Generational Threshold Theory for Mutable Digital Artifacts: When Does an Evolving Artifact Warrant a New Claim of Authorship or Inventorship?

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***Abstract*—Digital artifacts are not static objects. They are modified, versioned, aggregated, and redistributed across devices and contexts, producing successive generations of related but distinct entities. Yet the intellectual property frameworks governing authorship and inventorship were designed for fixed works and point-in-time inventions, not for artifacts that evolve continuously. This paper introduces *Generational Threshold Theory* (GTT), a conceptual framework for determining when an evolved version of a digital artifact accumulates sufficient difference from its predecessor to warrant an independent claim of authorship or inventorship. We ground GTT in the *Modifiable Digital Device Entity* (MDDE) framework developed by Fleshner, which provides a governed architecture for mutable digital artifacts, and situate it within three adjacent bodies of literature: information systems (IS) design theory (artifact mutability), copyright law (originality and derivative works), and patent law (non-obviousness and improvement patents). We argue that the measurement of *generational delta*—the cumulative difference between artifact versions—provides a principled, tractable basis for resolving attribution disputes in systems where digital artifacts evolve without a singular moment of creation.**

***Index Terms*—digital artifact; artifact mutability; MDDE; authorship; inventorship; provenance; generational delta; derivative works; non-obviousness; IS design theory**

I. Introduction

The intellectual history of authorship and inventorship is, at its core, a history of moments: the moment of composition, the moment of conception, the moment of fixation. Copyright law grants protection to an "original work of authorship fixed in a tangible medium of expression" [1]. Patent law awards rights to whoever first conceives of an invention [2]. Both frameworks assume that the act of creation has a discernible beginning—a point from which rights flow and around which disputes can be adjudicated.

This assumption is increasingly untenable. Digital artifacts—software modules, data models, computational workflows, AI-generated content, collaborative documents—do not merely exist at a moment of creation. They evolve. A software library passes through hundreds of commits. A machine learning model is retrained on new data. A collaborative research dataset accumulates annotations from dozens of contributors over years. An AI system produces a work that a human then curates, extends, and reshapes. In each case, the artifact at time $T+n$ bears a family relationship to the artifact at time T, but is meaningfully distinct from it. The question that current legal and technical frameworks cannot cleanly answer is: *at what point does the evolved artifact constitute something new enough to support an independent claim?*

This paper proposes *Generational Threshold Theory* (GTT) as a framework for answering that question. GTT draws on three bodies of knowledge: (1) the IS design theory literature on artifact mutability, particularly the concept of *semizoa* [3]; (2) copyright law's treatment of derivative works and the originality threshold [4], [5]; and (3) patent law's non-obviousness doctrine and the concept of improvement patents [6], [7]. We unify these through the lens of the MDDE framework [8], which provides a technical architecture for governing mutable digital artifacts and whose core premise—that digital artifacts are inherently dynamic and require governed evolution rather than static protection—forms the practical substrate on which GTT is built.

The paper is structured as follows. Section II reviews the MDDE framework and its core concepts. Section III surveys the relevant literature. Section IV introduces GTT, defines generational delta, and proposes threshold criteria. Section V discusses implications. Section VI concludes.

II. The MDDE Framework

A. Overview

The *Modifiable Digital Device Entity* (MDDE) is a conceptual architecture developed by Fleshner for governing the evolution of digital artifacts. Where conventional digital rights management (DRM) systems treat content as a fixed object to be locked and licensed, MDDE treats digital artifacts as inherently mutable entities whose changes must be tracked, governed, and attributed. The central premise of MDDE is that a digital artifact is not a static payload but a dynamic entity with a lifecycle: it has an identity that persists across modifications, a provenance chain that records those modifications, and a governance layer that enforces rules about who may modify it, under what conditions, and with what effects on ownership [8].

MDDE distinguishes itself from existing content protection systems along several axes. Whereas DRM operates at the application layer, MDDE integrates at the operating system and file-system level, enabling artifact governance that persists across applications. Whereas data provenance standards such as the W3C PROV ontology [9] focus on recording the history of data changes, MDDE adds a normative layer: not merely *what* changed and when, but *whether* this change was authorized,

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by whom, and what it means for the artifact's identity and ownership. Fleshner also incorporates a physical security layer—Bluetooth-based proximity detection and wearable authentication tokens—that ties artifact access rights to the physical location and identity of the modifier, a feature absent from any software-only provenance system.

