

## Reconstructing Legal Responsibility for Digital Signatures: A Socio-Semiotic Perspective in Indonesian Cyber Law

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**ABSTRACT:** Digital signatures play a vital role in facilitating electronic legal transactions. Despite being regulated by various Indonesian laws, their effective implementation remains limited due to gaps in legal culture, institutional readiness, and technical validation. This study addresses two core questions: (1) How is the legal basis for digital signature protection situated within Indonesia's digital legal culture? and (2) How can a fair legal accountability model be developed? The study offers a novel interdisciplinary perspective by combining legal protection theory, social change theory, legal responsibility theory, and legal semiotics. It frames digital signatures as legal symbols whose meaning has yet to be fully internalized by legal institutions and society. Using a normative-critical and qualitative approach, the study gathers insights from legal practitioners, regulators, academics, and digital signature users through semi-structured interviews. The data are thematically analyzed to identify institutional gaps and social perceptions. Findings indicate that digital signature protection in Indonesia remains overly formalistic. In judicial practice, they are not consistently accepted as legitimate legal evidence. Moreover, there is no strong accountability framework for misuse or digital identity fraud. The study concludes that digital signature protection must go beyond statutory recognition. It requires building legal meaning within society through increased public awareness, technological integration, and institutional reform. The state must develop an inclusive, adaptive framework that unites law, technology, and legal culture to ensure justice and trust in digital legal interactions.

**Keywords:** Reconstructing Legal Responsibility, Cyber Law, Semiotic, Digital Signature.



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## INTRODUCTION

The transformation of the legal landscape driven by the rapid development of digital technologies has generated new forms of legal relationships, one of which is the use of digital signatures in electronic transactions. On one hand, this innovation offers efficiency, speed, and security. On the other hand,

however, the validity and evidentiary strength of digital signatures remain subjects of legal contention, particularly in Indonesia (Budianto, 2022a). The core issue lies in the absence of a robust national legal framework that ensures comprehensive protection of users' rights to digital signatures, coupled with the lack of uniform standards for their application within law enforcement and judicial institutions. This makes the topic particularly urgent, as legal digitalization has become inevitable in the era of technological transformation.

The proliferation of digital technologies has transformed multiple sectors, including the legal domain. One key innovation is the digital signature, which serves as a tool to authorize electronic documents. Dewi (2019) Although it has been legally recognized under Indonesia's Law on Electronic Information and Transactions (ITE Law), the implementation of digital signatures still encounters various barriers, including legal cultural constraints, institutional limitations, and challenges in judicial proof (Nurfadillah, 2025).

While digital technologies are praised for their speed, convenience, and accuracy, their limitations have become increasingly evident. Issues such as data security, privacy, and authentication are growing concerns in digital legal interactions. Equally important are the challenges of ensuring equitable access to digital tools and bridging the prevailing digital divide (Solihin, 2024). These transitions present both opportunities and legal complexities. In terms of signatures, electronic signatures have emerged as a new standard for legal and business transactions.

A signature functions as a marker of identity and authority, proving that a specific individual has participated in a legal transaction or agreement. In other words, a signature is a legal symbol that affirms both the existence and participation of a party. It may also serve as evidence that the content of a document has not been altered post-signing, thereby preserving the document's integrity. Additionally, a signature can verify that a copy of a document is an accurate reproduction of the original—an important function for legal authenticity in document duplication (Bany, 2022).

In legal practice, signatures provide formal validation and legal authority to documents, indicating that the signing individual or entity agrees to the content, and is legally bound by it (Hakim, 2022). In commercial law, a signature—or equivalent means of authentication—ensures that a document is legitimate and trustworthy under legal standards (Albaaits, 2023).

This research seeks to examine the legal protection of digital signature rights through a semiotic and socio-legal approach. The study is motivated by the growing legal challenges that arise from the gap between technological advancement and the readiness of legal culture—both societal and institutional. While digital signatures are technologically secure and normatively recognized, their legal standing is still frequently questioned in practice by law enforcement officials and the general public. This gap raises broader concerns over public trust in digital legal systems that are meant to improve legal certainty and efficiency.

