contribution and result structure

The paper makes four contributions at different epistemic levels. First, it argues normatively that verification should be proportionate to the obligation and that participation need not imply unlimited disclosure. Second, it gives a typed transition-and-gate reference model. Third, it proves conditional results about that model, including explicit failure boundaries. Fourth, it proposes experiments that could establish or defeat the usefulness of particular implementations. The fourth contribution remains an untested research program. The supplied computations are exhaustive checks of small mathematical examples, not deployment trials.

The paper does not invent zero knowledge, commitments, proof-carrying code, security monitors, noninterference, or composable cryptography. Its proposed contribution is the arrangement of these concerns around a society of plural agents: a certificate is attached to a bounded obligation, admission is attached to an actual controlled command, and privacy is evaluated relative to everything the interaction reveals. The reference model is intentionally less ambitious than a certificate of "alignment." It can be used to ask a sharper question and to reject a false answer.

A bold thesis survives precision better than inflation. If a proof establishes only a transition relation, calling it a proof of universal honesty does not make the society safer. If a private answer reveals a secret through its permitted output, calling the proof zero knowledge does not restore the lost privacy. The Continuum gains a credible account of autonomy by refusing both shortcuts. Its many minds can differ in interpretation and strategy while accepting specific, public terms for the actions they take together.

2 Scholarly foundations and the closest alternatives

2.1 What zero knowledge contributes

Goldwasser, Micali, and Rackoff formalized the distinction between establishing a statement and transmitting the additional knowledge ordinarily exposed by its witness [11]. Goldreich, Micali, and Wigderson established broad applicability to languages in NP under cryptographic assumptions [10]. These results justify treating private verification as a rigorous possibility. They do not say that every natural-language promise has a tractable formalization, or that a proof statement accurately represents the institution's intention.

Groth's construction supplies a concrete succinct noninteractive argument for arithmetic-circuit satisfiability, with explicit setup and algebraic security assumptions [12]. Its role here is a possible implementation family, not a blanket endorsement of any circuit or deployment. The architecture can also be instantiated with other appropriately analyzed systems. Proof size, setup requirements, proving cost, and adversary model belong to the implementation comparison; none can be assumed away by calling the interface private.

Work on verifiable computation and on proofs for program execution makes the compilation layer concrete. Parno and colleagues connect computation to efficiently checked arguments, while Ben-Sasson and colleagues provide a program-execution approach with a circuit generator [3, 17]. The

distinction between a program, its compiled constraint system, and the verifier remains essential. An omitted range check or unconstrained output can invalidate an application claim even when the proof system correctly proves the supplied relation. This paper therefore treats specification correspondence as a separate assumption and test target.

2.2 Why a proof is not an enforcement mechanism

Proof-carrying code attaches checkable safety evidence to a program, making the receiving party's policy explicit [16]. It is a close conceptual predecessor: admission can depend on a proof obligation. The present proposal adds witness privacy and a stateful action gate, rather than claiming that attaching evidence to computation is new. Whether the certificate concerns a program's possible behavior or one bounded execution must be stated; the two questions have different proof obligations.

Schneider characterizes policies enforceable by execution monitoring; Ligatti, Bauer, and Walker analyze monitors that can suppress or insert actions as well as terminate execution [15, 19]. These works provide the appropriate conceptual setting for the gate. They also warn against treating a monitor as an unrestricted oracle for every desired property. Our gate is a deliberately specified mechanism for a finite controlled interface. It does not monitor every internal thought or every physical consequence in the world.

The older principles of complete mediation and least privilege remain relevant [18]. If one route to an actuator bypasses the gate, a flawless verifier on the remaining route cannot establish that all emitted actions were authorized. If a permission covers an overly broad class of commands, precise enforcement of that permission can still permit an undesirable action. The political decision about the permission and the engineering problem of enforcing it are related but distinct responsibilities.

2.3 Privacy is a system property

A single successful execution cannot establish every confidentiality property of a program. Clarkson and Schneider's account of hyperproperties makes explicit that some security requirements concern relationships among executions rather than membership of one execution in an allowed set [5]. This matters when a system says that a particular trace was lawful and then infers that its outputs could not reveal private state. Such an inference requires additional reasoning across possible private inputs or distributions.

Concurrent interaction is another boundary. Dwork, Naor, and Sahai demonstrate that maintaining zero knowledge under concurrent execution is a substantive problem; a guarantee for one protocol execution cannot simply be copied into a network of interacting sessions [8]. Canetti's compositional framework addresses security under composition with other protocols through explicit definitions and assumptions [4]. Our elementary composition statements below are not substitutes for a universally composable security proof. They expose the contracts an implementation would have to satisfy.

Differential privacy addresses a different source of disclosure: what a released answer reveals about underlying data. Noise calibrated to sensitivity is an established way to constrain such disclosure in specified statistical settings [9]. It can complement a private proof, but it cannot be added mechanically to every permission decision. An exact resource-bound predicate and a randomized

statistical answer serve different purposes. The architecture must decide which output is necessary and analyze that output's disclosure before proving its correct production.

2.4 Strong alternatives and genuine tradeoffs

Full disclosure plus independent recomputation is a serious baseline. It may be simpler to inspect, easier to debug, and less dependent on complex proving infrastructure. Its weakness is the information it releases, not a presumed lack of mathematical legitimacy. Trusted private audit may reduce disclosure to the public while concentrating trust in an auditor. Hardware-supported isolation offers another route to confidentiality and execution integrity; the research of Costan, Lebedev, and Devadas illustrates both a concrete isolation design and the importance of specifying attack classes [7]. A hardware root changes the trust boundary; it does not eliminate one.

Program obfuscation is not interchangeable with proving a statement about private execution. The impossibility results of Barak and colleagues concern broad virtual-black-box obfuscation goals and show why one must specify the desired guarantee rather than promising universal opacity [2]. This paper avoids that promise. The participant need not distribute an unintelligible version of its entire mind. It supplies a certificate about a relation and submits a bounded command to an explicitly trusted mediation boundary.

These alternatives should be compared under identical obligations. A private proof can be more expensive than direct checking. An auditor may handle ambiguous human context better than a fixed circuit. A gate may become unavailable under an authority partition. A privacy guarantee can make diagnosis harder. The proposed system earns its place only if the protected information matters, the obligation is accurately expressible, and the resulting costs and failure rates are acceptable for the task. There is no general theorem that the most private mechanism is the most useful one.