B. Core MDDE Concepts

Three MDDE concepts are central to GTT.

Artifact identity holds that each MDDE-governed entity has a persistent identifier that survives modifications; the artifact at version N and version $N{+}n$ are the same entity in terms of lineage, even if their content has substantially diverged.

Modification record is the structured log of all changes made to an artifact, timestamped and attributed to specific principals.

Stewardship model governs the transfer of governance rights over an artifact: as an artifact evolves, the question of who holds stewardship—and whether stewardship has transferred through modification—is a central concern of the framework. It is this third concept that most directly motivates GTT. MDDE tracks how artifacts change, but does not itself specify when a change is large enough to constitute a new work deserving independent attribution.

III. Literature Review

A. Artifact Mutability in IS Design Theory

The IS design theory literature has developed a nuanced treatment of artifact mutability over the past two decades. Gregor and Jones [10] established mutability as a core component of design theories, distinguishing between *in-design mutability* (the degree to which an artifact is designed to be adaptable) and *in-use mutability* (the degree to which users adapt the artifact over time). They argued that design theories should explicitly specify how artifacts are expected to evolve, rather than treating the designed artifact as a static endpoint.

Johnston [3] extended this reasoning by introducing the concept of *semizoa*—IS/IT artifacts understood as quasi-biological entities that exhibit homeostasis, learning, and evolution. Semizoa are "only in part designable": they emerge and adapt in ways that exceed their original specification. This framing captures an important intuition relevant to GTT: like biological organisms, digital artifacts may accumulate changes that constitute meaningful speciation—a point at which the evolved artifact is no longer merely a variant of its parent but a distinct entity in its own right.

More recently, Wessel et al. [11] linked artifact mutability to the concept of emergence, arguing that IS design theories must account for three types of emergent change: weak emergence (predictable from initial conditions), strong emergence (unpredictable but explicable post-hoc), and radical emergence (fundamentally discontinuous with prior states). GTT draws on this taxonomy: a generational delta reflecting weak emergence is unlikely to cross the authorship threshold; one reflecting radical emergence is far more likely to do so.

B. Copyright Law: Originality and Derivative Works

Copyright law in the United States protects "original works of authorship fixed in a tangible medium of expression" [1]. The originality requirement was clarified in *Feist Publications, Inc. v. Rural Telephone Service Co.* [12], where the Supreme Court held that a work must reflect at least a minimal "spark" of creativity attributable to a human author.

When a new work is derived from an existing work, it enters the legal category of *derivative works*, defined in 17 U.S.C. § 101 as works "based upon one or more preexisting works" that have been "recast, transformed, or adapted" [4]. A derivative work may earn its own copyright, but only in the new material it contributes; copyright in a derivative work does not extend to the underlying work. Critically, not all modifications produce a protectable derivative work: courts have held that only those modifications introducing "a distinguishable variation" qualify [5].

The unresolved question GTT addresses is: *how much variation is sufficient?* Current copyright doctrine provides a qualitative answer (more than trivial, exhibiting a creative spark) but no quantitative or systemic metric. For continuously evolving digital artifacts with thousands of intermediate versions, this ambiguity is a significant gap.

C. Patent Law: Non-Obviousness and Improvement Patents

Patent law addresses the evolution of inventions through the concept of *improvement patents*. Most patents granted by the USPTO are improvements to existing technology rather than wholly original inventions [6]. An improvement is patentable if it meets the statutory requirements of novelty (35 U.S.C. § 102) and non-obviousness (35 U.S.C. § 103) [2].

The non-obviousness requirement is the key threshold for improvement patents. Articulated in *Graham v. John Deere Co.* [13] and refined in *KSR International Co. v. Teleflex Inc.* [14], the test asks whether the differences between the claimed invention and the prior art would have been obvious to a person of ordinary skill in the relevant field at the time the invention was made. An improvement that merely applies known methods to produce predictable results is obvious and thus unpatentable.