Empirical evidence, both from Indonesia and internationally, points to the vulnerability of digital signature systems (Jayanti, 2005). Cases of forgery, identity misuse, and cryptographic manipulation

illustrate the inadequacy of existing legal protections. Notable incidents such as the 2009 Adobe Systems breach—where attackers accessed private signing keys and distributed malicious software as if it were official—highlight the risks (BBC, 2025). Similarly, the 2011 DigiNotar case in the Netherlands demonstrated how a breach of a certification authority allowed hackers to issue over 500 fraudulent SSL certificates, further undermining trust in digital validation mechanisms (Liebowitz, 2025).

The legal issues surrounding digital signatures are deeply complex, involving overlapping domains of information technology, civil and criminal law, and sociological dimensions of digital legal culture. The complexity is particularly visible in the disparity between formal doctrines of document authenticity and the institutional unpreparedness to accept digital evidence as valid. Even the courts often exhibit hesitation in treating digital signatures as legally binding. A multidisciplinary approach is therefore essential to understand and address the legal challenges posed by digital transformation.

Based on the above background, this study identifies two major problems: first, the legal protection for the use of digital signatures in Indonesia remains suboptimal; second, the legal responsibility framework for misuse is unclear. These issues contribute to legal uncertainty and risk weakening the reliability of electronic transactions in the digital society.

The research formulates two key questions: (1) How can the semiotic foundations of Indonesia's digital legal culture support the protection of digital signature rights? and (2) How can legal protection efforts be constructed based on the cultural context of Indonesia's digital society? These questions reflect the legal complexity arising from the paradigm shift from handwritten to digital signatures, especially in relation to evidentiary procedures and civil legal relationships.

To address these issues, the research applies three main theoretical frameworks. First, the theory of legal protection (Satjipto Rahardjo and P.A. Hamburger) is used to assess how the state should guarantee digital rights through both preventive and repressive legal mechanisms (Rahardjo, 2014). Second, the theory of social change (Erick, 1998; Nonet, 2017a; Rahardjo, 2014) is employed to explain how law must adapt to the social transformations caused by digitalization, including shifts in how individuals perceive signatures, identity, and legality (Erick, 1998). Third, the theory of legal responsibility (Calabresi, Posner, Cane, and Weinrib) is applied to explore how legal accountability may be constructed in cases of digital signature misuse, including through strict liability models (Calabresi, 1970). These theories are selected for their complementary capacities to address normative, sociological, and substantive justice aspects of digital law.

This study contributes both theoretically and practically by offering a legal framework that bridges normative doctrine with the realities of technological practice. It also presents a critique of legal formalism that has long dominated legal interpretations of electronic documentation. The research ultimately recommends a more adaptive legal model—one that is responsive to cultural shifts within Indonesia's digital legal landscape, and capable of safeguarding rights and building public trust in digital transactions.

## **METHOD**

This research employs a qualitative method with a normative-critical approach, combined with a socio-legal approach. This approach is used to examine the positive legal norms governing digital signatures in Indonesia while also analyzing the social practices and legal culture that shape how society and institutions interpret and implement those norms (Hayat, 2021). The study is both exploratory and reflective, aiming to understand the gap between normative texts and the reality of digital legal practice.

The research is situated within Indonesia's digital space, with data collected from sources such as libraries, the Ministry of Communication and Information Technology, and the Ministry of Law and Human Rights. These locations were selected due to the regulatory roles of both ministries in governing digital signature use, as well as the legal nature of digital signatures as actions requiring regulation and oversight by the Directorate General of General Legal Administration. Primary data collection sites include government institutions such as the Ministry of Communication and Information Technology, the National Cyber and Crypto Agency, or judicial institutions that hold legal documents related to digital signatures. Interviews with legal experts or IT practitioners were conducted either in person or online. Secondary data were gathered from the Jayabaya University library, online journal databases, news websites, and other media. Tertiary sources were obtained via internet search engines, online research databases such as JSTOR or PubMed, and official publications from international organizations such as the International Telecommunication Union (ITU) and the Organisation for Economic Co-operation and Development (OECD).

The primary research instrument was semi-structured interviews, used to explore the understanding, attitudes, and practical experiences of stakeholders regarding the legal protection of digital signatures. The choice of this instrument aligns with the qualitative approach, wherein the researcher serves as the main instrument (human instrument), directly interacting with informants to obtain in-depth and contextual data.