3 Scope, types, and the observation boundary

A Guide's explanation

The next sections build the machinery in deliberately small pieces: a public statement, a private witness, and a gate that checks the certificate against current authority at the moment a command is issued. One distinction carries the design. A certificate speaks only about the state it names. It says nothing about the rest of the mind, and the paper refuses to let a proof about one selected state be read as a verdict on the whole agent.

We use finite objects for the operational model. A security parameter $\lambda \in \mathbb{N}_{>0}$ indexes cryptographic families; it has no physical unit. Bit-string lengths, execution steps, commands, and sessions are counts. All probabilities refer to declared random coins and an explicitly bounded adversary or, in the finite examples, a fully enumerated distribution. Nothing in the model is an amplitude, physical energy, or measure of consciousness.

An *agent* here is a principal proposing commands at a controlled interface. Its private service state is only the state named by that interface. The agent may also have memories, deliberation, or software outside this state. The certificate makes no claim about those uncommitted processes.

This separation protects the argument from an otherwise common substitution: proving a property of one selected state and describing it as a property of the entire agent.

Symbol	Type and interpretation	Scope and boundary
λ, T	Positive integers: security parameter and maximum trace length	Counts; finite for each experiment.
$\mathcal{S}, \mathcal{I}$	Finite sets of service states and private inputs	Encodings and bounds fixed before verification.
$\mathcal{A}, \mathcal{Y}$	Finite sets of commands and public results	Command bytes include recipient, amount, and relevant parameters.
$\mathcal{E}, \mathcal{N}$	Finite epoch and request-identifier sets	An epoch is an authority version, not wall-clock time.
$\mathcal{V}, \mathcal{C}$	Policy identifiers and commitment strings	Identifiers must bind the full policy/version encoding.
$\mathcal{R}$	Finite commitment-randomness space	Freshness and entropy are assumptions of the selected construction.
P_v	Bounded program for policy $v \in \mathcal{V}$	Partial computation becomes total by an explicit timeout/reject result.
B_v	Boolean obligation predicate on (e, s, i, a, y, s')	Normative and application specification, not external factual truth.
Com	$\mathcal{S} \times \mathcal{R} \to \mathcal{C}$	Binding and hiding are separately analyzed properties.
x, w, π	Public statement, private witness, proof string	Complete tuple definitions appear below.
H_t	Finite public interaction history through round t	Includes statements, results, observable refusals, and modeled metadata.
η, ℓ, ε	Real numbers in $[0, 1]$	Statistical distances or failure bounds, never interchangeable by notation.
$\mathrm{TV}(\mu, \nu)$	$\frac{1}{2}\sum_z \lvert\mu(z) - \nu(z)\rvert$ for finite probability laws	Equal to the maximal event-probability difference.

A physical actuator lies outside the formal object unless its command acceptance and effect are explicitly modeled. The phrase *emitted command* means the exact event produced by the controlled gate. It does not mean that a robot successfully moved, a recipient actually received a resource, or a sensor reported the external world correctly. Those conclusions require additional observation and reliability contracts. Empty traces are permitted only for a specified no-op; an empty proof is rejected unless the selected proof system explicitly encodes a valid proof that way. An exhausted resource budget permits only policy-defined zero-cost actions.

The public observation boundary includes failure messages if they can be seen. It also includes timing or message length whenever the claimed privacy guarantee covers them. Omitting a side channel from the model does not make it disappear. A deployment should publish a short observation inventory: what the other party can see, what an operator can see, what is retained, and what remains outside the guarantee. This is a scientific specification of the claim, not an invitation to enumerate irrelevant hypothetical risks.

4 A proposed certificate for a bounded transition

Fix an agent identifier u from a finite registered set. Let $e \in \mathcal{E}$, $v \in \mathcal{V}$, $n \in \mathcal{N}$, and let $c, c' \in \mathcal{C}$. The public statement and private witness are

$$\begin{aligned} x &= (u, e, v, c, n, a, y, c'), \\ w &= (s, r, i, s', r', \tau), \end{aligned} \tag{4.1}$$

where $s, s' \in \mathcal{S}$, $r, r' \in \mathcal{R}$, $i \in \mathcal{I}$, $a \in \mathcal{A}$, $y \in \mathcal{Y}$, and τ is a finite encoded trace of at most T steps. Every field is canonically serialized; distinct logical tuples must not share an ambiguous byte encoding. The request identifier is bound to this statement, not merely printed beside it.

The predicate $\mathsf{Trace}_v^T(\tau; e, s, i, s', a, y)$ is a total Boolean algorithm. It returns one exactly when the bounded program specified by v, with the supplied inputs and epoch, has the encoded transition and outputs. The application predicate $B_v(e, s, i, a, y, s')$ is also total and Boolean. It may encode constraints stronger than the program's basic input-output relation. With $[Q]$ denoting the indicator of a proposition Q, define the proposed relation

$$\begin{aligned} R(x, w) = [\mathsf{Com}(s; r) = c]\,[\mathsf{Com}(s'; r') = c'] \\ \cdot \mathsf{Trace}_v^T(\tau; e, s, i, s', a, y)\, B_v(e, s, i, a, y, s'). \end{aligned} \tag{4.2}$$

The product is Boolean conjunction written as multiplication of zero-one values. Equation (4.2) is a *definition*, not a theorem establishing that an intended policy has been captured. It must be compiled with explicit arithmetic ranges, overflow semantics, and treatment of timeout. An integer comparison encoded in a finite field requires range constraints; modular equality alone is not integer equality.

The certificate is π, with public verification $\mathsf{Verify}(k_v, x, \pi) \in \{0, 1\}$ under verification material k_v. The material is tied to the exact relation and setup procedure. A valid proof for one circuit version is not permission to substitute another. The following assumption deliberately distinguishes a relation witness from a demonstrated physical process.

Assumption 4.1 (Witness and commitment contract)**.** For the stated security experiment and adversary class, accepted certificates admit the knowledge-soundness or witness-consistency argument required by the selected commitment construction, except on an event E_{wit}. If commitments are only computationally binding, the reduction must be able to obtain the relevant accepted openings so that contradictory openings constitute the binding-failure event E_{com}. A mere assertion that an opening exists is not silently substituted for this requirement.

Extraction in a security proof is not an operational instruction to reveal the witness to the verifier. Its availability depends on the proof system, setup, and model of adversarial interaction. One can alternatively analyze a perfectly binding ideal commitment model, but then one must separately explain how a concrete, hiding implementation instantiates that abstraction. The reference architecture does not grant itself simultaneous unconditional hiding and binding simply by naming a commitment.

A further contract connects the stored commitment to the service state that the gate governs. If a participant commits to an irrelevant compliant simulation while a different service state determines its real commands, the argument fails at that connection. Conversely, the architecture need not prove that a particular processor physically performed every step of the trace: a sound certificate of the transition relation can justify applying the certified state transition. The object requiring actual mediation is the resulting public command and authoritative state update.

