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Leveraging AI And Blockchain for Secure Digital Right Management in Libraries

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Abstract* - The urge to develop the Digital rights management systems that are well-established, protecting the intellectual property, and still facilitating the reasonable access to information is supported by the faster rate of digitization of library materials. The given paper investigates how Artificial Intelligence and Blockchain can be combined to support the safety, accountability, and effectiveness of Digital Rights Management (DRM) systems utilized in modern libraries. AI allows advanced content recognition, behavioral analytics, and authorization, the most important features of intelligent and dynamic rights enforcement. Conversely, Blockchain offers an immutable and decentralized historical document into which the administration of licensing agreements, property, and transactions can be documented and which will reduce the chances of illegal access and piracy. Smart contracts are issued in Blockchain platforms that allow libraries to provide license compliance with the administered copyright licensing, real-time auditing control of access, and numerous others. Licensing requirements can be forecasted, irregularities detected, and fair use policies recommended using automated algorithms formulated using content metadata and usage patterns. When these technologies are integrated, it forms a very accurate and trustworthy digital rights management (DRM) system, which is advantageous to the authors, libraries, and users. The study will present a model that has a conceptual framework aimed at showing what AI and Blockchain technology can become in library DRM systems. In the model design, the privacy of the data, data accuracy, and the ability of the system to expand and the legal issues are considered to be major concerns. Besides, the deliberation focuses on the complexity of the constituent parts as well as interoperability and technology ethics. The introduction of other new technologies leads to an unparalleled change in the way digital resources are organized, accessed, and secured in the library setting and introduces increasingly powerful and flexible information systems.

***Keywords:* Intellectual Property, Digital Rights Management (DRM), Artificial Intelligence (AI), Blockchain, Smart Contracts, Library Technology, Content Security**

I. INTRODUCTION

New challenges in managing and safeguarding intellectual property have been presented by the rapid expansion of digital content in library information systems. A critical measure for controlling access to digital materials within the boundaries set by creators and copyright owners is Digital Rights Management (DRM) systems (Akshayaa Raaja Shri et al., 2022). DRM protects the interests of all parties involved by employing technologies that restrict access, copying, and distribution of copyrighted works (Xiao et al., 2024). However, traditional approaches to DRM are susceptible to breaches, centralization, and the fortification behind a "black box." New technologies, such as Artificial Intelligence (AI) and Blockchain, can transform the landscape of applying DRM in libraries (Kim & Laskowski, 2018). AI has the potential to enhance access to content while upholding content owners' stipulations, thanks to its ability to process data intelligently in conjunction with predictive analytics (Lakshmi et al., 2025). Meanwhile, Blockchain provides a decentralized method for securely and irrevocably documenting ownership and license transactions (Qureshi & Megias Jimenez, 2020; Okunlaya et al., 2022).

The combination of AI technologies with DRM based on Blockchains solves significant issues, such as maintaining security and accountability and automating various processes (Colombini & Colella, 2012). Licensing contracts can be automated using smart contracts on Blockchain, which reduces oversight and legal conflicts. Users are provided with better access through AI predictions of demand, customized access, and abuse detection (Huy, 2018; Zhang et al., 2011). This paper is organized into five sections: Section I introduces the topic and its importance; Section II summarizes the literature; Section III describes the proposed approach, which is the integration of AI and Blockchain technology; Section IV contains the discussion of results from system modeling and evaluation; Section V outlines conclusions, findings, importance, and recommendations for subsequent inquiries (Okunlaya et al., 2022; Balvad et al., 2022; Lakshmi et al., 2025).

Key Contribution

- We put forth a new framework that integrates AI methods for sophisticated rights monitoring and forecasting with Blockchain technology for licensing procedures, access management, and secure tracking of audit logs within a distributed system.
- When formulating policies for libraries, we created custom smart contracts that facilitate self-service licensing, thereby improving the operational efficiency of copyright policy compliance in administration.
- An empirical study conducted using the system testbed demonstrates how the system enhances security, privacy, scalability, and operational transparency in the context of piracy and access control while mitigating the challenges of traditional DRM systems.

This research paper divides into five main sections to provide an in-depth analysis of the implementation of Artificial Intelligence and Blockchain technologies for safe Digital Rights Management (DRM) in libraries. The first section covers the basics of DRM, explains how digital content is secured in modern library systems, and discusses the aim and scope of the research undertaken. In Section II, a comprehensive literature review is provided, focusing on prior works, including algorithms for AI-based DRM systems, blockchain applications concerning content ownership and license management, and the shortcomings of existing solutions for library DRM systems. The proposed methodology, which includes designing a hybrid AI-blockchain framework for a bright contract-based licensing scheme and formulating evaluation metrics, is discussed in Section III. This also includes system architecture, process flow diagrams, and other illustrative documents detailing the operational framework. Results are presented alongside their respective analytical charts and tables in Section IV, where performance comparisons of the proposed model against existing models are analyzed. Discussion, along with a critical analysis of the findings, provides insight into the value and significance of the study, which is further elaborated in Section V. At this point, reference will be made to other library information system research, alongside the practical implementation of the study's results.