Data were collected through semi-structured interviews with informants including legal practitioners, technology and law regulators, academics, and digital signature users. The interviews were designed to explore the informants' views on the effectiveness of legal protection, barriers to implementation, and forms of accountability in digital signature use. Interviews were conducted both offline and online, recorded with consent, transcribed, and analyzed. Each interview followed a question guide tailored to the research focus, and the results were compiled narratively to map patterns relevant to this study.

The data collected were analyzed using a prescriptive qualitative analysis technique—namely, the analysis of qualitative legal materials to formulate recommendations for addressing specific problems. This analysis aimed to evaluate cases in order to formulate solutions and provide practical recommendations relevant to the issues examined in this study.

## **RESULT AND DISCUSSION**

### **The Semiotic Foundations of Indonesia's Digital Legal Culture in Protecting the Right to Digital Signatures**

Understanding the legal protection of digital signatures within Indonesia's digital society cannot be separated from the lens of legal semiotics, which emphasizes that legal symbols—such as digital signatures—derive their meaning from socially constructed interpretations (Mega Mustikasari, 2021). In this context, a digital signature is not merely a technical tool, but a legal sign that symbolizes identity, consent, and legal validity within electronic transactions.

From the standpoint of progressive and semiotic legal theory, digital signatures constitute a new legal symbol that carries the meaning of authorization, legal identity, and formal consent in the digital space (Efendi, 2024). However, in the Indonesian legal reality, such a symbol has not yet been fully internalized within the collective legal consciousness. Legal institutions and society remain strongly attached to traditional markers—wet signatures, physical stamps, and hardcopy documents—that are more easily understood within conventional evidentiary frameworks (Raihan Ade Izdihar, 2023).

John Perry Barlow's famous manifesto, *A Declaration of the Independence of Cyberspace*, asserts the autonomy of the digital world from government interference. Today, digital platforms have evolved into the epicenter of social, economic, and political life. These platforms represent various business models and corporate structures that dominate modern internet and mobile interactions (Barlow, 1996).

Legal theorists David Johnson and David Post, in their seminal work *Law and Borders: The Rise of Law in Cyberspace*, argued that cyberspace constitutes a unique geographic domain that challenges the territoriality of the nation-state legal order (Johnson, 1996). According to their theory, cyberspace is not merely a set of servers or networks—it is a social environment governed by its own norms and rules, forming a sui generis legal sphere.

In Indonesia, the use and legal validity of electronic signatures are regulated under the Electronic Information and Transactions Law (UU ITE), which provides a normative framework for digital signatures in electronic transactions. A signature represents the legal identity of the signer and is used to validate documents (Sterisa, 2025). The individual who signs a document assumes legal responsibility for its contents. Thus, the signature functions not merely as part of the transaction content, but as a legal representation of the act itself.

Signatures—whether physical or digital—are part of the legal habitus, providing symbolic and juridical meaning. Drawing from Bourdieu's theory, the signature can be understood as a form of symbolic capital within the legal field (Mustikasari, 2023). This perspective clarifies how signatures operate within legal processes and how their meaning is shaped and interpreted within juridical structures.

This study finds that the legal meaning of digital signatures remains underdeveloped within Indonesia's legal culture. Many legal actors—including law enforcement, courts, and the public—continue to

equate legal validity with tangible symbols such as wet signatures and physical stamps. This indicates that, semiotically, digital signatures have not yet been widely accepted as “legal signs” carrying recognized and binding authority within Indonesia’s collective legal consciousness (Budianto, 2022b).

In the framework of legal protection theory, this condition reflects a failure of the state to provide substantive legal protection—one that goes beyond the mere existence of normative regulations. Satjipto Rahardjo argued that the law must be more than textual; it must live within social reality. Protection of digital signature rights should not rely solely on statutory provisions, but must also involve the social construction and recognition of legal meaning by both the public and institutions (Nurdiansyah, 2024).

Moreover, from the perspective of social change theory, the limited acceptance of digital signatures reveals a legal culture resistant to the introduction of new digital symbols. As noted by Nonet and Selznick, a responsive legal system must be capable of accommodating social transformations (Nonet, 2017b). Therefore, the formation of a semiotic foundation for protecting digital signature rights must be seen as part of a broader transformation of Indonesia’s digital legal culture.