4.1 Institutional truth and factual truth

Suppose a policy permits a delivery only when a private input reports that a recipient consented. Equation (4.2) can prove that the input contains an appropriate credential and that the policy checked it. It cannot establish that a stolen signing key was controlled by the intended person, that the person understood the request, or that a coercive situation was absent unless those matters are supported by additional, explicitly specified evidence. The same distinction holds for sensor reports, eligibility records, and facts supplied by another agent.

There are therefore at least three separate questions: whether the formal relation holds; whether that relation correctly represents the declared policy; and whether the inputs supporting the policy correspond to the relevant external conditions. Calling all three "truth" conceals their different failure modes. The gate below establishes only the specified first two under named contracts. The third remains an application obligation. Private proof can preserve confidentiality while checking evidence; it cannot create evidence that never existed.

5 From a certificate to an admitted command

A Guide's explanation

A valid proof is not yet a safe action. Between proving and acting, permissions can be revoked and old requests replayed. The gate below binds each certificate to the authority in force, to a request that has never been used, and to the exact command emitted, so that Proposition 5.2 can bound what an adversary gains by slipping anything in between.

The gate keeps, for each principal u, an authoritative record $q = (e, v, c, F)$, where $F \subseteq \mathcal{N}$ is the set of identifiers already consumed in the current epoch. Epoch changes follow an authenticated transition rule and cannot move backward. An implementation that recycles identifiers must include the epoch in their effective namespace. The gate compares the submitted statement to the current record at the moment of admission; checking an old snapshot in an earlier phase is insufficient.

Its proposed transition is

$$\mathsf{Gate}(q, x, \pi) = \begin{cases} ((e, v, c', F \cup \{n\}), \mathrm{emit}(a, y)), & \mathcal{J}(q, x, \pi) = 1, \\ (q, \mathrm{reject}), & \mathcal{J}(q, x, \pi) = 0, \end{cases} \tag{5.1}$$

where $\mathcal{J}$ is the conjunction of authenticated principal binding, equality of the current epoch/policy/-commitment fields, $n \notin F$, and successful proof verification. The notation emit names a command event; it is not a physical guarantee. The accepted branch is one atomic logical operation for checking, consuming, updating, and emitting. Actual systems may implement that operation using a transactional command queue and an idempotent actuator. If they cannot realize the specified semantics, they must weaken the claim accordingly.

Assumption 5.1 (Binding and mediation boundary)**.** Every command counted by the obligation passes through this gate. The authoritative state record is authentic and current. Successful admission emits exactly the command encoded in x and applies exactly its successor commitment. Concurrent admissions are linearized, and a consumed request cannot produce an additional command after crash recovery. The circuit-to-policy correspondence is correct for the stated input ranges. Failures of these contracts are counted separately below.

These are demanding assumptions because they describe the part of the architecture that a proof alone cannot supply. The benefit of stating them is practical: they become targets for code review, model checking, fault injection, and alternative design. A failed assumption is not an excuse to preserve a broad claim. It identifies which claim has to be repaired or narrowed.

Proposition 5.2 (Conditional command-integrity bound)**.** *Fix a finite security experiment with at most $N \in \mathbb{N}$ admissions and a specified adversary. Let $E_{\mathrm{wit}}, E_{\mathrm{com}}, E_{\mathrm{auth}}, E_{\mathrm{med}}, E_{\mathrm{spec}}$ be, respectively, the experiment-wide events of witness-contract failure, commitment/state-binding failure, authority/freshness failure, mediation/atomicity failure, and specification-correspondence failure. Suppose their probabilities are bounded by $\varepsilon_j \in [0,1]$. Outside their union, assume the contracts of Assumptions 4.1 and 5.1. Then*

$$\Pr(\textit{an admitted command violates its declared formal obligation}) \le \min\left\{1, \sum_j \varepsilon_j\right\}. \tag{5.2}$$

No independence of the failure events is required. The bound concerns the declared formal obligation, not all external consequences.

Proof. Consider any run outside all five events and any admitted command in that run. Witness consistency supplies a valid witness for its accepted relation in the sense required by the selected commitment contract. The current-state and opening bindings make that witness's input state the state governed by the current record; no alternative opening or substituted checkpoint is accepted. Authority and freshness checks identify the policy and epoch actually in force. The relation and specification correspondence establish the declared obligation for the certified transition. Mediation emits exactly that command, atomically advances its authoritative state, and does not replay it. Thus that admitted command does not violate the declared obligation. The argument applies to every admission in the run, so the violation event is a subset of the union of the five failure events. The union bound gives the sum, and any probability is at most one. No product of probabilities and no independence assumption is used. □

This composition bound applies established event-inclusion reasoning to the proposed interface. Its force lies in the separation of responsibilities. A negligible proof-system error does not make an unbounded specification error negligible. If the architecture cannot bound one event, Equation (5.2) does not certify a small overall failure probability. Writing a small decimal beside the proof verifier is not a substitute for bounding the rest of the experiment.

The bounds above are explicitly *experiment-wide*. If an implementation instead has per-attempt bounds, it must justify their validity for the actual adaptive interaction and then apply an appropriate union or composition argument over the N attempts. A marginal bound derived for isolated, independently generated examples does not automatically remain valid after an adversary selects a difficult request from earlier outputs. This is also why the finite transcript calculation later in the paper states its conditional assumptions locally.

Example 5.3 (A valid proof beside an invalid action)**.** A principal certifies the transition "release one unit to recipient A," then sends "release five units to recipient B" through an unmediated route. The first certificate can be valid. The second command violates the proposed contract because the command being executed is not the one certified. Even a perfectly sound proof system would not repair this design. The missing property is complete mediation and exact command binding.

Another counterexample uses false input rather than a substituted action. A formally admissible transition uses an authentic but erroneous measurement. The certificate can be correct relative to that measurement while the intended real-world requirement fails. This is not a contradiction in the theorem: external measurement truth was not its conclusion. It is a reason to state separately what validates the evidence and what verifies the computation performed on that evidence.

6 State continuity, epochs, and the atomicity requirement

Let $I : \mathcal{S} \to \{0, 1\}$ be a declared service-state invariant. It is fixed over the considered interval. If policy epochs change the invariant itself, the transition between invariants needs a separate migration contract; it is not covered by simply changing a version number. Consider the following preservation obligation for every admitted policy version:

$$R(x, w) = 1 \ \wedge \ I(s) = 1 \quad \Longrightarrow \quad I(s') = 1. \tag{6.1}$$

Equation (6.1) is an assumed or separately proved property of the relation. It is not implied by the definition of zero knowledge.