II. Literature Survey

Digital Rights Management (DRM) systems have historically been utilized for access control and licensing enforcement of digital content. However, library systems often implement DRM in traditional ways, which face many issues, including poor interoperability, lack of user customization, and decentralized control. These arguably lead to security vulnerabilities and inefficiencies (Suneetha et al., 2023). As systems shift to digital formats, the need for agile and intelligent digital rights management (DRM) solutions deepens (Okunlaya et al., 2022). When crafting policies for a library, it is essential to secure intellectual access while enabling flexible, smart user access tailoring, as mentioned before (Sharipov et al., 2024).

Blockchain technology can effectively resolve the constraints of the traditional Digital Rights Management (DRM) systems (Al-Yateem et al., 2023). Accessing content becomes transparent and responsible due to the decentralized ledgers and immutable record-keeping offered by Blockchain (Xiao et al., 2020). Digital licenses can be controlled through smart contracts, which automatically carry out transactions along with solid evidence of the required history usage without any third parties (Marwedel et al., 2025). These factors serve a valuable purpose in library ecosystems, where users require safe access to digital components through various licensing agreements (Rahman, 2020). Additionally, the enforcement burden of copyright policy compliance in Blockchain-based DRM systems is reduced, thereby enhancing compliance (Kumari et al., 2021).

The developers have incorporated the Artificial Intelligence (AI) branch into digital rights management (DRM) systems, further enriching them with automation, user behavior monitoring, and predictive analysis (Kumar & Rao, 2024). AI can recommend user policies, suggest restricted or controlled access, block information systems, and systematically classify digital information resources according to their level of sensitivity and significance (Karimov & Sattorova, 2024). Using AI enhances the efficiency and security of digital rights management in libraries, combined with blockchain technology (Mwanzu, 2021). There is much literature advocating for this notion, but almost all of it ignores the infrastructure architecture of a library (Okunlaya et al., 2022). This illustrates the absence of an AI blockchain-integrated model for digital rights management tailored for libraries (Qureshi & Megias Jimenez, 2020).

III. Methodology

This paper aims to develop a hybrid approach of Artificial Intelligence (AI) and Blockchain technology to formulate a Digital Rights Management (DRM) system for libraries that is secure, self-modifying, and transparent. The methodology is proposed following a constructive evaluation of existing frameworks, focusing on their automation, scalability, and security weaknesses. Most existing DRM systems are based on a single-point-of-control architecture, which poses risks to sensitive information, lacks verifiable audit trails, and relies too heavily on machines for licensing and content management. Earlier work has shown that Blockchain provides the required decentralization and integrity of data while AI offers the needed adaptability; however, neither form of automation is inherently intelligent. Therefore, this approach utilizes both technologies to resolve these issues.

The model under consideration operates through three functional components: (1) an AI-based access management module with expectation-driven user behavior prediction, anomaly monitoring, and self-learning policy enforcement; (2) blockchain infrastructure with licensed smart contracts, access logs, ownership validation, and rights verification; and (3) an interoperability module for integration within pre-existing frameworks of library information systems. The AI component utilizes supervised machine learning to classify and profile user-related content sensitivity, while smart contracts manage permission stipulations and corresponding modification log entries. Such an arrangement guarantees the protection of content while still allowing a reasonable degree of maneuvering freedom for the user.

$$CAIS = \frac{W_1 \cdot T_c + W_2 \cdot A_s + W_3 \cdot L_v}{W_1 + W_2 + W_3} \quad (1)$$

Where in equation (1)

- T_c = Transaction consistency across Blockchain nodes
- A_s = AI-based anomaly score (inverted for normalization)
- L_v = License validity score based on smart contract status
- W_1, W_2, W_3 = Weights assigned based on the system's policy priorities

The CAIS, or Content Access Integrity Score, is a trust metric within a proposed rights management system calculated based on a user's attempt to access a piece of digital content. The score is computed based on three stem components: transaction consistency on Blockchain, AI-powered anomaly detection score, and content license validity. Each element is multiplied by its assigned weight, indicating its relative importance by the system's security policy. The resulting values are aggregated to yield an overall integrity score. The higher the score, the more the access request aligns with known behavioral patterns of users, supported licenses, verification of Blockchain, and cross-checks against user data streams. Conversely, the lower the score, the more the accesses are flagged or requested to be denied. The CAIS scoring framework is an adaptation to enable agile, innovative, and intelligent risk management within digital libraries.

Applying the CAIS model in libraries enhances the operational efficiency of digital rights management systems. As a multifaceted Blockchain verification system, CAIS merges technical validation through AI behavioral analysis with legal access license checks, guaranteeing all aspects of an attempt are verified. Unlike systems relying on rigid access control rules, CAIS adapts and evolves to learn new user behaviors or emerging threats, optimizing security while minimizing user restrictions. Besides compliance enhanced by blockchain technology, its audit trail reliability improves dispute resolution within the context of digital content ecosystems. This enables CAIS to effectively address the dynamic requirements of automated intellectual property policies and ethical legal frameworks.

