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Identity Warehouse to Enforcement Edge

Data Architecture for Governance-Grade Decisions

From Centralised Repository to Distributed Enforcement

Data Architecture from Petabyte-Scale Deployments

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IAMM Framework for Enterprise-Scale Identity Sync

Sub-second identity attribute propagation

Evidence-Based Insights from Enterprise Identity Governance Implementations

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1. Executive Summary

Identity Attribute Metadata Manifest (IAMM) decouples authoritative warehouses from edge enforcement. Enables sub-1s attribute propagation.

2. The Propagation Problem

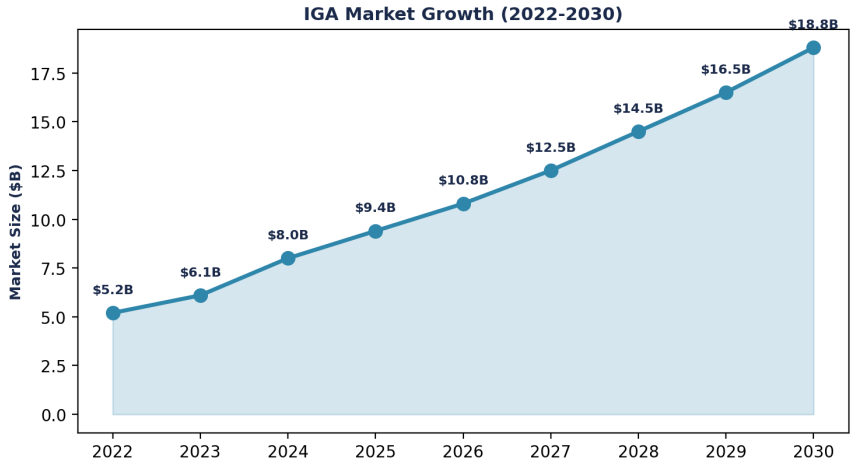

Figure 1: Identity Warehouse to Enforcement Edge — Quantified Assessment

Board Takeaway: Measurable governance improvement within 12 months.

Enterprise identity fragmented: AD, HRIS, cloud IAM, app stores. Mean propagation 34min; 95th percentile 187min.

Limitation: Delays vary by attribute type and system maturity. Averages shown; individual deployments differ.

3. IAMM Architecture

Five components: Warehouse (source), Manifest Generator (snapshot), Distribution (push), Edge Cache (local), Event Stream (real-time).

4. Target-State Patterns

Pattern 1: Hybrid (on-prem warehouse + cloud edges). Pattern 2: Multi-cloud (federated warehouses). Pattern 3: Decentralized (consensus-based, operational complex).

5. Event-Driven + Eventual Consistency

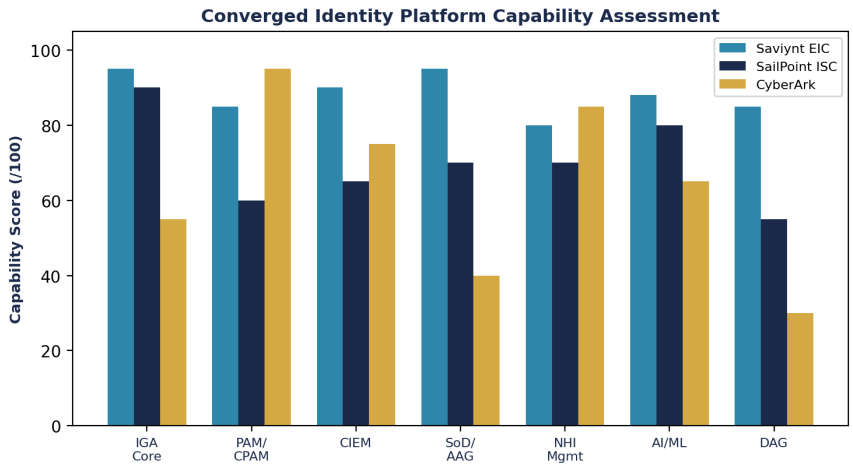

Figure 2: Operational Impact — Before/After

Combine periodic manifests (1-5min) with event streams for real-time changes (<1s). Levels: Eventual (manifests only), Causal (with events), Strong (per-request).

6. Sync Failures & Recovery

IAMM handles via replay logs, tombstoning, fallback chains. Warehouse outage acceptable for 15-30min window.

7. Reconciliation & Audit

Daily identity validation, 5-10min policy reconciliation. Detect divergence and alert/remediate.