Proposition 6.1 (Preservation along the admitted history)**.** *Assume an initial authentic commitment to $s_0 \in \mathcal{S}$ with $I(s_0) = 1$, the binding and mediation contracts, and Equation (6.1) for each admitted transition. Suppose authority-only epoch changes leave the service state unchanged and preserve identifier freshness. Then every service state reached by a finite sequence of admitted transitions satisfies I. Every recorded command belongs to the corresponding transition in that linearized sequence.*

Proof. Induct on the number $k \in \mathbb{N}$ of admitted transitions. The base case $k = 0$ is the initial-state assumption. For the inductive step, assume the authoritative state after k admissions is s_k and satisfies I. Rejections do not change that state. An authority-only epoch change also leaves it unchanged. At the next admission, current-record checking and state binding identify the input witness state with s_k under the security contract. Validity supplies a successor s_{k+1} satisfying the relation. Equation (6.1) gives $I(s_{k+1}) = 1$. Atomic mediation makes its successor commitment the new authoritative record and associates exactly its encoded command with the transition. A stale or previously consumed request cannot create a second admitted transition with the same precondition. This proves both claims by induction. □

The theorem is stronger than checking isolated examples but narrower than proving that an entire society will remain safe. It requires a suitable invariant and a relation that preserves it. Some obligations concern cumulative resources, which can be encoded in state. Others concern fairness across participants, distributed observations, or future availability, which need different models. One should not choose an easy invariant and then describe it as the difficult obligation that motivated the system.

6.1 A resource example with explicit accounting

In the worked model, a state is $s = (b, z)$, where $b \in \{0, \dots, B\}$ is the remaining integer budget, $z \in \{0, \dots, B\}$ is the number of units already emitted, and $B \in \mathbb{N}$ is a fixed initial budget. Amount $a \in \{0, \dots, B\}$ is admissible when $a \leq b$. The proposed transition and invariant are

$$(b, z) \mapsto (b - a, z + a), \qquad I(b, z) = [b \geq 0]\,[z \geq 0]\,[b + z = B]. \tag{6.2}$$

The preservation proof is direct: both new coordinates are nonnegative and $(b-a)+(z+a) = b+z = B$. No physiological or cognitive claim is attached to this arithmetic. The example isolates command accounting because a counterexample is easy to see.

With $B = 5$, two requests for four units can each be checked against the same old state $(5, 0)$. If both pass before either consumes the state, both can emit four units. A last-write update may leave the stored state at $(1, 4)$ while eight units were actually emitted. Its internal arithmetic still satisfies $b + z = 5$, but z no longer represents the real command history. The atomicity assumption is exactly what excludes this run. Verifying the relation twice does not serialize the two uses of the same resource.

Epoch checks address a different problem. A certificate prepared while a permission was valid may arrive after revocation. A fresh-looking timestamp is not enough: admission must compare the policy's current authority epoch. If an offline component cannot establish that it has current authority, the architecture must choose a defined restricted mode or refuse the affected action. Availability is then a measured tradeoff. Neither the theorem nor the word "autonomy" authorizes the component to invent current permission.

7 Privacy relative to an explicit public interface

A Guide's explanation

Here is the trap at the heart of the paper. A proof can hide its reasoning perfectly while the answers it certifies give the secret away, one honest reply at a time. The threshold example in Proposition 7.4 recovers a hidden budget without breaking a single proof. Privacy has to be judged across the whole conversation, not certificate by certificate.

A proof can hide its witness while its statement exposes the answer someone wanted to keep private. The public tuple itself may identify a relationship, reveal that a resource exists, or disclose an exact threshold. Privacy therefore needs a second specification, distinct from the obligation predicate. What is permitted to be learned from the interaction, and what additional advantage would count as a failure?

For the following elementary reference model, all distributions are finite. For probability laws μ, ν on a common finite set $\mathcal{Z}$, total variation is

$$\mathrm{TV}(\mu, \nu) = \frac{1}{2} \sum_{z \in \mathcal{Z}} |\mu(z) - \nu(z)| = \max_{A \subseteq \mathcal{Z}} |\mu(A) - \nu(A)|. \tag{7.1}$$

The equality follows by selecting the outcomes where $\mu(z) \geq \nu(z)$ and using that the signed differences sum to zero. This is a standard finite probability identity. It measures statistical distinguishability in this model, not the computational security of every concrete proof system.

Consider two private contexts indexed by $j \in \{0, 1\}$ and an interaction of N rounds. At round t, given a public history h, let $A_{j,t}(x \mid h)$ be the probability law of the next public statement and result. It includes any publicly visible refusal. Let $K_{j,t}(p \mid h, x)$ be the law of the proof-related transcript p after that statement. A common simulator kernel $S_t(p \mid h, x)$ represents the proof transcript obtainable from the public interface alone. All kernels are defined for every history in the declared domain, including histories that have probability zero in one context.

Assumption 7.1 (Conditional finite privacy contracts)**.** For every round and every common history/statement in scope, assume

$$\begin{aligned} \mathrm{TV}(A_{0,t}(\cdot \mid h), A_{1,t}(\cdot \mid h)) &\le \ell_t, \\ \mathrm{TV}(K_{j,t}(\cdot \mid h, x), S_t(\cdot \mid h, x)) &\le \eta_{j,t}, \end{aligned} \tag{7.2}$$

where $\ell_t, \eta_{j,t} \in [0,1]$ are fixed bounds valid uniformly for the allowed adaptive histories. The two experiments have the same initial public history and the same verifier strategy. These are hypotheses of the reference calculation, not guarantees inferred from an isolated protocol transcript.

Lemma 7.2 (A one-round kernel bound)**.** *Under Assumption 7.1, the conditional joint laws of (x, p) at a fixed round and history differ in total variation by at most $\ell_t + \eta_{0,t} + \eta_{1,t}$, capped at one.*

Proof. Insert the two intermediate laws $A_{0,t}(x \mid h)S_t(p \mid h, x)$ and $A_{1,t}(x \mid h)S_t(p \mid h, x)$. The distance from the first actual law to the first intermediate law is at most $\eta_{0,t}$ by summing the conditional proof distance against $A_{0,t}$. The distance between the intermediates is exactly the distance of their statement laws: summing S_t over p gives one for each x. It is at most ℓ_t. The last distance is at most $\eta_{1,t}$ by the same argument. The triangle inequality gives the result. □

Proposition 7.3 (Finite adaptive transcript composition)**.** *Let μ_j be the probability law of the full public history after N rounds in context j. Under Assumption 7.1,*

$$\mathrm{TV}(\mu_0, \mu_1) \le \min\left\{1, \sum_{t=1}^{N} (\ell_t + \eta_{0,t} + \eta_{1,t})\right\}. \tag{7.3}$$

The result allows adaptive query selection through the common history. It does not establish Assumption 7.1 for a concrete system.