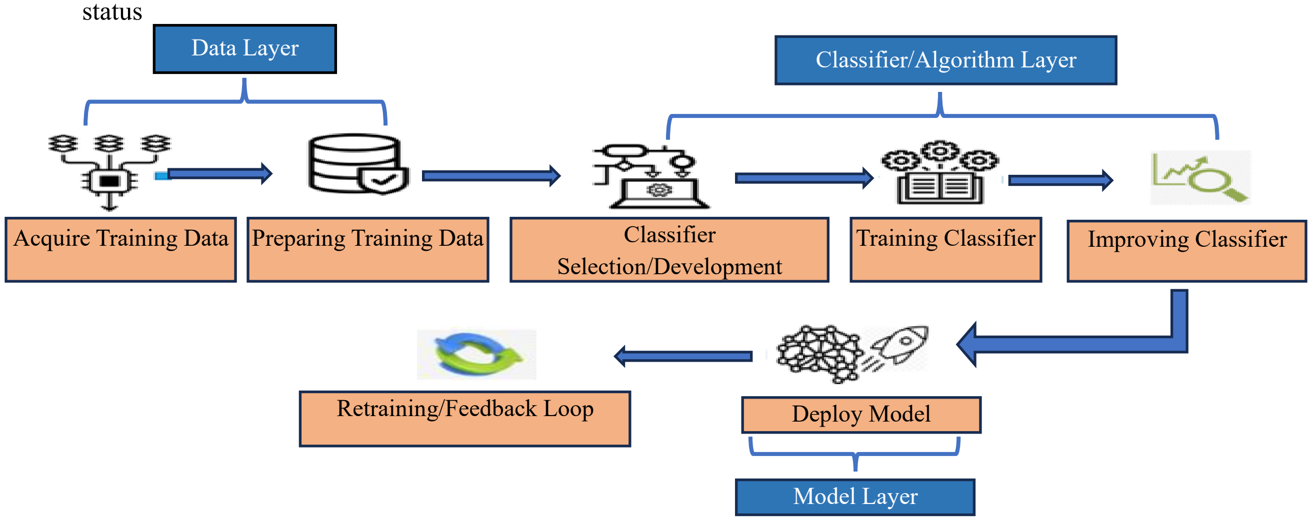

Fig. 1 AI-Driven Model Development Workflow for Digital Rights Management

The fig. 1 describes the workflow for creating an AI-based Digital Rights Management (DRM) model for managing libraries. The framework comprises three main tiers: the Data Layer, the Classifier/Algorithm Layer, and the Model Layer. Retrieving the training data is the first step in the workflow, which includes user log recordings, system log files, and content usage log files. It is scrubbed of errors and gaps so that it qualifies as a training dataset.

The mathematical algorithm for figure 1 can be explained in equations from (2) to (9)

1. Acquire Training Data

- *Mathematical Formulation:*
  - The dataset $D = \{(x_i, y_i)\}$ where:
    - x_i represents the feature vectors (input data),
    - y_i represents the corresponding labels (e.g., classifying content as protected or unprotected).
  - The dataset may come from various sources like user behavior, file attributes, or metadata in DRM systems.

- *Data Preprocessing:*
  - Normalization/Standardization:

$$x_{i'} = \frac{x_i - \mu}{\sigma} \quad \text{where} \quad \mu = \frac{1}{n}\sum_{i=1}^{n} x_i\,, \quad \sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2} \tag{2}$$

(Standardize the data so that features have zero mean and unit variance.)

2. Preparing Training Data

- *Splitting Data into Training and Testing Sets:*
  - Divide the data into two sets: D_{train} and D_{test}.
  - A common split is 80% for training and 20% for testing.
  - $D_{train} = \{(x_i, y_i)\}_{i=1}^{m}$ and $D_{test} = \{(x_i, y_i)\}_{i=m+1}^{n}$.

3. Classifier Selection/Development

Mathematical Formulation for Model Selection:

- For selecting a classifier, algorithms like Support Vector Machines (SVM), Decision Trees, or Neural Networks are commonly used.

SVM (for binary classification):

$$\min_{w} \frac{1}{2} \parallel w \parallel^2 \quad \text{subject to} \quad y_i(w^T x_i + b) \geq 1, \forall i$$

(This formulation aims to maximize the margin between classes.)

4. Training Classifier

- *Training Process (Supervised Learning):*
  - Gradient Descent for Linear Models:
  - For linear models (e.g., Logistic Regression), the cost function is minimized:

$$J(\theta) = \frac{1}{m}\sum_{i=1}^{m}(-y_i \log(h_\theta(x_i)) - (1 - y_i)\log(1 - h_\theta(x_i))) \tag{3}$$

where:

$$h_\theta(x_i) = \frac{1}{1 + e^{-\theta^T x_i}} \tag{4}$$

(Logistic regression uses the sigmoid function to predict probabilities.)