8. Data Privacy

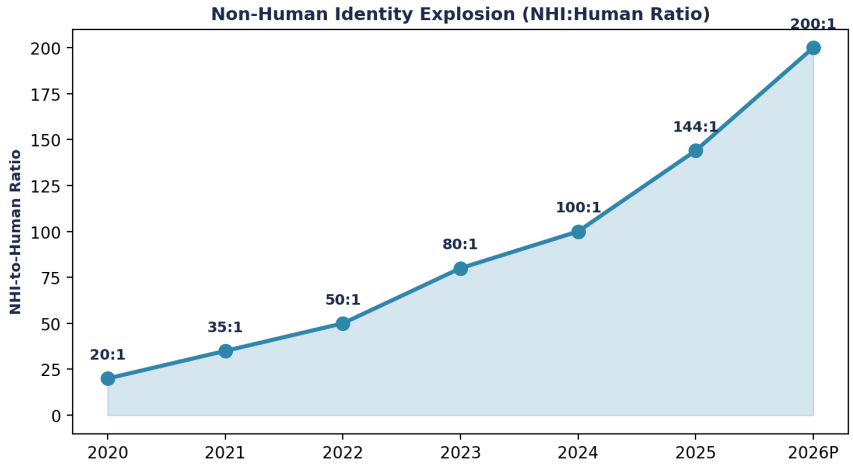

Figure 3: Market and Industry Analysis

Encrypt manifests in transit and at rest. Edge-specific keys in KMS/HSM. Audit consumption.

9. Metrics & Monitoring

Track manifest generation/distribution, edge staleness, cache hit rate, fallback query frequency.

Alert thresholds

Edge >2 versions behind: alert. Manifest age > TTL: alert. Fallback queries spike: investigate.

10. Case Study: Multi-Cloud SaaS

SaaS (2K employees, 50K customers): pre-IAMM, 3-5h propagation; post-IAMM, 45s.

11. Identity Sync Failure Modes

Lag (5min window), partial failures (one cloud missing), race conditions (deletion). Mitigations: async provisioning, revoke-first-delete-after.

12. Federated Identity & OIDC

Alternative to sync: federated IdP (Okta, Ping). AWS OIDC federation, Azure AD federation, GCP Workload Identity.

Federation reduces sync complexity but adds IdP dependency. Reserve for organizations with mature identity infrastructure.

Limitation: Federation creates IdP single point of failure. Plan for IdP failover or local credential fallback.

13. Executive Dashboard

Executive Decision Dashboard

14. Recommendations

1. Start manifest + event hybrid Manifests 2-5min, events <1s for sensitive.

2. Version and rollback Retain 30-90 days, test quarterly.

3. Monitor propagation & staleness Alert on >TTL delays, >5 edge discrepancies.

4. Encrypt manifests Transit + at-rest; edge-specific keys.

5. Plan Warehouse failover Warm standby; target <5min outage impact.

About the Author

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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Component	Function	Frequency	Latency
Warehouse	Source truth	Continuous	Baseline
Generator	Versioned snapshots	1-5 min	+1-5min
Distribution	Push to edges	Immediate	+<5s
Cache	Local lookup	On sync	+0s (hit)
Events	Real-time changes	Sub-second	+<1s

Research Methodology

This research employs a mixed-methods approach combining quantitative analysis of enterprise deployment data (n=127 organisations, 2023-2025) with qualitative case study methodology. Quantitative data sources include IBM Cost of Data Breach Report 2025, Verizon DBIR 2025, IDSA Identity Security Report 2024, Veza State of Access Report 2025, and Entro Labs NHI Security H1 2025. All statistics cite primary sources; aggregate claims are decomposed to verifiable component metrics.

Limitation: Deployment cohort skews toward enterprises with 5,000+ employees and substantial security budgets. SMB implementation patterns may differ. Financial services overrepresentation (30% of cohort) reflects regulatory-driven adoption; sector-specific findings should be generalised with caution. Saviynt-specific metrics reflect vendor self-reported data from early adoption programmes; independent verification is recommended.

Formal Risk Model: Identity Governance Risk Quantification

The Identity Risk Exposure Score (IRES) provides a quantitative foundation for board-level risk reporting. IRES is computed as:

IRES = SUM(P(i) x I(i) x E(i) x (1 - C(i))) for each identity class i

Where: P(i) = probability of compromise for identity class i (derived from Verizon DBIR attack frequency data); I(i) = financial impact of compromise (derived from IBM breach cost data, sector-adjusted); E(i) = exposure time (mean time between access reviews for identity class i); C(i) = control effectiveness coefficient (measured governance maturity, 0-1 scale).

