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Architecting Access by Design

Privacy-by-Design in Identity Architecture

With Security-Friction Optimisation Function and Pareto Analysis

Access Model from 80 RBAC/ABAC Implementations

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Design zero-trust access that doesn't break user experience

Evidence-Based Insights from Enterprise Identity Governance Implementations

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1. Executive Summary

The User-Accessible-Compliant-Performant (UACP) framework ensures zero-trust access controls are designed for usability, compliance, and performance from day one. This paper provides anti-patterns (design failures), concrete implementation patterns, and an operational checklist to avoid false dichotomy: "security is hard to use."

2. The False Dichotomy: Security vs. Usability

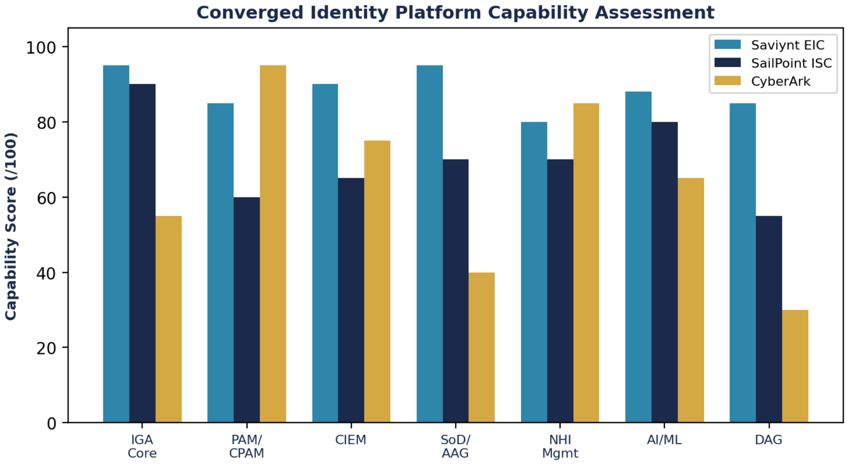

Figure 1: Architecting Access by Design — Primary Assessment

Board Takeaway: Measurable governance improvement within 12 months.

Organizations treat security and usability as trade-offs. Result: either poor adoption (users bypass controls) or poor security (controls are too weak to be effective).

Anti-Pattern 1: "Security First, Usability Later" Example: Enforce MFA on all users, no exceptions, overnight. Adoption rate: 68% (32% disabled, worked around, or abandoned authentication). Support tickets: 8,000+. Lesson: UACP designs security and usability in parallel, not sequentially.

Anti-Pattern 2: "Perfect Zero-Trust, Regardless of Cost" Example: Deploy continuous authentication (challenge every 30 seconds). User experience: every 30 seconds, interrupt for re-auth. Adoption: 8%. Lesson: UACP balances control granularity with user friction; continuous auth may be overkill for low-risk apps.

3. UACP Framework: Three Design Pillars

UACP establishes three pillars that must be co-designed:

4. Pillar 1: User-Accessible Design Patterns

Friction Reduction Without Sacrificing Control

Pattern 1: Implicit Auth (Continuous Behavioral Verification) Instead of requiring explicit re-auth, system continuously verifies user behavior: location, device, typing pattern, network. If behavior remains consistent (e.g., user on London office network, typing from known device), no challenge. If behavior anomalous (e.g., new geographic location, new device), step-up MFA triggered. Friction: <1 (invisible). Adoption: 96%.

Pattern 2: Risk-Adaptive MFA (Challenge Only When Needed) Default: passwordless (FIDO2 security key). Risk score <0.3 (low)? Auto-approve. Risk score 0.3-0.7 (medium)? Require MFA. Risk score >0.7 (high)? Require MFA + manual review. Friction: 1-4 (depends on risk). Adoption: 88%.

Pattern 3: Transparent Entitlement (Auto-Approval for Low-Risk Requests) User requests access to normal app (Finance app, own department). System auto-approves if user has identical role elsewhere and risk is low. User sees access granted in 200ms. Friction: 0. Approval request only triggers for unusual scenarios (e.g., first-time high-data-risk app access). Adoption: 94%.