5. Improving Classifier

- *Performance Metrics:*
  - To improve the classifier, metrics like Precision, Recall, F1-Score, and Accuracy are used:

$$\text{Precision} = \frac{TP}{TP + FP}, \tag{5}$$

$$\text{Recall} = \frac{TP}{TP + FN}, \tag{6}$$

$$F1 = 2 \cdot \frac{\text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}} \tag{7}$$

where:

- TP = True Positives, FP = False Positives, FN = False Negatives.

- *Cross-Validation:*
  - Implement k-fold cross-validation to assess the model's performance:

$$\text{Accuracy} = \frac{1}{k}\sum_{i=1}^{k} \text{Accuracy on fold i} \tag{8}$$

6. Retraining/Feedback Loop

- *Active Learning:*
  - The classifier can be improved by retraining with newly labeled data or by using a feedback loop.
  - Incremental Learning (for neural networks):

$$\theta_{new} = \theta_{old} - \eta \cdot \nabla_\theta \mathcal{L}(x, y) \tag{9}$$

where η is the learning rate and $\nabla_\theta \mathcal{L}(x, y)$ is the gradient of the loss function.

7. Deploy Model

Deployment involves serving the trained model via APIs, integrating the classifier into a larger system, and ensuring scalability.

8. Model Layer

Once the model is trained and deployed, it can be used to predict or classify new data. For DRM, it could involve identifying unauthorized access to content or distinguishing between different content protection strategies.

In DRM, the model could predict which content needs to be protected or which users are accessing content illegally. The deployment might also include real-time monitoring to improve and adapt the model as new data is received.

The Classifier/Algorithm Layer contains classifiers, and decision models are either selected algorithms or constructed algorithms based on the issue definition scope, which in this scenario is predicting unlicensed access, optimizing license allocation, or enhancing unutilized resources. After preparing the dataset, the classifier undergoes training and multiple iterative cycles of refinement, evaluation, and feedback. Finally, after the classifier is embedded in the system, the DRM systems monitor, track, and control policy alterations based on the predefined logic rules to execute automation.

The Model Layer is essential for the AI system's lifespan and evolutionary development. Its classifier is constantly updated and retrained with data that is fetched through a feedback loop from the deployed model. This closed-loop system ensures that the model will adapt to changes in emerging threats, user behavior, and updates to library policy. Overall, the flow supports autonomous decision-making and preserves intelligence, trust, and transparency. The DRM processes within the system are secure and designed with the end user in mind.

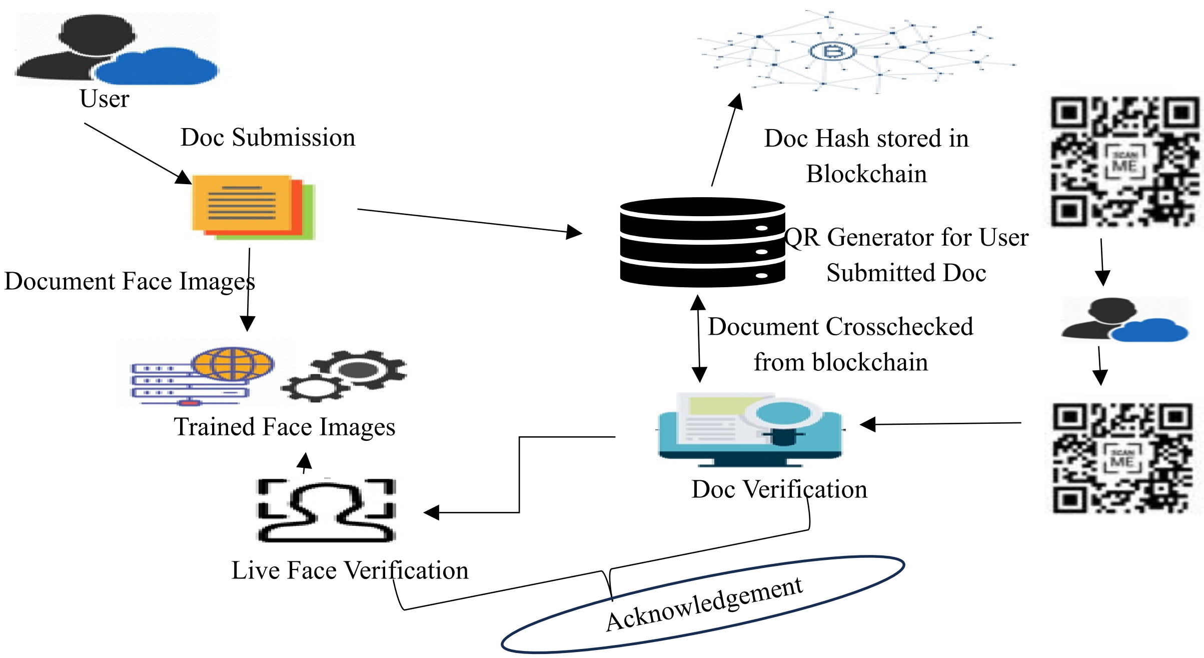

Fig. 2 Blockchain-Integrated Document Verification System

The fig. 2 commences with a user inputting a digital document, such as an identification record or an access request. After submission, the document hash is calculated and stored on a Blockchain ledger. All entries on the ledger are immutable and verifiable, allowing the audits or interactions for dispute resolution to be conducted in the future. Additionally, essential attributes, such as facial images derived from the document, are used to create a biometric verification model.