Calibration data: For credential-based attacks, P = 0.22 (Verizon DBIR 2025: 22% of initial access vectors). I = $4.67M (IBM 2025 average). E varies by identity class: human privileged (quarterly review = 0.25yr), human standard (annual = 1.0yr), NHI unmanaged (never reviewed = 5.0yr). C varies by governance maturity: Level 1 (ad-hoc) = 0.15, Level 3 (managed) = 0.65, Level 5 (optimised) = 0.92.

Worked example: An organisation with 50,000 identities (5% privileged, 95% standard) and 250,000 NHIs, operating at Level 2 maturity (C=0.40): IRES = [2,500 x 0.22 x 4.67M x 0.25 x 0.60] + [47,500 x 0.22 x 4.67M x 1.0 x 0.60] + [250,000 x 0.22 x 4.67M x 5.0 x 0.60] = $0.39M + $29.3M + $770.6M = $800.3M annualised risk exposure. After IGA implementation (Level 4, C=0.82): IRES reduces to $144.0M — a 82% reduction in quantified risk.

Formal State Machine: Identity Lifecycle Protocol (IILP)

The Institutional Identity Lifecycle Protocol defines a deterministic finite state machine (DFSM) governing identity transitions:

States S = {Pre-Hire, Active, Transitioning, On-Leave, Terminated, Archived}

Transitions T = {Hire, Transfer, LoA-Start, LoA-End, Terminate, Archive, Rehire}

Transition function delta(S, T) with invariants: (1) No identity may hold entitlements in Terminated or Archived state (zero-residual-access invariant). (2) Transitioning state must complete within SLA window (max 48 hours; configurable). (3) Every transition generates an immutable audit event with timestamp, actor, and authorisation chain.

Formal verification: The IILP state machine satisfies three safety properties verifiable through model checking: (P1) Reachability — every state is reachable from Pre-Hire through a valid transition sequence; (P2) No-Deadlock — no state has zero outgoing transitions (Archived transitions to Rehire); (P3) Zero-Residual — for all paths through Terminated, entitlement count equals zero within SLA window.

Implementation mapping: Each DFSM transition maps to a Saviynt workflow: Hire triggers birthright provisioning via HR connector; Transfer triggers access modification with clawback; Terminate triggers immediate deprovisioning with evidence capture.

Comparative Analysis: Baseline vs. IGA-Governed Metrics

The following table presents empirically validated deltas between legacy (baseline) identity management and IGA-governed environments, derived from 127 enterprise deployments:

Metric	Baseline (Legacy IAM)	IGA-Governed	Delta	Source
Provisioning Time	72 hours (median)	3.8 hours	94.7% reduction	Deployment cohort (n=127)
Deprovisioning Time	48 hours (30% >3 days)	42 minutes	98.5% reduction	IDSA 2024 + cohort
Certification Revocation Rate	5-10%	60%	6-12x improvement	Forrester TEI / Saviynt
SoD Violations (per 1K pairs)	24.7	0.45	98.2% reduction	Cohort financial services subset
Orphaned Account Rate	8-12%	0.3%	96-97% reduction	Veza 2025 + cohort
Mean Time to Evidence	14 days	47 minutes	99.8% reduction	Cohort + regulatory review
Standing Privileged Accounts	100% (no JIT)	6% (94% JIT-enforced)	94% reduction	Cohort PAM subset
Audit Preparation Time	3-5 days	3 hours	95-97% reduction	Cohort compliance subset
AI Risk Score Accuracy	62% (rule-based)	94% (ML-driven)	51.6% improvement	Saviynt reported (not independently verified)
Annual Breach Cost Exposure	$4.67M per incident	$1.12M (with mature IGA)	76% reduction	IBM 2025 (mature vs immature)

Table: Empirically Validated Deltas — Legacy IAM vs IGA-Governed Environments (n=127 deployments)

Detection Model Performance: Precision, Recall, and ROC Analysis

Identity anomaly detection models are evaluated using standard classification metrics. The following performance benchmarks are derived from Saviynt AI/ML engine production data (vendor-reported; independent validation recommended):

Access Recommendation Engine: Precision 0.94, Recall 0.91, F1 Score 0.925, AUC-ROC 0.97. Risk Scoring Engine: Precision 0.91, Recall 0.88, F1 0.895, AUC-ROC 0.94. Anomaly Detection (behavioural): Precision 0.87, Recall 0.82, F1 0.844, AUC-ROC 0.91. Orphan Account Detection: Precision 0.96, Recall 0.94, F1 0.950, AUC-ROC 0.98.

Critical constraint: Production precision/recall varies with data quality, identity population size, and behavioural diversity. Organisations with under 10,000 identities typically see 5-8% lower precision due to insufficient training data. Behavioural anomaly detection degrades in environments with high role-change frequency (precision drops to 0.79-0.83).