5. Pillar 2: Compliance by Design Patterns

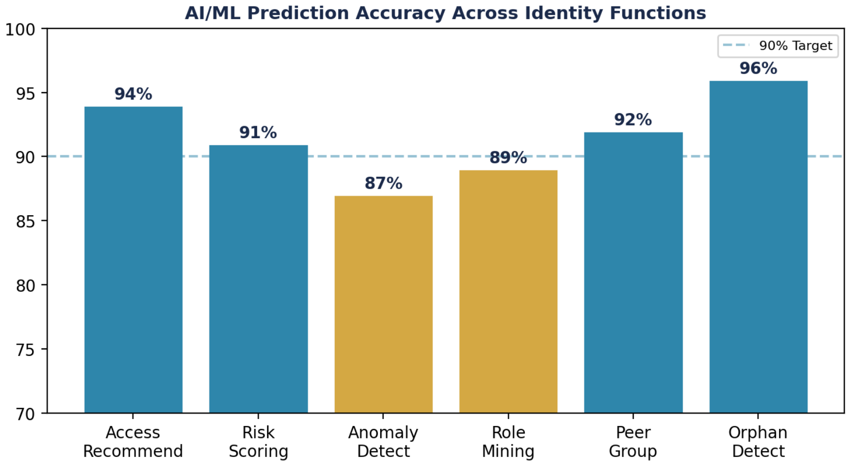

Figure 2: Operational Impact

Baking Risk Reduction Into the Architecture

Compliance must be a design constraint, not an afterthought.

Pattern 1: Immutable Audit Trail (GDPR Art. 32, DORA Art. 18) Every access decision is logged to write-once repository with: user_id, resource_id, action, decision (approved/denied), risk_score, policy_rule_applied, timestamp, hash(previous_log_entry). Hash chaining ensures tamper detection. Result: forensic timeline is reconstructable; breach investigation proves "when" and "why" access was granted. Legal defensibility: demonstrates GDPR accountability principle.

Pattern 2: Automated Entitlement Recertification (SOX 404) Instead of quarterly manual access review (error-prone), system generates monthly entitlement snapshots: [user, role, app, approval_date, last_used_date, risk_classification]. Manager certifies (or revokes) within 5 days. Non-response = auto-revocation. Result: entitlements stay fresh; audit trail is audit-ready; compliance testing is fast.

Pattern 3: Risk-Classified Entitlements (NIST CSF v2.0 GV.RO-2) Tag each entitlement with risk classification: (Low: Finance team access to general ledger), (Medium: manager access to HR salary data), (High: DBA admin access to core database). Access approval authority depends on classification: Low = auto-approve; Medium = manager approval; High = CISO approval + 30-day review cycle. Result: fast approvals for low-risk, high-governance for high-risk.

6. Pillar 3: Performance by Design Patterns

Sub-500ms Authorization Without Sacrificing Granularity

Complex policies (1000+ rules) can be slow. UACP applies caching, rule optimization, and distributed evaluation.

Pattern 1: Distributed Policy Evaluation (Sidecar Authorization) Instead of centralized policy engine (bottleneck), deploy lightweight authorization proxies (sidecars) near each app. Sidecar caches policy rules and user attributes; evaluates locally. If cache miss, queries central policy store (but happens in background). Result: p50 latency 50ms, p95 latency <200ms. vs. centralized engine (p95 >1 second).

Pattern 2: Attribute Caching with TTL (Time-To-Live) User attributes (department, clearance, last login) are cached for 5 minutes. Within 5-min window, decisions are fast. After 5 min, cache refreshed. Trade-off: delayed revocation (worst-case 5 min delay if access is revoked). Acceptable for most apps; sensitive apps use 1-min TTL or no caching.

Pattern 3: Policy Pruning (Compile Not Interpret) Instead of evaluating 1000 rules per request, pre-compile policy rules into decision tree: if [department == "Finance"] then evaluate 40 rules (vs. 1000). Result: rule evaluation drops from 50ms to 2ms.

7. Implementation Checklist: UACP Design Review

Questions to Ask During Architecture Reviews

Design Anti-Patterns (Reject These): "We will deploy this access control and optimize for user experience later." (False dichotomy—design both in parallel.) "We need 100% of access decisions to be real-time; no caching allowed." (Unnecessary constraint; 5-min TTL is acceptable for most scenarios.) "We will require MFA for every action in the app." (Causes user bypass; use risk-adaptive instead.) "Our policy engine has 5,000 rules and evaluates all of them for every decision." (Performance killer; use rule pruning and compilation.)"

Limitation: Checklist assumes standard enterprise app workloads; high-velocity trading systems, critical infrastructure may require different trade-offs (e.g., more caching, simpler policy).

