

Beyond Certificates

Provenance graphs as civic, educational, economic, defence and international infrastructure

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Executive determination

In an information economy, the most valuable credential is not a certificate. It is a verifiable history of how capability, judgment and trust were formed.

Modern institutions rely on compressed proxies. A certificate stands in for years of learning. A curriculum vitae stands in for professional development. A security clearance stands in for a complex assessment of conduct and reliability. A trade document stands in for the provenance of goods, labour, compliance and custody. These proxies are efficient, but they are weakly expressive and often expensive to verify.

A temporal provenance graph offers a different model. Instead of presenting a terminal assertion - qualified, competent, trusted, compliant, experienced - it preserves the ordered path by which that assertion became supportable. Evidence, feedback, corrections, transitions, role changes, prior states and current capabilities remain attached to the record.

The result is not simply a better portfolio. It is a new class of infrastructure: a human-readable, machine-processable and auditable provenance artifact capable of travelling across education, employment, defence recruitment, business, professional regulation, international exchange and trade.

Its significance is larger than accountability or education. Accountability uses the graph to reconstruct what institutions did. Education uses it to preserve how a learner developed. The larger opportunity is to make provenance itself portable, inspectable and reusable across civic and economic life.

1. The weakness of terminal credentials

A terminal credential records an outcome while omitting most of the process that produced it. An examination certificate may establish that a candidate performed to a specified standard on a particular date. It does not ordinarily preserve the pattern of effort, revision, feedback, transfer, collaboration, resilience, specialist aptitude or contextual support through which capability formed.

The same compression occurs elsewhere. Employers receive claims of experience without the underlying developmental record. Procurement teams receive certifications without a complete chain of operational provenance. Defence recruiters receive qualifications, references and test scores that must be interpreted as indirect evidence of aptitude, reliability and fit.

This creates a verification burden. Institutions must reconstruct provenance after the fact through references, interviews, background checks, document validation, professional registers and forensic review. The credential is portable; the evidential path behind it is not.

2. The provenance graph as a primary artifact

A provenance graph reverses that relationship. The artifact does not merely state the conclusion. It carries the evidential route to the conclusion.

Conventional artifact	What it asserts	What a provenance graph adds
Certificate	A standard was met	The sequence of learning, evidence, feedback, correction, transfer and independent performance.
Curriculum vitae	Experience occurred	The developmental and evidential path through roles, projects, decisions and outcomes.
Reference	A third party endorses the person	The underlying events and artifacts from which the endorsement can be tested.
Security or suitability decision	The person meets a threshold	A proportionate, consent-governed record of relevant judgment, conduct, training and review.
Compliance certificate	A product or organisation satisfied a rule	The chain of custody, testing, corrective action and responsible authority behind the conclusion.

This does not mean that every recipient should see every underlying record. Portability must be selective, role-based and consent-governed. The central point is that provenance can remain attached, cryptographically or procedurally verifiable, and capable of controlled disclosure when required.

3. Education: from attainment to capability formation

The educational temporal graph demonstrates the model at human scale. Instead of treating the student as the subject of institutional outputs, it allows the learner to author a longitudinal account of significant learning events, evidence, barriers, support, feedback, revision, consolidation and transfer.

An examination remains useful as one evidential event. It no longer has to carry the entire weight of the educational record. A graph can show whether a capability was reproduced independently, transferred to another context, strengthened after feedback and sustained over time.

For further education, universities, apprenticeships and professional training, this produces a richer admissions and progression artifact. It can reveal trajectories that terminal grades miss: late acceleration, practical mastery, interdisciplinary transfer, self-correction, leadership, perseverance and unusual combinations of aptitude.

4. Employment and business

4.1 Recruitment

Recruitment currently depends upon lossy summaries. A provenance graph could permit candidates to present selected evidence of capability formation: projects completed, decisions made, feedback incorporated, errors corrected, responsibilities assumed and skills transferred across contexts.

This would not eliminate interviews or testing. It would improve them. Interviewers could question the actual developmental record rather than attempting to infer capability from titles and certificates.

4.2 Workforce development

Inside organisations, graphs could preserve professional formation across roles. Training, mentoring, incidents, corrective action, project delivery, collaboration and leadership development could form one longitudinal artifact. Promotion and deployment decisions would become less dependent on recent visibility, managerial memory or static competency matrices.

4.3 Organisational memory

Projects could carry provenance graphs of their own: who made which decision, on what evidence, after which review, with what later correction. This would improve handover, audit, root-cause analysis and institutional learning without requiring every successor team to reconstruct the history from email archives.

5. Defence and national capability

Defence recruitment is a particularly strong vector because intake must assess more than academic attainment. Aptitude, judgment, discipline, adaptability, technical learning, teamwork, stress response, ethical reasoning and role suitability are multi-dimensional and developmental.

A provenance-based intake could refine selection by receiving a consent-governed graph of relevant educational and vocational development. The intake process could then add its own evidence: assessments, observed exercises, training performance, instructor feedback, remediation, specialist aptitude and progression.

- Selection could move from qualification matching toward evidence-based capability matching.
- Training pipelines could identify which supports or instructional methods produce durable performance.
- Specialist aptitude could be detected earlier through patterns of transfer and recurrence.
- Reassignment decisions could use the longitudinal record rather than treating unsuccessful placement as global incapacity.
- Veterans could export a civilian-readable provenance artifact translating military formation into demonstrable commercial capability.

The strategic value lies in refined intake and better deployment, not total informational exposure. Sensitive data, welfare information and protected characteristics would require strict minimisation, compartmentalisation and independent governance.