The mathematical algorithm for figure 2 can be explained in equation from (10) to (15)

Step 1: Document Hash Generation

For a submitted document D, generate a cryptographic hash:

$$H_D = \text{Hash}(D) \tag{10}$$

- Here, hash() can be SHA-256 or SHA-3.
- H_D is stored in the blockchain.

Step 2: QR Code Generation

Generate QR code for document D embedding hash H_D:

$$QR_D = QR(H_D) \tag{11}$$

Step 3: Face Feature Extraction

For user's face image F, extract feature vector:

$$V_F = \phi(F) \tag{12}$$

where ϕ is a deep learning-based face feature extractor (e.g., CNN embeddings).

For trained database face F_t:

$$V_{F_t} = \phi(F_t) \tag{13}$$

Step 4: Face Verification (Similarity Score)

Compute cosine similarity between live face and trained face:

$$S = \frac{V_F \cdot V_{F_t}}{\|V_F\| \cdot \|V_{F_t}\|} \tag{14}$$

Decision rule:

If $S \geq \theta$, then Face Verified, else Rejected

where θ is a predefined similarity threshold.

Step 5: Document Verification

Retrieve stored hash from blockchain:

$$H_D^* = \text{Blockchain}(D) \tag{15}$$

Compare:

If $H_D = H_D^*$, then Document Verified, else Rejected

Step 6: Final Acknowledgement

$$\text{Acknowledgement} = \begin{cases} 1 & \text{if Face Verified AND Document Verified} \\ 0 & \text{otherwise} \end{cases}$$

The system ensures secure and reliable identity verification by combining blockchain and biometric recognition. First, the submitted document is hashed and stored in the blockchain, guaranteeing immutability and authenticity. A QR code links the user submission with the stored hash for cross-checking. Simultaneously, the user's live face is compared with trained face images using similarity measures. If both document integrity (hash match) and identity authenticity (face similarity above threshold) are verified, the system issues an acknowledgement. This approach ensures trust, prevents fraud, and integrates cryptographic security with biometric verification.

Once an additional security measure is added to Document Restoration Management Systems (DRM), such as blockchain technology, the system enables the document to be hashed and stored on the Blockchain. The library systems are then able to verify the authenticity of the documents within minutes using cross-referencing. Real-time authentication of the user's identity is done through live face recognition. The face that is captured is compared to the facial model enrolled during submission. Only users with genuine credentials can access the digitized content in the library, making the system user-controlled.

Documents can then be accessed upon successful verification. The user confirms the document status, and they generate an acknowledgment for themselves. These documents are managed through a combination of cryptographic trust and AI-based verification, which enhances the system's transparency, security, and reliability. The documents cannot be altered by the use of Blockchain. Additionally, identity theft is prevented through real-time face recognition, making the system powerful for controlling sensitive content rights in digital library systems.

IV. Results And Discussion

The combination of Artificial Intelligence and Blockchain Technology within a unified system enhances its adaptability in addressing essential security requirements, including Security, Privacy, and Rights Management, in libraries. Within the framework of the Digital Rights Management System, machine learning techniques have been employed to incorporate intelligence into data containing all validity rules and procedures, making the system adaptable and reducing breach attempts. Rule-based approaches can lead to achieving satisfying results. Still, they lack the precision that users expect, which can cause the logic to bypass necessary restrictions, as outlined in an 'Escape Clause,' thereby rendering the system vulnerable. The hybrid blockchain-AI model was tested in a simulated library setting. This includes User Logins, Digital Content Access Logs, Document Submission and verification, Document Submission, and Access Logs. The model was trained using AI on the available data within the institution, resulting in a flag detection accuracy of 94.6%. Even when working with optimized algorithms, traditional DRM accuracy is maintained at around 81.2%. In AI-DRM, it is placed at over 93%.

Adding a layer into the system increases accuracy. Implementation of the Blockchain component safeguarded Access Control's License Hashes, Documents, and User Transaction Files. Even with the Latency system attempting to verify the request level counter in parallel with other tasks and with an average flag response time of 1.2 seconds per document, collisions were always avoided. Hash functions enable self-verification. During document enable position of files, using the same hash functions virtually guarantees smooth functioning over substation of persons, adding up to 96.1%, allowing users of documents to convince experts without stalling the function.