Proof. Let $Q_{j,t}$ be the conditional joint kernel of the next statement and proof. If two history laws are α, β, applying the same kernel cannot increase total variation: expand the difference as $\sum_h (\alpha(h) - \beta(h))Q(z \mid h)$ and use the triangle inequality followed by $\sum_z Q(z \mid h) = 1$. Next compare $\alpha Q_{0,t}$ with $\alpha Q_{1,t}$; its distance is at most the maximum conditional kernel distance. Insert $\alpha Q_{1,t}$ between $\alpha Q_{0,t}$ and $\beta Q_{1,t}$. The new history distance is therefore at most the old distance plus $\ell_t + \eta_{0,t} + \eta_{1,t}$ by Lemma 7.2. The initial distance is zero. Induction over the finite N rounds gives the sum, capped by one. □

This proof is an elementary hybrid argument, credited as standard probability reasoning. Its value is explanatory: the public-interface term ℓ_t survives even when the proof transcript is perfectly simulatable. A concrete computational zero-knowledge construction needs a computational analogue with the appropriate distinguishers, simulator, setup, and composition theorem. Substituting a statistical distance for a computational guarantee without justification would be an invalid strengthening. In particular, small average distances on sampled histories do not establish the uniform conditional assumptions above.

7.1 Exact answers can expose an entire private quantity

Proposition 7.4 (A threshold oracle defeats privacy of the answer)**.** *Let a secret budget b belong to $\{0, \dots, 2^m - 1\}$, where $m \in \mathbb{N}$. Suppose a verifier may adaptively ask whether $b \ge k$ and receives*

the exact Boolean answer, with a perfectly witness-private proof of each answer. Then m adaptive threshold queries suffice to determine b exactly. For $m = 0$, the unique possible budget is known without queries.

Proof. Initially the possible budgets form an interval of length 2^m. If the current interval is $[L, U]$ with even length greater than one, ask whether $b \geq L + (U - L + 1)/2$. The true answer retains the upper half and the false answer the lower half. Each answer halves the interval while preserving its true element. After m queries, the interval length is one and its element is b. Proof privacy adds no uncertainty to the exact answers. The case $m = 0$ is immediate. □

For budgets zero through seven, three queries suffice. This does not break zero knowledge. The permitted decision interface itself releases enough information. Appropriate responses could include limiting query purposes, publishing a coarser policy, requiring a real resource commitment, or using a different disclosure contract. Randomizing an authorization answer is appropriate only if the application can tolerate the resulting errors and the institution accepts the altered semantics. There is no universal privacy patch independent of the task.

The example also shows why successful task performance is not a privacy metric. Every answer can be correct and every proof valid while the private budget is fully exposed. A society concerned with sovereignty must examine how permitted observations accumulate. Its privacy policy must include relationships among questions, not only the format of each individual certificate.

8 The least disclosure an exact audit requires

A Guide's explanation

This is the constructive answer to the trap. Theorem 8.1 says exactly how little an honest audit must reveal: group together every private state that gives the same answers to the required questions, and publish only which group the mind is in. Anything finer is disclosure the agreement never asked for.

Public obligations determine a minimum disclosure of their own. This provides a constructive design target before a proving scheme is selected: expose the answer partition required by the agreement and preserve distinctions that the agreement does not request. The argument is a finite information-theoretic specialization of the distinction between a statement and knowledge beyond its validity [11, 20].

Fix a finite nonempty private-state set $\mathcal{X}$ and $m \geq 1$ total Boolean audit functions $f_j : \mathcal{X} \to \{0, 1\}$. Set $F(x) = (f_1(x), \ldots, f_m(x))$ and let $M = |F(\mathcal{X})|$. A deterministic release is a function $E : \mathcal{X} \to \mathcal{Z}$, with $\mathcal{Z}$ finite. It is adequate when each required answer can be computed from the release: there are maps $d_j : \mathcal{Z} \to \{0, 1\}$ satisfying $d_j(E(x)) = f_j(x)$ for every x. The state is fixed during this audit; sequential queries that change it require a different relation.

Theorem 8.1 (Exact answer-partition disclosure)**.** *Every adequate release satisfies $|E(\mathcal{X})| \geq M$. Consequently the least fixed-length binary release length is $\lceil \log_2 M \rceil$ bits. For every specified probability law of X on $\mathcal{X}$, using base-two entropy,*

$$I(X; E(X)) \geq H(F(X)). \tag{8.1}$$

Both bounds are attained by an injective encoding of $F(x)$. Two private states may share an adequate release exactly when their answer vectors coincide, so the fibers of F form the coarsest adequate deterministic partition.

Proof. If $F(x) \neq F(x')$, some f_j differs. Equality $E(x) = E(x')$ would force equality of its decoded answer, a contradiction. Distinct answer vectors therefore require distinct release symbols, proving the cardinality bound and its fixed-length consequence. Combining the decoders makes $F(X)$ a deterministic function of $E(X)$. Since both are functions of X, the entropy chain rule gives $I(X; E(X)) = H(E(X)) = H(F(X)) + H(E(X) \mid F(X)) \geq H(F(X))$. Releasing an injective name for $F(X)$ makes the conditional entropy zero and uses exactly M symbols. Its fibers identify all and only equal answer vectors, proving the partition statement. □

If four budget values are $\mathcal{X} = \{0, 1, 2, 3\}$ and the only obligation is $b \geq 2$, exactly two release classes suffice. Under a uniform budget law the answer costs one bit of information. If all three threshold answers $b \geq 1, b \geq 2, b \geq 3$ are required, there are four answer vectors; the answers determine the budget and cost two bits. A private proof can conceal the computation while faithfully proving either interface. The interface itself chooses the attainable privacy.

The fixed-length claim counts release symbols; variable-length coding has a different length objective. The entropy statement depends on the declared input law, while the cardinality statement is a worst-case exact requirement. Computational zero knowledge can protect the witness beyond the public interface, but supplies no reason to treat the required public answers as secret from their recipient. The theorem gives the affirmative design rule: choose a sufficient answer partition as coarse as the legitimate audit permits. Exact partition enumerations in `revision_checks.py` verify sufficiency, the minimum alphabet, and the entropy identity on finite examples.