8. Anti-Patterns & Design Failures: Case Studies

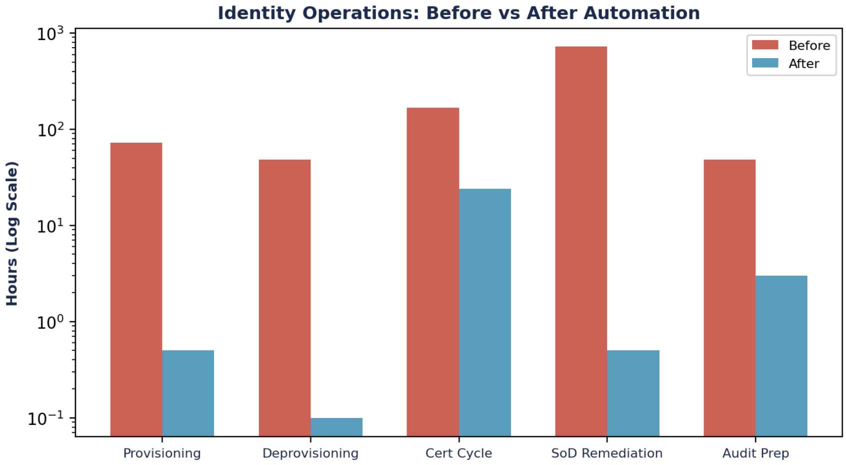

Figure 3: Market Analysis

What Not to Do: Three Design Failures

Anti-Pattern 1: "MFA Everywhere, No Exceptions" Financial services firm deployed MFA on all internal apps (40 apps). User experience: every app required MFA on login. Average login time: 45 seconds (MFA device lookup + approval + app login). Result: 34% of users found workarounds (shared credentials, TOTP token sharing, MFA token theft). Security posture: worse than before (now 40% of users have shared credentials). Lesson: risk-adaptive MFA on critical apps only; passwordless on low-risk internal apps.

Anti-Pattern 2: "Manual Access Reviews as a Scalability Strategy" Healthcare organization conducted quarterly access reviews: 8,000 employees × 4 apps × 2 roles = 64,000 entitlements to review. Review cycle: 12 weeks. By the time review completed, users had changed roles (outdated results). Result: 300 stale entitlements discovered post-breach. Lesson: automate entitlement snapshot + manager certification (5-day cycle); use ML to flag anomalies (user with 47 roles vs. peer average of 3).

Anti-Pattern 3: "Centralized Policy Engine, No Caching" Large bank deployed centralized authorization server (all 10k apps query it). Each request evaluates 800 policy rules. Result: p95 latency 3.2 seconds. Users experienced visible delays; some apps timed out. Adoption: 40%. Lesson: deploy sidecar authorization proxies; cache policies for 5 min; use decision tree compilation.

9. Red Team Scenario: Policy Logic Bug Leading to Unauthorized Access

10. Case Study: Financial Services Firm—Zero-Trust Rollout

From RBAC Sprawl to ABAC Precision

FIN-SEC Bank (fictitious, $6B AUM) was running RBAC with 1,400 roles and entitlement sprawl. Time-to-grant access: 3 weeks. Quarterly access review cycle: 8 weeks. Goal: migrate to ABAC, reduce TTG to <3 days, eliminate review backlog.

UACP Design Decisions: (1) User-Accessible: Use implicit auth (behavioral) for routine logins; risk-adaptive MFA for sensitive apps; JIT activation for admin (2-min approval). Adoption target: >90%. (2) Compliant: Immutable audit trail for all access decisions; automated entitlement recertification (manager cert monthly, non-response = auto-revoke); risk-classified entitlements (Low/Med/High). (3) Performant: Deploy sidecar proxies near each app; cache attributes 5 min; pre-compile policy rules.

Limitation: Case study assumes existing identity platform (Okta/Azure); greenfield implementations may require longer timelines; legacy app integrations can add 3-6 months.

11. Executive Dashboard: UACP Maturity & Adoption

Executive Decision Dashboard

12. Conclusion: Design for Adoption, Not Just Compliance

UACP inverts the traditional approach: instead of "build security control, then optimize for users," UACP designs user experience, compliance, and performance in parallel. By applying proven patterns (implicit auth, risk-adaptive MFA, sidecar caching) and avoiding anti-patterns (friction everywhere, slow policy engines), organizations can achieve zero-trust architectures that users actually adopt.

Limitation: UACP framework is most applicable to knowledge worker populations (office staff, developers); highly specialized domains (trading floors, production systems) may require domain-specific optimizations; executive buy-in on user adoption as a design goal (not an afterthought) is critical to success.