6. International exchange and trade

6.1 Portable human capability

International education and labour mobility depend on the recognition of certificates issued under different systems. A provenance graph could accompany the credential with a versioned account of the standards, evidence classes, assessment events and capabilities represented. Receiving institutions would not need to rely solely on equivalence tables.

6.2 Product and supply-chain provenance

The same grammar can apply to goods and services. A product graph could preserve source materials, manufacturing stages, inspections, custody transfers, certifications, corrective actions and responsible actors. Trade partners could inspect the path behind a compliance claim rather than relying upon a terminal certificate whose provenance must later be reconstructed.

6.3 Contract and transaction provenance

Complex transactions could preserve negotiation states, authority, approvals, variations, performance evidence and dispute-resolution steps. This would reduce ambiguity around who had authority, which version governed and what evidence supported later representations.

7. A general model of provenance-bearing identity

The larger conceptual shift is from identity by assertion to identity by inspectable formation. A person is not reduced to a score, title or clearance. Nor is the graph a permanent dossier of every event. It is a governed representation of selected developmental and evidential continuity.

Such an artifact could contain multiple profiles or views:

- an educational view for admissions or progression;
- an employment view for recruitment and professional development;

- a defence or public-service view for role-specific suitability;
- a professional-regulatory view for competence and continuing development;
- a trade or commercial view for authenticated capability and responsibility;
- a private personal view preserving the complete record under the subject's control.

The graph becomes a form of provenance-bearing identity: not a universal score, but a controlled set of evidence-backed claims whose origins and development remain inspectable.

8. Governance architecture required

The same power that makes provenance graphs valuable creates serious governance obligations. A poorly governed system could become a mechanism for surveillance, exclusion, permanent stigma or automated social ranking.

Safeguard	Requirement
Subject control	The person must be able to inspect, export and contest the record.
Purpose limitation	A graph created for learning must not silently become a behaviour, risk or insurance profile.
Selective disclosure	Recipients should receive only the profile and evidence necessary for the stated purpose.
Typed authorship	Facts, reflections, assessments, automated inferences and third-party observations must remain distinguishable.
Versioned grammar	Taxonomies and relationship meanings must be published and historically stable.
Correction without erasure	Errors should be corrected through append-only provenance rather than silent rewriting.
Expiry and review	Some claims and evidence should lapse, refresh or require renewed assessment.
No universal ranking	The graph should preserve multidimensional provenance, not collapse the person into one score.
Independent audit	High-stakes profiles should be subject to external validation and bias review.

9. Economic and institutional value

Provenance graphs could reduce the transaction costs created by weak credentials and fragmented records. The value is not only better decision-making. It is reduced duplication of verification.

- Admissions teams spend less time interpreting incomparable qualifications.
- Employers spend less time reconstructing experience through references and background checks.
- Professional bodies receive continuous evidence of formation rather than episodic declarations.
- Defence and public-service recruitment gain richer intake without inventing new tests for every capability.
- Supply chains carry evidence of compliance and custody across borders.
- Individuals retain portable proof of development when institutions close, merge or lose records.

The economic artifact is therefore not the graph alone. It is the reduction in uncertainty around capability, authority, custody, compliance and trust.

10. Risks of concentration and misuse

A universal provenance system would be dangerous if controlled centrally, scored opaquely or made compulsory without meaningful exit. The instrument must not become a social-credit architecture or an immutable record of youthful error.

The preferred model is federated and profile-based. The subject retains a canonical personal record or durable export. Institutions contribute typed events under declared authority. Recipients receive bounded proofs or selected graph views. Independent standards bodies govern grammar interoperability without owning the underlying life record.

The methodology also has dual-use characteristics. A grammar capable of identifying developmental trajectories and institutional patterns could be used to manipulate intake, construct misleading records or target people at vulnerable transition points. Defensive governance must therefore address the grammar and its use, not only the software container.

11. Implementation pathway

Stage	Action	Purpose
1	Define a common provenance core	Specify nodes, evidence types, authorship, time, relationship jumps, cumulative state and correction rules.

2	Create domain profiles	Develop distinct educational, employment, defence, professional and trade taxonomies without importing inappropriate semantics between them.
3	Establish identity and signature standards	Allow contributions to be authenticated while preserving selective disclosure.
4	Pilot bounded use cases	Begin with student learning journeys, apprenticeships, professional development and voluntary recruitment portfolios.
5	Measure decision improvement	Compare selection quality, verification cost, learner agency, mobility and error rates against conventional credentials.
6	Create independent governance	Separate standard-setting, platform operation, institutional participation and dispute resolution.
7	Build international interoperability	Map profile semantics across jurisdictions while retaining local standards and human readability.

12. The larger proposition

The certificate compresses a life into an assertion. The provenance graph preserves the route by which the assertion became true.

The historical role of the certificate was to make trust portable. In an age of limited records, that compression was necessary. In an age of abundant information, the same compression

increasingly becomes a weakness because the recipient must either trust the issuer or reconstruct the missing provenance.

A governed temporal graph offers a more powerful artifact. It can preserve development without reducing the person to one score; support selective disclosure without severing evidence from claims; and allow capability, authority and trust to travel across institutional and national boundaries.

The educational graph is therefore not a niche teaching tool. It is the first accessible expression of a broader architecture in which people, organisations, products and transactions can carry their provenance with them.

The central public-interest question is no longer whether such graphs are technically possible. It is whether they can be designed so that provenance increases agency and lawful trust rather than surveillance and control.

Source architecture

This paper develops the educational temporal-grammar model, the exemplar-to-factory distinction, the case-agnostic multi-axes methodology, the authorship and infrastructure analysis, and the dual-use assessment into a wider account of provenance graphs as civic and economic infrastructure.