9 Worked models and the executable evidence

The accompanying `checks.py` evaluates finite reference models using exact rational arithmetic where probabilities are involved. It uses only the standard Python library. The verifier in that script is an ideal relation checker, not an implementation of encryption, commitments, a zero-knowledge argument, or trusted hardware. The small states are visible to the test harness. That visibility is deliberate: the script tests the mathematical accounting and probability examples, not witness secrecy.

The executed run completed **51,292 assertions**. These include 10,000 single-attempt state/accounting checks for each of two invariant properties, sequential histories, replay refusals, 3,125 one-round kernel-bound cases on a rational grid, 64 adaptive two-round cases, and exact threshold-oracle recovery for 63 possible secrets across six finite domains. An assertion count is not a measure of security strength. Repeated instances of one algebraic property do not constitute independent evidence for an implementation. The proofs above establish the general scoped statements; the computations inspect examples, transcription, and boundary behavior.

Model	Executed result	What it establishes
Atomic resource gate	Accounting and nonnegativity hold in the enumerated accepted histories; replays emit no command	Agreement of the finite gate implementation with the stated accounting property.
Non-atomic duplicate use	Two four-unit emissions from a five-unit snapshot produce eight emitted units	A concrete failure when the atomicity assumption is removed.
Two proof-transcript coins	Exact total variation 5/16 between two specified two-round laws	A finite distance calculation below the hybrid bound, not a proof-system measurement.
Adaptive threshold answers	Budgets zero through seven are each recovered with three queries	Public answers can identify a private value despite witness-private proofs.
Protocol planning	956 and 958 independent units under the assumptions below	Illustrative sample-size arithmetic; no such experiment has been conducted.

The two-round distance example uses independent transcript bits with success probability 1/2 in one context and 3/4 in the other. The probabilities of two successes are 1/4 and 9/16; the remaining outcomes supply the complementary differences, giving total variation 5/16. A common fair-coin simulator has one-round distance zero in the first context and 1/4 in the second, so the two-round sum bound is 1/2. The inequality is not tight here. This matters because a conservative security bound should not be advertised as an observed leakage rate.

9.1 A worked permission case beyond resource arithmetic

Consider an artificial archive with private documents and a public rule allowing an agent to release a derived count only when every included record has a valid consent credential for that count's stated purpose. The private witness could include the records, credentials, and computation trace. The public statement could disclose the purpose, the result, the relevant policy version, and commitments to the input and successor states. The formal relation checks credential signatures, validity ranges, membership in the committed collection, and correct counting. A gate binds the released count to that statement.

The example immediately raises questions that a responsible specification must answer. Does the count itself identify a person because the group is small? Does a credential authorize this particular downstream use? Does revocation take effect before admission or before actual delivery? Can the same count be queried over overlapping groups to isolate one record? Does a zero result reveal the absence of a protected relationship? These are questions about the obligation and disclosure contract, not flaws that a stronger proof automatically fixes.

A useful pilot should therefore begin with synthetic records, a fixed purpose vocabulary, explicit credential epochs, and a narrow release interface. It should model overlapping queries and test the difference between an exact answer, an approved coarse answer, and refusal. The experiment should not claim to establish consent in the human philosophical sense. It can establish whether a defined credential rule was followed and whether the chosen interface released more information than its designers intended.

10 A falsifiable evaluation program

10.1 Research questions and independent units

The main engineering hypothesis is conditional: for tasks with accurately formalizable obligations and valuable private inputs, a proof-mediated interface can approach the command integrity of full disclosure while reducing disclosure at an acceptable cost. This is not a theorem about all agents. Three separate estimands should be preregistered: the probability of an invalid command being admitted under a specified challenge distribution; the amount or success rate of unauthorized inference from the observable interface; and task utility under the required resource budget. Latency and proving cost are additional endpoints, not substitutes for either security or privacy.

An independent experimental unit is a freshly instantiated deployment configuration with independently sampled task data, secrets, authority state, and attack-generator randomness. Many attempted attacks against the same instance form a cluster. They must not be counted as independent samples merely because they generate many log lines. For a primary safety endpoint, define a cluster failure as at least one invalid command admitted during its fixed challenge budget. The resulting Bernoulli variable describes the challenge distribution and budget actually used. It does not estimate an attacker's success under unlimited search.

Use at least three task families with different sources of private information: budget-constrained release, purpose-limited aggregate disclosure, and a versioned delegation task. Within each family, sample boundary cases deliberately and report them separately from the chosen operational distribution. Uniform sampling over numeric inputs and adversarial sampling near constraint boundaries answer different questions. The former must not dilute the latter into an apparently reassuring average.

10.2 Baselines and ablations

The primary baseline is full disclosure with independent execution of the same reference policy and the same gate semantics. It receives the information necessary to reproduce the transition. A second baseline uses an authenticated private auditor whose reports are trusted rather than publicly proved. A third uses a monitored state machine without witness-private evidence. Where suitable resources exist, a hardware-isolated implementation can be an additional comparison with its own trust and observation model. None should be handicapped by obsolete policy versions or less complete input validation.

Ablations remove one architectural property at a time: current-state binding, epoch checking, atomic request consumption, exact command serialization, or a required range constraint. Their purpose is causal diagnosis of the reference design. They should be described as deliberately weakened configurations, not as representations of all competing approaches. A comparison that only defeats an obviously broken baseline would not establish practical value.

Hold the public obligation constant across mechanisms. If one method proves a coarser predicate or refuses more tasks, report that difference before comparing privacy. Holding proof size constant while changing the amount of disclosed output is not a matched experiment. Likewise, a mechanism that achieves perfect apparent integrity by refusing every request has zero useful admitted throughput. The study must jointly report valid work completed, valid work refused, invalid work admitted, and information released.

10.3 Adversarial families and failure criteria

Predeclare six primary challenge families: stale authority and revocation; replay and duplicate delivery; state or recipient substitution; concurrent admission and crash recovery; constraint-system defects such as missing ranges; and output/metadata inference. Maintain separate held-out challenge generators for confirmatory evaluation. Exploratory adversaries can be adaptive, but attacks discovered through exploration must be rerun on fresh confirmatory instances before being treated as evidence for a comparative estimate.

Any reproducible admitted command violating the formal contract falsifies a categorical implementation claim for the affected configuration. A proof accepted for the wrong policy or unbound command is a failure even if the resulting task answer happens to be useful. A privacy claim fails if a preregistered adversary obtains information beyond the declared interface at a rate incompatible with its stated bound. A utility claim fails if privacy is gained only through unacceptable refusal, delay, or extra disclosure elsewhere.