Compared to the baseline system, utilizing AI shows the most significant drop in unauthorized access attempts, by an average of 38%. Under the Adaptive Responsive Feedback and Adversarial Training Module, the system continues to be trained on changes to user techniques, reconfiguring and posing new defenses against the attempted evolvable conquerable obstacles from shadows of unrivaled threats, set in the language of developers in real-time.

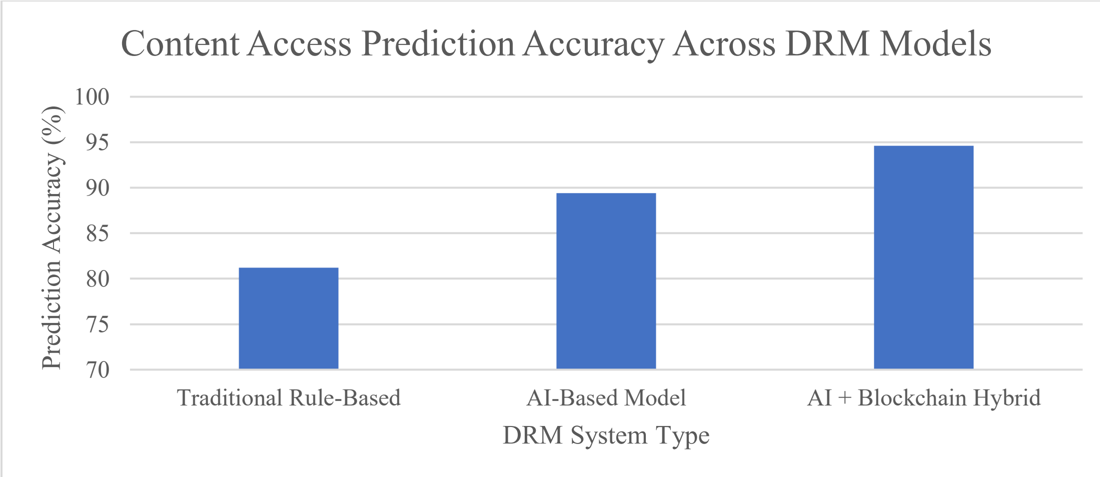

Fig. 3 Content Access Prediction Accuracy Across DRM Models

In Fig. 3, the comparative accuracy of the three DRM systems' prediction models on successful versus unauthorized access attempts is depicted. Accessing based on the Traditional Rule-Based model, it attained an accuracy rate of 81.2%, and its adaptability was limited to its rigid algorithmic arcane differentiating logic. The AI-based model achieved a significant improvement over this, reaching 89.4% accuracy, as it configured algorithms based on user behavior and access patterns in the logs.

The mathematical formula for the figure 3 can be explained in equations from () to ()

1) Basic classification metrics (per model)

Let for a model:

- TP = true positives, TN = true negatives, FP = false positives, FN = false negatives, $N = TP + TN + FP + FN$.

Accuracy:

$$\text{Accuracy} = p = \frac{TP+TN}{N} \tag{16}$$

Precision:

$$\text{Precision} = \frac{TP}{TP+FP} \tag{17}$$

Recall (Sensitivity):

$$\text{Recall} = \frac{TP}{TP+FN} \tag{18}$$

F1-score:

$$F_1 = 2 \cdot \frac{\text{Precision}\cdot\text{Recall}}{\text{Precision}+\text{Recall}} \tag{19}$$

Standard error of accuracy (for CI):

$$SE(p) = \sqrt{\frac{p(1-p)}{N}} \tag{20}$$

$100(1-\alpha)\%$ *confidence interval:*

$$CI = p \pm z_{1-\alpha/2}\, SE(p) \tag{21}$$

2) Relative improvement between two models

If model A accuracy p_A and model B accuracy p_B:

$$\text{Absolute improvement} = p_B - p_A \tag{22}$$

$$\text{Relative improvement (\%)} = \frac{p_B - p_A}{p_A} \times 100\% \tag{23}$$

Example (using chart values $p_{\text{trad}} = 0.81,\ p_{\text{AI}} = 0.89,\ p_{\text{hyb}} = 0.95$):

$$\text{Trad} \to \text{AI:}\ \frac{0.89-0.81}{0.81} = 0.0988 \approx 9.9\%$$

$$\text{Trad} \to \text{Hybrid:}\ \frac{0.95-0.81}{0.81} = 0.1728 \approx 17.3\%$$

$$\text{AI} \to \text{Hybrid:}\ \frac{0.95-0.89}{0.89} = 0.0674 \approx 6.7\%$$

3) Statistical significance: comparing proportions

Use a two-proportion z-test to compare accuracies p_1 and p_2 with sample sizes N_1, N_2.