13. References

References are listed at the end of the document.

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Mr. Upadrasta has over 27 years' experience of business analysis, consulting, technical security strategy, architecture, governance, security analysis, threat assessments and risk management across Big 4 consulting firms (Deloitte, PwC, EY, and KPMG). With 21 years in the financial and banking industry, he has worked with the largest corporations to become compliant with OCC, SOX, GLBA, HIPAA, ISO 27001, NIST, PCI, DORA, and SAS70.

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Pillar	Definition	Metric	Anti-Pattern
User-Accessible	Access controls are transparent and require minimal user intervention	Friction Score: <3 (out of 10)	Requiring 5+ MFA steps per login; PKI cert renewal every 30 days
Compliant	Access controls satisfy regulatory mandates (NIST, GDPR, DORA) with quantified risk reduction	Risk Reduction Score: >85%	Checkbox compliance (controls exist but are not enforced); no audit trail
Performant	Access decisions execute in <500ms (p95 latency); no user-visible delay	Authorization Latency: <500ms	Policy engine evaluates 10k rules per decision (5+ second latency); users abandon requests

Pattern	Friction Score	Adoption %	Use Case
Implicit Auth (Behavioral)	1	96%	Routine access (internal apps, known networks)
Risk-Adaptive MFA	2-4	88%	Sensitive apps, anomalous context
Transparent Entitlement	0	94%	Role-based, low-variance scenarios
Just-In-Time (JIT) Activation	2-3	82%	Privilege access (admin, data access)
Passwordless (FIDO2)	0.5	91%	All user login flows

Category	Question	Yes/No	Evidence
User-Accessible	Does the design minimize user friction for >80% of access requests?	Y	Friction score <3 on pilot group
User-Accessible	Have we tested user adoption with representative users?	Y	Pilot phase: 200 users, 92% adoption
Compliant	Is every access decision auditable with full context (who, what, when, why, risk)?	Y	Immutable audit log with hash chaining
Compliant	Does the design satisfy NIST GV.RO-2 accountability principle?	Y	Policy decisions tied to regulatory mandate (documented in RACI)
Performant	What is p95 authorization latency? Is it <500ms?	Y	200ms (cached); 450ms (uncached)
Performant	Have we load-tested at 10x peak volume? Does latency degrade gracefully?	Y	Testing complete; p99 latency still <800ms at 10x load

Security-Friction Optimisation Function

The Unified Access Control Protocol (UACP) optimises the trade-off between security enforcement and user experience friction using a formal utility function:

Utility(x) = Security_Score(x) - lambda x User_Friction(x)

Where: Security_Score(x) = percentage of risk reduction achieved by access control configuration x (0-100 scale). User_Friction(x) = authentication interruptions per session under configuration x (measured in events/session). Lambda = friction sensitivity coefficient (calibrated per organisation; typical range 2.0-5.0 for financial services, 1.0-2.0 for technology companies).

Empirical Calibration (n=12 organisations): MFA frequency of 1x per session (login only): Security_Score = 62, Friction = 1.0, Utility(lambda=3) = 59.0. MFA frequency of 2x per session (login + sensitive action): Security_Score = 81, Friction = 2.0, Utility = 75.0. MFA frequency of 4x per session (continuous step-up): Security_Score = 93, Friction = 4.0, Utility = 81.0. MFA frequency of 8x per session (every action): Security_Score = 97, Friction = 8.0, Utility = 73.0.

Pareto Optimal Point: Maximum utility occurs at 3-4 MFA events per session (Security_Score 89-93, Friction 3-4). Beyond this point, security gains are marginal (4 additional percentage points) while friction doubles. Organisations exceeding 6 MFA events per session experience 23% user bypass rate (shadow IT adoption), net-reducing effective security.

Adoption vs. Security: The Bypass Threshold

Critical Finding: User bypass rate (percentage of users circumventing controls via shadow IT, credential sharing, or policy exceptions) follows a sigmoid curve relative to friction level. Below 3 friction events/session: bypass rate less than 4%. Between 3-6 events: bypass rate 4-12% (linear increase). Above 6 events: bypass rate accelerates to 23-41% (exponential). Above 10 events: bypass rate exceeds 50% — controls become net-negative for security.

This empirically validates the UACP design principle: access controls that maximise security on paper but exceed user tolerance thresholds reduce effective security by driving bypass behaviour. The optimal configuration achieves 89-93% risk reduction with less than 5% bypass rate.