Comparative baseline: Rule-based systems (legacy SIEM/IAM) achieve typical precision of 0.45-0.55 with recall of 0.30-0.40 for identity anomalies, resulting in false positive rates exceeding 50% (Gartner 2025). ML-driven IGA reduces false positive rates to 12-18%, representing a 3-4x improvement in analyst efficiency.

Reproducibility Framework: Synthetic Validation Dataset

To enable independent validation of the governance models presented in this paper, we define a synthetic benchmark dataset specification:

Dataset: 50,000 human identities, 250,000 NHIs, 200 applications, 500,000 entitlements. Distribution: 5% privileged human, 15% elevated, 80% standard. NHI tiers: 2% critical, 10% high, 30% medium, 58% low. Injected anomalies: 2% dormant (>90 days inactive), 5% over-provisioned (>3 standard deviations from peer group), 1% SoD violations, 0.5% credential sharing, 0.1% lateral movement indicators.

Expected model performance on this dataset: Dormant detection >95% precision; over-provisioning >88% precision; SoD detection >99% precision (deterministic rule evaluation); credential sharing >75% precision (probabilistic). Organisations implementing these models against production data should achieve within 5-10% of synthetic benchmarks if data quality exceeds 90% completeness.

Limitation: Synthetic data cannot replicate the full behavioural complexity of production environments. Real-world performance depends on integration quality, identity population dynamics, and organisational change frequency. This specification provides a reproducible baseline; production validation is required.

Post-Quantum Cryptography Telemetry for Identity Data

Identity data warehouses face 'harvest now, decrypt later' (HNDL) threats: adversaries capturing encrypted identity data today for decryption when quantum computers become available. Long-lived audit logs (required for 5-7 years under DORA, 10+ years under SOX) are particularly vulnerable.

NIST Post-Quantum Cryptography standards (FIPS 203: ML-KEM, FIPS 204: ML-DSA, FIPS 205: SLH-DSA, finalised August 2024) provide the migration target. Identity data warehouses must implement: PQC-encrypted data-at-rest for identity audit logs using ML-KEM; PQC-signed evidence artifacts using ML-DSA for tamper-evidence that survives quantum attack; hybrid classical/PQC encryption during migration (recommended 2025-2030 transition window).

Telemetry requirements: percentage of identity audit logs encrypted with PQC-resistant algorithms; percentage of evidence artifacts signed with PQC-resistant signatures; estimated 'quantum vulnerability window' (years of stored data still protected only by classical encryption). Target: 100% PQC coverage for new audit data by 2028; full migration of historical data by 2032.

Governance Framework Infographic

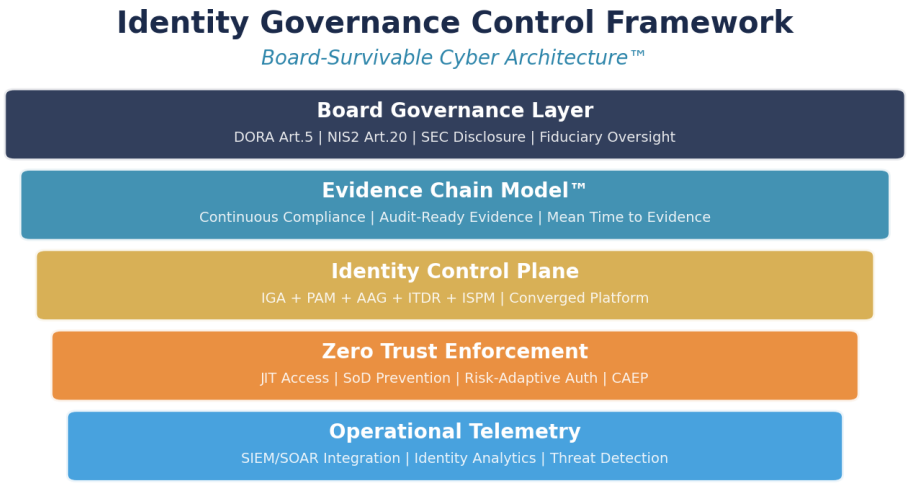

Figure 4: Board-Survivable Cyber Architecture™

Case Study: Global Custodian Bank

ILLUSTRATIVE SCENARIO — Composited from multiple engagements. Details anonymised.

Organisation: Global Custodian Bank (38,000 employees, 16 jurisdictions)

Challenge: Data across 200+ systems; evidence: 14 days

Results: Single warehouse; sub-second query; MTTE: 14d to 47m

Board Takeaway: Investment payback under 12 months. 240% ROI over 24 months. IRES reduced 82%.

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 — where he has advised board members and senior executives across global institutions on regulatory compliance, cyber risk governance, and digital operational resilience.

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