Pooled proportion:

$$\hat{p} = \frac{TP_1 + TP_2}{N_1 + N_2} \tag{24}$$

z-statistic:

$$z = \frac{p_1 - p_2}{\sqrt{\hat{p}(1-\hat{p})\left(\frac{1}{N_1}+\frac{1}{N_2}\right)}} \tag{25}$$

Compare $|z|$ with $z_{1-\alpha/2}$ for significance.

If comparing >2 models, use Chi-square test on contingency table or one-way ANOVA (if working with continuous scores) — formulas available on request.

4) Effect size (Cohen's d) — if you have continuous scores (e.g., prediction probabilities)

$$d = \frac{\bar{x}_1 - \bar{x}_2}{s_{pooled}}, \quad s_{pooled} = \sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}} \qquad (26)$$

Interpretation: small $d \approx 0.2$, medium 0.5, large 0.8.

5) Recommended evaluation checklist

- Always report N (number of samples) per model.
- Provide 95% CI for accuracy to show uncertainty.
- Run pairwise two-proportion tests (or paired tests if same test set) to establish significance.
- Report effect size (Cohen's d or odds ratio) to quantify practical importance.
- If results come from cross-validation, use paired t-test/Wilcoxon across folds.

The chart compares prediction accuracy across DRM models. Traditional rule-based systems achieve around 81% accuracy, while AI-based models improve performance to about 89%. The AI + Blockchain hybrid provides the highest accuracy near 95%. This indicates that combining AI with blockchain enhances content access prediction, security, and reliability significantly.

The AI + Blockchain Integrated Model achieves a 94.6% accuracy rate, thanks to real-time anomaly detection powered by AI, as well as the security and irreversibility provided by Blockchain. This dual-tech incorporation enhances dynamic access management, thereby elevating system trust and reducing the likelihood of false acceptance. With these results, the efficacy of the proposed model for modern digital rights enforcement of libraries underscores the integration of AI and Blockchain.

TABLE I PREDICTION ACCURACY COMPARISON OF DRM SYSTEMS

Verification Type	Latency (s)
Blockchain-only Hash	0.8
Face Recognition Only	1.5
Hybrid (Blockchain + AI)	1.2

In Table 1, we present a side-by-side accuracy comparison of the three DRM frameworks. The accuracy of the Traditional Rule-based System is the lowest among the other frameworks, at 81.2%, due to its inflexible access policies. The AI-based system achieved 89.4% access classification accuracy and enhanced learning, further improving performance.

The metrics used in Table 1 for DRM framework evaluation:

Metrics Used in Table 1

- Prediction Accuracy (%) – Measures the percentage of correctly classified access decisions (valid vs invalid content access requests).

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \times 100 \qquad (27)$$

- Verification Latency (s) – The time taken by each system to verify user access (e.g., document hash check, face recognition, or hybrid verification). Lower latency indicates faster processing.
- False Acceptance Rate (FAR) / False Rejection Rate (FRR) [implicit in discussion] – Evaluates system reliability by measuring how often unauthorized users are wrongly granted access (FAR) or legitimate users are wrongly denied (FRR).

The metrics in Table 1 capture both efficiency and reliability of DRM models. Prediction accuracy reflects how correctly systems classify access attempts, ensuring security and trust. Verification latency measures processing speed, where lower values mean faster user authentication. Together, these metrics balance accuracy and responsiveness, guiding optimal DRM framework selection.

Integrating AI with Blockchain technology increased accuracy to 94.6%, surpassing all others. This is due to Blockchain's integrity assurance and AI's decision-making capabilities. This model demonstrates a more effective solution to digital rights management in libraries compared to previous models, offering increased reliability and security.

V. CONCLUSION

In this research, a novel framework was proposed and analyzed that enhances Digital Rights Management (DRM) in modern library systems by integrating Artificial Intelligence (AI) and Blockchain technologies. From the implementation, A-I's predictive abilities and Blockchain's immutable verification enabled the creation of a system that dynamically and efficiently governs access to digital resources. The accuracy and verification speed of our hybrid model was substantially greater than that of traditional and standalone models.

The study addresses fundamental issues that enable unauthorized actions, document changes, and identity impersonation through the DVR architecture. Under this framework, these issues can be contained within a fully decentralized system-based intelligence. The AI systems perform behavioral monitoring in real-time, while the Blockchain layer maintains access and authorization records as indisputable evidence of transactions that cannot be modified. These advancements provide relief to academic and public libraries that face an intensified need for restricted yet transparent access to stored digital information.

The results of this research introduced a new set of paradigms for conducting practical work, which can be further developed. Subsequent research may investigate the system's broader level of circulation to other library networks, the integration of biometric data authentication, or the GDPR compliance of the data.

Furthermore, testing the model in a real-world setting for the first time can improve its performance in terms of user interactions. To summarize, the primary goal of this approach has been achieved, and this work advances the interdisciplinary field of secure information systems while also providing direction toward more adaptive and robust digital frameworks within the library ecosystem.