Inventorship itself is grounded in conception: "the threshold question in determining inventorship is who conceived the invention" [15]. This is significant for GTT because it shifts the analysis from the artifact itself to the cognitive act of the modifier—even if an evolved artifact differs substantially from its predecessor, the modifier's contribution must reflect genuine inventive conception to support an inventorship claim.

IV. Generational Threshold Theory

A. Core Proposition

GTT proposes that the evolution of a digital artifact can be characterized by a *generational delta* (ΔG)—a composite measure of the differences between an artifact at version N and version $N{+}n$ across a set of dimensions. When ΔG exceeds a domain-specific threshold Θ, the evolved artifact crosses a *generational boundary*: it acquires sufficient distinctiveness from its predecessor to support an independent attribution claim under the applicable legal or normative framework.

GTT does not specify a single universal threshold. Different domains—copyright law, patent law, scientific data attribution, AI content governance—impose different Θ values reflecting different policy objectives. What GTT provides is a unified conceptual architecture for measuring ΔG and mapping it to domain-specific thresholds, enabling comparison across frameworks and informing the design of systems (such as MDDE) that must operationalize these distinctions.

B. *Dimensions of Generational Delta*

We propose that ΔG is a function of change across six dimensions, adapted from the IS design theory literature, copyright doctrine, and patent law.

Structural delta (ΔS) measures changes to the organization and architecture of the artifact—its data model, module structure, or compositional arrangement. High ΔS corresponds to radical emergence in Wessel et al.'s taxonomy [11] and is most relevant to patent claims about structural inventions.

Functional delta (ΔF) measures changes to what the artifact does—its inputs, outputs, and behavioral specification. A change that introduces new functionality contributes high ΔF. In patent terms, a high ΔF is necessary but not sufficient for an improvement claim: the functional change must also be non-obvious.

Expressive delta (ΔE) measures changes to the expressive content of the artifact, relevant for copyright purposes. Modifications that introduce new creative choices (selection, arrangement, voice) contribute to ΔE. This dimension maps most directly to the copyright originality threshold.

Provenance delta (ΔP) measures changes to the attribution chain—which principals have contributed, and in what proportion. MDDE's modification record provides the primary data source for ΔP. A version in which a new principal has contributed substantial modifications exhibits high ΔP, relevant to both joint authorship and joint inventorship determination.

Contextual delta (ΔC) measures changes in the deployment context of the artifact—the technical environment, use case, or intended audience. A dataset repurposed from scientific research to clinical decision support may exhibit high ΔC even with low ΔS and ΔF.

Temporal delta (ΔT) is a modifier rather than an independent dimension: it captures elapsed time between versions. Time matters for patent law (prior art accumulates; improvement patent windows have temporal limits [16]) and for copyright (passage of time may affect transformativeness assessments).

C. *Threshold Mapping*

Table I maps the six dimensions of ΔG to the threshold criteria of the three legal frameworks reviewed in Section III, and to the MDDE governance model. The table illustrates how the same artifact evolution may cross the threshold in one framework but not another—a dynamic with significant practical implications for systems that must simultaneously satisfy multiple legal regimes.

D. *The Threshold Determination Problem*

A central challenge for GTT is operationalizing the threshold Θ. In copyright law, the threshold is qualitative and judicially determined. In patent law, it is assessed by examiners and courts applying the non-obviousness standard, guided by secondary considerations such as commercial success and long-felt need [13]. Neither framework provides an algorithmic rule applicable *ex ante* to a continuously evolving artifact.

GTT does not resolve this problem, but reframes it. Rather than asking "is this particular version a new work?", GTT asks "what combination of dimensional deltas, aggregated over what time period, constitutes a generational crossing in this domain?" This reframing opens the question to empirical investigation—it becomes possible to study a corpus of legal decisions and extract implicit threshold criteria, and to design MDDE-governed systems that accumulate sufficient delta data to make threshold determinations tractable.

The MDDE modification record is critical here. Because MDDE tracks every change to an artifact—who made it, when, what was modified, and under what authority—it provides the raw data from which ΔG can be computed. A system built on MDDE could alert stakeholders when an artifact's accumulated delta approaches a domain-specific threshold, enabling proactive attribution management rather than retrospective dispute resolution.