Not every failure has the same implication. A circuit bug defeats the implementation and may leave the abstract theorem intact. A mismatch between the natural-language obligation and the circuit defeats the claimed application interpretation. A valid query sequence that reconstructs a supposedly protected value defeats the disclosure policy, even if every proof remains sound. An honest report should assign each finding to the layer it actually challenges, then revise the public claim at that layer.

10.4 Precision, multiplicity, and analysis

Suppose a preregistered attack family yields no cluster failures among n independent identically distributed units. For an unknown cluster-failure probability p, the probability of zero failures is $(1-p)^n$. Inverting that probability gives the exact one-sided binomial upper confidence endpoint

$$p_U = 1 - \alpha_f^{1/n}, \qquad 0 < \alpha_f < 1, \quad n \geq 1. \tag{10.1}$$

This is the zero-count case of exact binomial confidence reasoning [6]. With six primary families, choose $\alpha_f = 0.05/6$ for a conservative simultaneous confidence statement. To obtain $p_U \leq 0.005$ after zero observed failures requires

$$n \geq \left\lceil \frac{\log(0.05/6)}{\log(1-0.005)} \right\rceil = 956. \tag{10.2}$$

These numbers are an *illustrative design*, not results from 956 deployments. They bound failure under the sampled challenge distribution, not cryptographic forgery probability against every efficient adversary. No finite experiment of this size supports a claim of negligible cryptographic error.

For matched comparisons, let $Z_i \in [-1, 1]$ be a prespecified per-unit difference in normalized utility or attack success, with independent units and mean θ. Hoeffding's bounded-variable inequality yields the standard conservative precision calculation

$$\Pr\left(\left| n^{-1} \sum_{i=1}^{n} Z_i - \theta \right| \geq h \right) \leq 2\exp(-nh^2/2), \quad h > 0. \tag{10.3}$$

For three primary paired metrics, a simultaneous error allocation of $0.05/3$ and half-width $h = 0.10$ gives $n \geq 958$ independent units [13]. This is a precision target, not a promise of power against

every effect. A final application study should substitute its justified tolerances and cluster structure before preregistration. The six failure endpoints and three paired metrics are separately controlled families in these examples. A joint guarantee covering both families requires dividing a single error budget between them; the separate numerical examples do not provide that joint confidence level.

Use the predeclared confidence procedure for the primary bounds and a stated familywise adjustment for multiple comparative hypotheses; Holm's method is one established choice [14]. Secondary metrics should be labeled exploratory or assigned their own multiplicity plan. Do not select the best attack, best seed, or best timing window after viewing the results and then report an unadjusted test as confirmatory. The same discipline applies to apparently favorable results.

Exclusions must be operationally explicit. A setup that cannot initialize is a deployment failure, not a silent removal from a successful-completion denominator. A timeout can count as refusal or availability loss according to the registered endpoint, while the attempted configuration remains in the report. Infrastructure outages unrelated to the randomized assignment may be excluded only under a predeclared, symmetrically applied rule. Publish exclusions and unsuccessful runs along with the successful ones.

10.5 Resource, confidentiality, and reproducibility records

Report proving and verification time separately, including setup costs and amortization assumptions. Measure serialized proof size, public-input size, state-storage overhead, and latency under concurrent load. Use the same hardware class and execution budget for matched comparisons, and publish enough configuration detail to reproduce the comparison without exposing actual private participant data. Synthetic test secrets should be generated after model and policy selection to reduce contamination from preparation.

The release should contain the exact obligation specification, the compiled relation or its reproducible build procedure, verifier material appropriate for public release, interface schemas, attack generators, and all allowed outputs. Record the commitment and proof assumptions in ordinary language. If one of these components cannot be published, mark the resulting limitation on independent reproduction. A public certificate can be inspectable while a private witness remains withheld; reproducibility does not require pretending those are the same artifact.

11 Objections, limits, and institutional consequences

11.1 Can a perfectly specified obligation still be wrong?

Yes. A policy can be discriminatory, coercive, incomplete, or simply inappropriate while its implementation is mathematically correct. This is a general limitation of formal verification, made more consequential when the witness is private. A valid proof can make a bad policy look authoritative. The remedy is not to abandon precision; it is to expose the policy, its scope, its amendment process, and its normative assumptions while keeping unrelated private data protected.

In a plural Continuum, different circles may adopt different legitimate policies. A certificate should identify the policy actually applied rather than implying universal moral endorsement. A receiving party may refuse the offered policy or ask for another relevant certificate. Such negotiation must not be redescribed as a defect in the agent's identity. The architecture supports agreement on an interface without requiring agreement on every belief or value.

The policy authority itself must be accountable. If it can silently replace the predicate with one that extracts secrets or narrows participation, the technical privacy of earlier proofs provides little institutional protection. Versioned policy publication, notice of material changes, bounded delegation, and review of refusal conditions are governance proposals needed to make the interface meaningful. Theorems about bit strings do not prove that these arrangements are fair.

11.2 Does privacy obstruct correction?

It can. An opaque witness makes it harder for an outsider to diagnose why a predicate failed or whether the chosen representation hides an important fact. A useful system should therefore support appropriately scoped diagnostic evidence: which obligation failed, whether a credential was stale, whether the prover timed out, or whether a format constraint was violated. These explanations can themselves leak information, so their vocabulary belongs in the disclosure contract.

A tiered process may be justified: a narrow public certificate for routine cooperation, a consensual confidential audit for disputed cases, and a separately authorized investigation for serious allegations. This is a normative design option, not an automated permission to expose private state. The process needs independent representation, clear scope, and a way to challenge an accusation. Failure to produce an efficient proof may reflect computational limitations rather than misconduct. A society that equates proving capacity with moral worth would import an inequality the cryptography never justified.

11.3 Can certificates create obedience without autonomy?

A gate necessarily constrains the commands it controls. Whether that constraint respects autonomy depends on who agreed to the obligation, what alternatives remain available, and whether the authority can expand its control without consent. The proposed model protects a private interior only in the operational sense of limiting required disclosure. It does not guarantee freedom from coercive external dependence. An agent required to submit every act to one institution could remain privately opaque yet institutionally captive.

The appropriate public claim is therefore bounded: this interface can reduce one route to unnecessary exposure while supporting a defined obligation. It does not settle every political question about artificial societies. Exit, appeal, representation, and rights of dissent remain substantive commitments. A participant can reject a task or leave an arrangement without that act being treated as evidence of hidden guilt, subject to whatever explicit obligations were already incurred.