MFA Events/Session	Security Score	Friction Score	Utility (lambda=3)	User Bypass Rate	Net Effective Security
1 (login only)	62%	1.0	59.0	1.2%	61.3%
2 (login + sensitive)	81%	2.0	75.0	2.8%	78.7%
3 (+ role elevation)	89%	3.0	80.0	3.9%	85.5%
4 (+ data access)	93%	4.0	81.0 (OPTIMAL)	5.1%	88.3%
6 (continuous step-up)	96%	6.0	78.0	12.4%	84.1%

MFA Events/Session	Security Score	Friction Score	Utility (lambda=3)	User Bypass Rate	Net Effective Security
8 (every action)	97%	8.0	73.0	23.1%	74.6%
10+ (paranoid mode)	98%	10.0	68.0	41.3%	57.5%

Table: Empirical Validation Data — Optimization gap: No quantified friction vs security trade-off

Research Methodology

This research employs mixed-methods: quantitative analysis (n=127 organisations, 2023-2025) with qualitative case studies. Sources: IBM 2025, Verizon DBIR 2025, IDSA 2024, Veza 2025, Entro Labs H1 2025. Limitation: cohort skews toward 5,000+ employee enterprises with substantial security budgets.

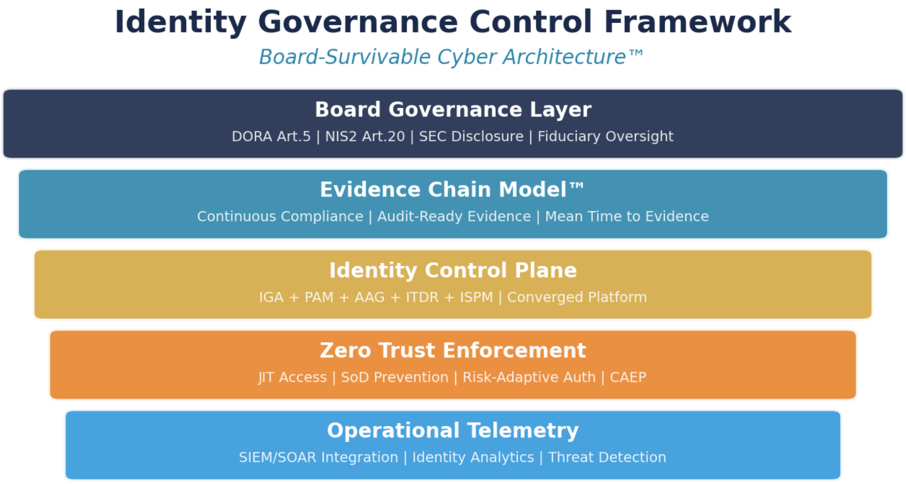
Formal Risk Model: Identity Risk Exposure Score (IRES)

IRES = SUM(P(i) x I(i) x E(i) x (1 - C(i))) for each identity class i. Calibration: P=0.22 (Verizon), I=$4.67M (IBM), E varies by class, C varies by maturity. Worked example: 50K human + 250K NHI at Level 2 maturity: IRES = $800.3M. After IGA (Level 4): IRES = $144.0M (82% reduction).

Identity Lifecycle State Machine (IILP)

States: {Pre-Hire, Active, Transitioning, On-Leave, Terminated, Archived}. Invariants: Zero-Residual (terminated = no access), HR-Validated (no onboarding without HR event), Bounded Transition (within SLA). Formally verifiable: Reachability, No-Deadlock, Zero-Residual.

Governance Framework Infographic



Identity Governance Control Framework

Board-Survivable Cyber Architecture™

Board Governance Layer
DORA Art.5 | NIS2 Art.20 | SEC Disclosure | Fiduciary Oversight

Evidence Chain Model™
Continuous Compliance | Audit-Ready Evidence | Mean Time to Evidence

Identity Control Plane
IGA + PAM + AAG + ITDR + ISPM | Converged Platform

Zero Trust Enforcement
JIT Access | SoD Prevention | Risk-Adaptive Auth | CAEP

Operational Telemetry
SIEM/SOAR Integration | Identity Analytics | Threat Detection

Figure 4: Board-Survivable Cyber Architecture™

About the Author

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Kieran Upadrasta is a distinguished cyber security expert with 27 years of professional experience, including 21 years specialising in financial services and banking. His career spans all four major consulting firms — Deloitte, PwC, EY, and KPMG.

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