V. Implications

A. *For Systems Design*

GTT has direct implications for the design of systems that govern mutable digital artifacts. Systems built on the MDDE model should instrument the six delta dimensions, recording not merely that a change occurred but what kind of change it was and what its magnitude was along each dimension. Version control systems already capture something close to ΔS and ΔE; what is largely absent from current systems is capture of ΔF (functional change), ΔP (provenance change), and ΔC (contextual change). Extending MDDE-governed systems to capture these dimensions would enable automated threshold monitoring and reduce the attribution uncertainty that currently plagues collaborative digital artifact development.

The physical authentication layer in MDDE—Bluetooth proximity, wearable tokens—has a specific role in the GTT context: it binds ΔP measurements to verified human principals, addressing the emerging challenge of AI-assisted artifact evolution. When an AI system contributes to an artifact's modification, the physical layer ensures that a human steward has authorized and overseen that contribution, preserving the human authorship requirement that current copyright and patent law impose.

B. *For Intellectual Property Practice*

For IP practitioners, GTT suggests a new type of analytical tool: the *generational audit*. A generational audit traces the evolution of a digital artifact across its version history, measures ΔG across the six dimensions for each significant version transition, and maps those measurements to the applicable legal

TABLE I
MAPPING OF GENERATIONAL DELTA DIMENSIONS TO LEGAL AND TECHNICAL THRESHOLDS

Dimension	**Copyright Law**	**Patent Law**	**Data Provenance (PROV)**	**MDDE Framework**
Core object	Fixed expressive work	Novel, useful invention	Data entity + lineage	Governed mutable artifact
Change assumption	Static; fixity required	Static at filing date	Dynamic; tracked	Dynamic; governed
Threshold trigger	Originality spark	Non-obviousness	Version commit	Generational delta (ΔG)
Ownership model	Author-centric	Inventor-centric	Provenance chain	Stewardship chain
Physical layer	None	None	None	Bluetooth / wearable token
Mutable artifacts	Poor fit	Poor fit	Partial fit	Native support

threshold. Such an audit would be valuable both prospectively (when establishing authorship records) and retrospectively (when litigating an attribution dispute).

GTT also clarifies the relationship between improvement patents and derivative works for digital artifacts. An improved software system may simultaneously constitute a derivative work under copyright (if ΔE is sufficiently high) and a patentable improvement (if ΔF and ΔS are sufficiently high and non-obvious). The overlap between these frameworks—currently managed through separate legal proceedings—could be addressed more efficiently through a unified generational audit grounded in GTT.

C. *For AI-Assisted Creative Work*

The rapid growth of AI-assisted content creation makes the generational threshold problem more urgent. When a human uses an AI system to generate an initial artifact and then modifies it, the question of authorship turns on the extent and character of the human's contribution—precisely the question that ΔE and ΔP are designed to capture. Current guidance from the U.S. Copyright Office focuses on whether the human has exercised "sufficient creative control" [17], a standard that is functionally equivalent to asking whether the human's modifications exceed the copyright threshold. GTT provides a dimensional structure for that analysis that is more tractable than the current qualitative approach.

VI. CONCLUSION

This paper has introduced Generational Threshold Theory (GTT) as a framework for determining when an evolved digital artifact warrants an independent claim of authorship or inventorship. GTT defines generational delta (ΔG) as a composite measure across six dimensions—structural, functional, expressive, provenance, contextual, and temporal—and proposes that attribution thresholds be mapped to these dimensions within specific legal and normative frameworks.

GTT is grounded in the MDDE framework, which provides the technical architecture for governing mutable digital artifacts and the modification record from which ΔG can be computed. It is situated within a broader intellectual context spanning IS design theory, copyright law, and patent law. The framework addresses a gap that these bodies of knowledge have not jointly resolved: a principled, tractable basis for generational attribution in systems where digital artifacts evolve continuously.

Future work should focus on three directions. First, *empirical validation*: applying GTT's dimensional framework to a corpus of copyright and patent decisions to extract implicit threshold criteria and assess their consistency. Second, *system implementation*: extending MDDE-governed artifact systems to capture and expose the six delta dimensions in a form suitable for generational audit. Third, *policy development*: engaging legal scholars and practitioners in the design of GTT-informed attribution standards that can be adopted by IP registries, standards bodies, and courts.

Digital artifacts will continue to evolve. The frameworks governing their attribution must evolve alongside them.

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