This discrepancy demonstrates that the semiotic evolution of law remains incomplete. Digital signatures have yet to become widely accepted legal signs. Most judges, law enforcement officers, and segments of society still do not regard them as authoritative legal symbols. This signals that the construction of new legal symbols requires further strengthening through legal education, institutional support, and the systematic internalization of digital legal norms.

### **Legal Protection Efforts for Digital Signature Rights within the Legal Culture of Indonesia’s Digital Society**

Legal protection efforts for digital signatures must transcend a purely formalistic legal approach that focuses solely on the existence of statutory provisions. This study reveals that despite normative recognition through the Electronic Information and Transactions Law (ITE Law) and other technical regulations, the actual protection of digital signature users remains weak in practice (Izdihar, 2023). This is largely due to limited understanding among law enforcement personnel, the absence of binding technical guidelines, and a lack of collective awareness regarding the legal validity of digital instruments.

Electronic signatures aim to achieve efficiency and flexibility by allowing various forms of authentication—such as public key cryptography and bilateral trust—without necessarily requiring a trusted third party (Revi Fajar Marta, 2008). In principle, the law does not mandate a specific method for signing, but rather any method that fulfills the functions of authentication, attribution, and validation may be accepted.

While regulatory frameworks such as the ITE Law, Government Regulation on Electronic Systems and Transactions (PP PSTe), and the regulations issued by the National Cyber and Crypto Agency



(BSSN) exist, the study finds that protection of user rights remains fragmented, non-operational, and overly textual. Law enforcement agencies currently lack standardized procedures to assess the legal validity of digital signatures, leading to inconsistent and subjective enforcement practices (Hayat, 2021b).

From the standpoint of legal protection theory, this reflects a failure to deliver either preventive or repressive forms of protection effectively. As Satjipto Rahardjo emphasizes, the mere existence of law does not guarantee real legal protection unless the law functions as a liberating force—one that adapts to societal needs and prevents potential harm. Therefore, the right to a digital signature can only be meaningfully protected when the law operates substantively, not just procedurally (Yanto, 2020).

According to social change theory, legal protection for digital rights in a digital society requires acknowledgment of evolving norms and patterns of social interaction. As Ewick and Silbey argue, law operates within narratives, experiences, and identities (Mara, 2001). Hence, legal protection strategies must include public education, increased digital legal literacy, and the integration of legal technology into the existing legal culture.

From the perspective of legal responsibility theory, this study also reveals the absence of a clear liability mechanism in cases of digital signature misuse—whether due to system manipulation, identity theft, or negligence on the part of service providers. This regulatory gap creates injustice for victims (Windari, 2015). In such cases, the application of strict liability becomes crucial to ensure both legal certainty and substantive justice. As Calabresi and Posner suggest, responsibility should fall not on the victim, but on the party best positioned to prevent the harm—the "cheapest cost avoider," such as digital technology providers or cybersecurity administrators (Sugianto, 2014).

Therefore, protecting digital signature rights within Indonesia's digital legal culture demands a comprehensive design that includes: reconstructing the meaning of digital legal instruments (semiotic approach), institutional and cultural transformation (social change approach), and the development of a progressive and justice-oriented accountability regime (legal responsibility approach).

Strong legal protection must be based not only on normative texts, but also on a fair, preventive, and measurable liability system. The state must act as the primary guardian of the digital legal order—ensuring trust and justice in cyberspace, especially as new legal symbols like digital signatures become foundational to legal infrastructure in the digital society (Handoyo, 2024).

This research reveals a series of findings that reflect the legal complexity surrounding the protection and accountability mechanisms for the use of digital signatures in Indonesia's digital society. These findings are organized into several key aspects:

First, there is a gap between normative recognition and practical implementation of digital signatures. Although legal instruments such as the ITE Law, Government Regulation No. 71 of 2019, and BSSN regulations provide a formal legal framework recognizing the existence and enforceability of digital signatures, operational legal protection remains absent at the level of law enforcement. Legal

practitioners acknowledge that digitally signed documents are often treated as inferior to physical, handwritten signatures, particularly in civil and criminal proceedings.

Second, from an institutional standpoint, a lack of coordination persists among key actors in the legal system—courts, law enforcement agencies, regulatory bodies (such as Kominfo and BSSN), and digital signature service providers. This dissonance creates ambiguity in assessing validity, authentication mechanisms, and legal responsibility for misuse incidents. The absence of a standardized technical protocol leads to legal interpretations that depend heavily on the subjective judgment of judges or investigators, ultimately creating legal uncertainty.