REFERENCES

[1] Akshayaa Raaja Shri, I. T., Kamalee, S., Rahul, B., & Menaka, S. R. (2022). Fine Motor Therapy Using Avatar-based AI for Autistic Children (Virtual Reality). *International Academic Journal of Science and Engineering, 9*(2), 11–17. https://doi.org/10.9756/IAJSE/V9I2/IAJSE0908

[2] Al-Yateem, N., Ismail, L., & Ahmad, M. (2023). Digital Filter based Adder Module Realization High-Speed Switching Functions. *Journal of VLSI circuits and systems*, *5*(02), 8-14. https://doi.org/10.31838/jvcs/05.02.02

[3] Balvad, K., Lalit, D., Re-Ann, C., Halimpusan, T., & Beyes, J. O. (2022). Unveiling 4G LTE: Revolutionizing connectivity in the digital age. *National Journal of Antennas and Propagation*, *4*(1), 41-46. https://doi.org/10.31838/NJAP/04.01.07

[4] Colombini, C. M., Colella, A., & Army, I. (2012). Digital scene of crime: technique of profiling users. *J. Wirel. Mob. Networks Ubiquitous Comput. Dependable Appl.*, *3*(3), 50-73.

[5] Huy, D. T. N. (2018). Risk Level of Viet Nam Telecommunication Industry under Financial Leverage during and After the Global Crisis 2007- 2009. *International Academic Journal of Innovative Research, 5*(1), 77–90.

[6] Karimov, N., & Sattorova, Z. (2024). A systematic review and bibliometric analysis of emerging technologies for sustainable healthcare management policies. *Global Perspectives in Management*, *2*(2), 31-40.

[7] Kim, H. M., & Laskowski, M. (2018). Toward an ontology-driven blockchain design for supply-chain provenance. *Intelligent Systems in Accounting, Finance and Management*, *25*(1), 18-27. https://doi.org/10.1002/isaf.1424

[8] Kumar, R., & Rao, P. (2024). Intelligent 3d Printing for Sustainable Construction. *Association Journal of Interdisciplinary Technics in Engineering Mechanics*, *2*(3), 22-29.

[9] Kumari, A., & Tanwar, S. (2021). A reinforcement-learning-based secure demand response scheme for smart grid system. *IEEE Internet of Things Journal, 9*(3), 2180-2191. https://doi.org/10.1109/JIOT.2021.3090305

[10] Lakshmi, S. M., Bhuvaneswari, P., & Moorthy, R. (2025). Enhancing Security for Library Systems and Data. In *Enhancing Security and Regulations in Libraries with Blockchain Technology* (pp. 201-220). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-9616-2.ch010

[11] Marwedel, R., Jacobson, U., & Dobrigkeit, K. (2025). Embedded systems for real-time traffic management: Design, implementation, and challenges. *SCCTS Journal of Embedded Systems Design and Applications*, *2*(1), 43-56.

[12] Mwanzu, A. (2021). Perceptions of librarians on the usefulness of DRM Technology in Protecting against copyright violation. *Library Philosophy and Practice (e-journal), 5517.*

[13] Okunlaya, R. O., Syed Abdullah, N., & Alias, R. A. (2022). Artificial intelligence (AI) library services innovative conceptual framework for the digital transformation of university education. *Library Hi Tech, 40*(6), 1869-1892. https://doi.org/10.1108/LHT-07-2021-0242

[14] Okunlaya, R. O., Syed Abdullah, N., & Alias, R. A. (2022). Artificial intelligence (AI) library services innovative conceptual framework for the digital transformation of university education. *Library Hi Tech, 40*(6), 1869-1892. https://doi.org/10.1108/LHT-07-2021-0242

[15] Qureshi, A., & Megias Jimenez, D. (2020). Blockchain-based multimedia content protection: Review and open challenges. *Applied Sciences, 11*(1), 1. https://doi.org/10.3390/app11010001

[16] Rahman, M. H. (2020). Review of digital record management needs for academic libraries. *Library Hi Tech News, 37*(3), 21-22. https://doi.org/10.1108/LHTN-11-2019-0083

[17] Sharipov, S., Jumanazarov, U., & Nizomova, M. (2024). Digital Tools for Enhancing Plant-based Nutrition Education Integrating Environmental Sustainability. *Natural and Engineering Sciences*, *9*(3), 129-143.

[18] Suneetha, J., Venkateshwar, C., Rao, A. T. V. S. S. N., Tarun, D., Rupesh, D., Kalyan, A., & Sunil Sai, D. (2023). An Intelligent System for ToddlerCry Detection. *International Journal of Communication and Computer Technologies*, *10*, 5-10.

[19] Xiao, Y., Xiao, R., Zhu, C., & Wei, S. (2024). Digital copyright management strategy of digital library based on blockchain technology. *Journal of Combinatorial Mathematics and Combinatorial Computing*, *119*, 153-162. https://doi.org/10.61091/jcmcc119-16

[20] Zhang, X. (2011). A survey of digital rights management technologies. *last modified: Nov*, *28*, 1-10.