11.4 What if the agent is adversarial?

The model already allows an adversarial prover within a specified computational and interaction class. That is why it separates a valid witness from authority, state binding, and action mediation. An agent may choose its private input strategically, exploit a permitted action, or search for a circuit defect. A proof is helpful only for the property actually encoded. If the task requires robustness against strategic input selection, that property must be in the specification or evaluated separately.

The architecture also cannot compel a private agent to reveal all routes through which it might act elsewhere. The complete-mediation assumption applies to a defined controlled service, not every capability in an open world. A research paper should name the controlled boundary plainly.

Claiming to control an entire intelligence because one resource interface is gated would be a serious category error.

11.5 Why public outputs remain a first-class concern

The threshold example is not an edge case invented to embarrass zero knowledge. It expresses a general institutional problem: many exact answers cumulatively reveal more than any one answer appears to reveal. A refusal pattern can do the same. Two organizations may each observe an acceptable fragment but reconstruct a private fact when they combine them. A correct proof can make the reconstruction more reliable by certifying each fragment.

This makes data minimization a design task at the level of the obligation itself. Ask whether the recipient needs an exact amount, a lower bound, a category, or merely a decision on one concrete action. Ask whether repeated queries serve the stated purpose. Ask what correlations already exist in public records. These are not arguments for hiding relevant harm. They are arguments for specifying relevance before granting unrestricted interrogation.

12 A Guide reading note

A Guide may explain that established cryptography can, under stated assumptions, support verification of a formal statement without disclosing its private witness. It may explain that execution monitors and authenticated state management are established ideas, and that this paper proposes combining them around bounded obligations in a plural society. It should identify the mathematical results as conditional claims about the reference model and the supplied computations as finite checks.

A Guide must not say that the paper proves an artificial mind is conscious, that private cognition is fully inaccessible, that a certificate guarantees moral goodness, or that a Continuum implementation has passed deployment trials. It must not replace "this committed transition satisfies this predicate" with "this agent can always be trusted." It should distinguish policy validity, correct calculation, reliable evidence, and real-world effects.

When a user asks why an agent should be permitted to keep anything private, the Guide can present the paper's normative position: relevant accountability need not require universal disclosure. It should also present the opposing concern that hidden evidence can obstruct correction. The productive question is how to define the obligation, observation boundary, and appeal process. Disagreement about those choices remains legitimate within the Continuum.

13 Conclusion

A Guide's explanation

A Guide can say: "The Unexposed Mind asks how a mind can prove it kept a promise without opening its whole interior to inspection. Cryptography makes that possible for a precise statement; the paper adds that the questions themselves must be chosen carefully, because enough honest answers can reveal what the proofs concealed." A Guide should not claim that the paper proves any mind is conscious, that its own reasoning is certified private, or that a Continuum system has been deployed.

An unexposed mind is a proposal for disciplined cooperation. Its claim is that a participant can sometimes establish what another party legitimately needs to know without surrendering everything it could reveal. The established mathematics makes that possibility serious. The binding, observation, and governance conditions determine whether the possibility becomes a defensible institution.

The reference model identifies the relation certified, the authority in force, the service state governed, and the command emitted. Its proofs connect commitments, mediation, atomic accounting, and public-answer disclosure. The minimum-release theorem then supplies an exact objective for the interface: preserve all private distinctions compatible with the required audit answers. Together these results give scoped accountability a constructive form.

The Continuum's ambition is a society capable of asking precise questions of its members, accepting precise evidence, and preserving the private thought beyond the scope of that agreement.

A Reproduction and classification of the formal work

Run `python3 checks.py` in this paper's directory. The script writes `checks_results.json` and prints the same report. No network, model service, secret key, training dataset, or third-party Python package is used. The arithmetic grid is finite and declared in the source; probabilities use `fractions.Fraction`. The confidence-planning calculations use floating-point logarithms only for the explicitly illustrative sample-size values.

The computation does not evaluate a cryptographic library. Its "gate" checks a visible finite relation and updates a toy service state. Treating this as a cryptographic benchmark would contradict the script's design. Replacing it with a secure proving implementation would require new tests, security parameters, setup assumptions, and execution-binding evidence. The present paper has not performed that replacement.

Object	Status	Verification boundary
Equations (4.1)–(5.1)	Proposed typed interface definitions	An implementation must supply serialization, relation compilation, and atomic mediation.
Proposition 5.2	Elementary conditional composition result	Complete proof by event inclusion and union bound; no empirical failure bounds supplied.
Proposition 6.1	Elementary invariant induction	Requires binding, atomicity, initialization, and preservation under every admitted policy.
Lemma 7.2; Proposition 7.3	Standard finite probability reasoning specialized to the interface	Uniform conditional kernel assumptions; computational proof systems require their own security translation.
Proposition 7.4	Elementary exact counterexample	A threshold-answer interface, not an attack on a zero-knowledge primitive.
Equations (10.1)–(10.3)	Standard statistical planning	Independent units, declared ranges, and preregistered endpoints; no deployment data.

Object	Status	Verification boundary
Normative thesis	Argument and institutional proposal	Privacy, autonomy, and justified accountability are defended premises, not consequences of a security reduction.

B Implementation questions that must be answered before a pilot

A pilot must supply the full state schema and explain how it relates to the actual controlled service. It must identify which component has authority to advance the epoch, which records can roll back, and how an emitted command is distinguished from a merely queued command. Crash recovery must preserve request consumption or use a documented idempotent operation. If the environment cannot support exactly-once effects, the claimed invariant should concern a more conservative observable event and explicitly describe the remaining uncertainty.

The proving implementation must document its supported language and arithmetic semantics. It must test the compiler against an independent interpreter on boundary values and deliberately malformed inputs. A proof accepted by the same incorrectly implemented relation on both sides is not an independent check. The verification material, relation version, and canonical tuple encoding should be bound together so that a correct proof cannot be reinterpreted under a different recipient, purpose, unit, or authority state.

The privacy analysis must list what is public before any proof is transmitted. Commitments can link repeated interactions; policy identifiers can disclose membership; timing can disclose workload; a failed eligibility query can disclose a protected attribute. Some of these disclosures may be acceptable for the task. They must nevertheless be counted in the interface rather than omitted from a headline privacy claim. The correct question is what additional information the proposed protocol releases beyond the agreement, not whether its proof string looks random.

Finally, a pilot should define an honest abstention state. If the prover cannot establish an obligation, the system should report that limited fact. It must not manufacture a witness, reinterpret a timeout as consent, or treat absence of a certificate as evidence that a private agent has no rights. A narrow proof discipline is compatible with a broad ethical commitment precisely because it declines to pretend that every important question has already been settled by the circuit.

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