Third, in terms of legal culture, resistance and distrust toward digital instruments as valid legal tools remain prevalent. Many informants note that low levels of legal digital literacy—both among the public and law enforcement—pose a major barrier to the acceptance of digital signatures. This suggests that new legal symbols like digital signatures have yet to be fully integrated into the semiotic structure of Indonesia's legal culture, causing the meaning of legality to remain vague and contested.

Fourth, in the context of legal responsibility, the study finds that the existing legal framework does not provide clarity regarding who should be held accountable for the misuse of digital signatures. The current liability regime still relies on traditional fault-based models, while most violations stem from systemic vulnerabilities rather than individual misconduct. Informants thus recommend adopting a strict liability approach to ensure fairer protection for victims and to compel service providers to maintain secure and trustworthy systems.

Fifth, transnational legal issues emerge when digital signature service providers or their servers are located outside Indonesia's jurisdiction. In such cases, victims struggle to access effective legal remedies, and Indonesia's national legal system lacks responsive mechanisms to address cross-border digital conflicts. This underscores the urgency of legal reforms that are not only national in scope, but also oriented toward extraterritorial responsibility and cross-border legal interoperability.

Sixth, from a theoretical perspective, the findings highlight that a formalistic-legalistic approach to assessing evidence and assigning responsibility in digital contexts is no longer sufficient. An alternative approach based on legal semiotics is needed, one that sees law not merely as a normative text, but as a dynamic system of meaning embedded in social and cultural structures. Likewise, a socio-legal approach is essential for understanding that digital society is no longer anchored in physical presence or traditional authentication, but operates through electronic systems of trust.

Overall, these findings show that the main challenge in protecting digital signature rights lies not only in regulatory gaps, but in the unpreparedness of the legal system and its culture to transform in accordance with digital logic. A fundamental reconstruction of legal norms and accountability models is required—integrating formal legal understanding with the new symbolic infrastructure of digital legality.



The legal discourse surrounding digital signatures has gradually drawn attention from both scholars and practitioners in Indonesia, although much of the literature remains focused on normative or technical perspectives. Prior research—such as that of Nusye Kusuma Indah in her 2005 thesis titled “Digital Signatures as Valid Evidence in International Trade Transactions in Electronic Commerce” primarily addressed the normative use of digital signatures in e-commerce. Her study emphasized the legal standing of electronic money and digital signatures as valid evidentiary tools in international transactions. Although informative, the analysis remained limited to commercial law and did not explore the semiotic or philosophical dimensions of legal meaning in digital society.

Similarly, a paper presented at the 2019 National Seminar INOBALI by Sang Ayu Made Ary Kusumawardhani from Universitas Dwijendra, entitled “The Legal Strength of Digital Signatures in Civil Dispute Evidence Based on Law No. 11 of 2008”, focused on how electronic transactions—under Article 1 paragraph (9) of the ITE Law—are defined as legal relations conducted via electronic media. The study highlighted the use of digital signatures as authentic written evidence in shareholder resolutions (RUPS), but its primary lens was procedural validity under civil procedural law.

In another study, Abdur Rachman from the Master of Notary Program at the University of Surabaya, through his 2021 article in *Jurnal Education and Development* titled “The Legal Validity of Digital Signatures in the Creation of Fiduciary Deeds”, analyzed whether digital notarial acts conducted via cyber notary systems could be equated with authentic deeds. He concluded that such instruments still lack the formal and material requirements prescribed by statutory law, and thus cannot be deemed equal to authentic deeds under Indonesian legal doctrine (Rachman, 2021).

Across these studies, a common pattern emerges: traditional legal thinking remains bound to physical manifestations of legal actions—such as verbal consent, handshakes, inked signatures, or thumbprints. In contrast, the digital space allows for legal acts to be performed virtually, without physical presence. This shift raises deeper questions about how Indonesian legal culture interprets and accepts the digital signature as a legitimate legal symbol, and whether it carries the same evidentiary and normative weight as its physical counterpart.

The growing body of legal scholarship underscores the need for a more comprehensive and philosophical inquiry into the legal meaning of digital signatures—especially concerning identity rights, evidentiary authority, and technical reliability. These challenges call into question long-standing assumptions within Indonesian legal tradition, and demand a legal philosophy that is compatible with the evolving character of digital transactions.

This study has several limitations that must be acknowledged to contextualize the findings appropriately. First, the research adopts a qualitative approach based primarily on semi-structured interviews with selected informants. While this method offers deep contextual insights, it may not capture the full spectrum of legal actors’ perspectives or industry-wide practices. The purposive selection of informants also introduces potential bias, especially concerning their professional backgrounds and familiarity with digital legal technologies.

Second, the study is specifically focused on Indonesia's legal and cultural context, making generalization to other jurisdictions limited. Although international norms and comparative principles are occasionally referenced, the analysis remains firmly rooted in local socio-legal realities.

Third, the research relies heavily on legal interpretation and thematic synthesis of qualitative data. As such, the analysis is shaped by the researcher's theoretical orientation and may differ if alternative frameworks or disciplinary lenses were applied. Furthermore, since the study does not employ quantitative methods, its conclusions are exploratory rather than statistically conclusive.

Given the dynamic nature of both regulation and digital technology, several of the legal gaps identified in this study may evolve rapidly due to future legislative reforms, jurisprudential developments, or technological innovation. The findings should therefore be read as a snapshot of Indonesia's legal system during a transitional period in its digital transformation.

Based on the findings and limitations described above, several directions are recommended for future research:

1. Mixed-method studies should be conducted to provide a broader understanding of public perceptions, legal practitioners' experiences, and industry practices concerning the use and validity of digital signatures. Quantitative data could complement this study's qualitative insights by offering statistically significant findings.
2. Further research is needed on the effectiveness of technical regulations and the role of electronic certification authorities (PSEs), particularly in ensuring integrity, security, and public trust in digital signature systems. This remains an underexplored area in the context of public-private governance of digital legal infrastructure.
3. Cross-border legal accountability should be investigated, especially regarding digital signature services hosted outside Indonesia. Comparative and transnational legal research could help establish frameworks for extraterritorial responsibility and legal interoperability in global digital transactions.
4. Interdisciplinary legal research combining law, information technology, and social sciences should be prioritized to develop normative frameworks that are adaptive and responsive to digital complexity. Law must evolve not only reactively but also proactively to shape the direction of digital transformation with justice in mind.
5. Future research may also explore issues of distributive justice and digital accessibility, especially for vulnerable groups or regions lacking digital infrastructure. Digital legal development must not only be normatively sound but also socially inclusive.

## **CONCLUSION**

This study investigates legal responsibility and protection mechanisms for the use of digital signatures within the Indonesian legal framework, with a particular emphasis on socio-semiotic dimensions and

the legal culture of digital society. The objective of the research is to critically evaluate how digital signatures are recognized, legitimized, and protected—both normatively and in legal practice.

The findings reveal a persistent gap between formal legal recognition and social acceptance of digital signatures. Although legal instruments such as the Electronic Information and Transactions Law (ITE Law) and its implementing regulations provide a normative basis for digital signatures, these instruments continue to be challenged both culturally and institutionally. Specifically, this study contributes a novel analytical framework grounded in legal semiotics, which helps explain the failure of digital signatures to function as collectively accepted legal symbols within the Indonesian legal system.

These results underscore the importance of legal reform that not only keeps pace with technological advancement, but also addresses the symbolic legitimacy and cultural readiness of the legal system. This study recommends practical reforms including enhanced digital legal literacy, the establishment of operational technical standards, improved institutional coordination, and the implementation of a strict liability regime to ensure justice for victims of digital system misuse.

While the study offers significant insights into the complex dynamics between law, technology, and digital culture—particularly regarding digital signatures—it also acknowledges several limitations. First, the qualitative approach and purposive selection of informants may not fully capture the diverse range of stakeholder perspectives. Second, the focus on Indonesia's domestic context limits the generalizability of findings to other jurisdictions with differing legal systems and cultural environments.

Future research is encouraged to develop comparative cross-jurisdictional frameworks for legal responsibility in digital technology use, integrate quantitative approaches to map broader public and institutional perceptions, and explore the role of international cooperation in building responsive and inclusive digital legal infrastructures. In doing so, subsequent studies may enrich the understanding of digital legality and support the development of legal policies and practices that are culturally sensitive and technologically adaptive in an increasingly interconnected world.

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