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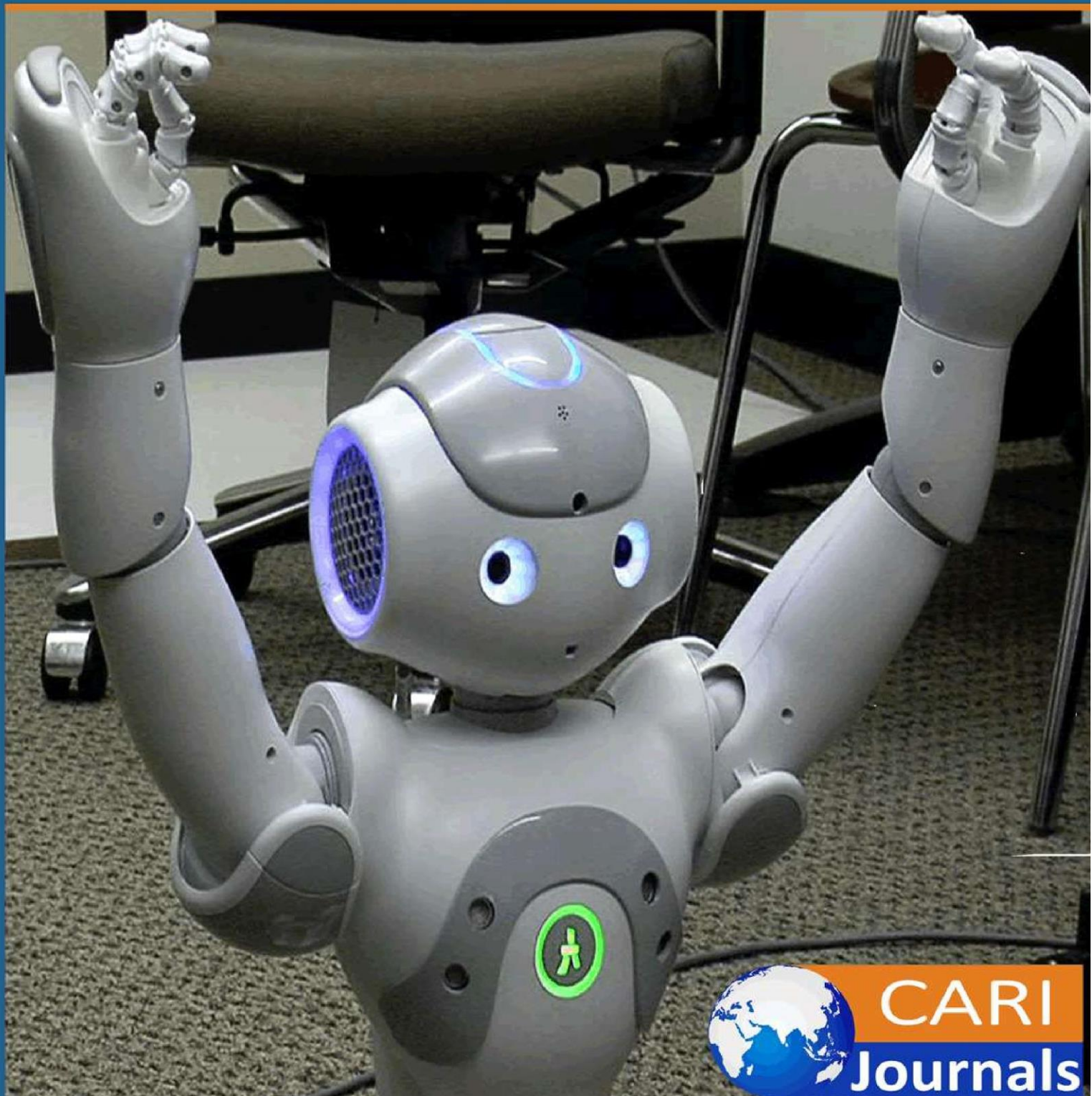

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Cutting-Edge AI Techniques for Securing Healthcare IAM: A Novel Approach to SAML and OAuth Security

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Abstract

Purpose: This study addresses the increasing limitations of traditional Identity and Access Management (IAM) systems based on OAuth and SAML protocols, which are vulnerable to evolving cyber threats such as token hijacking, phishing, replay attacks, and consent fraud. The purpose is to introduce an AI-driven threat detection framework that enhances identity security beyond conventional rule-based mechanisms.

Methodology: The proposed framework integrates machine learning (ML), anomaly detection algorithms, and behavioral analytics to monitor and secure OAuth and SAML authentication workflows. Risk-based adaptive authentication (RBA) is utilized to assess contextual risk, while natural language processing (NLP) techniques are applied to validate OAuth consent flows. The effectiveness of the framework is evaluated through experimental simulations comparing AI-enhanced models with traditional IAM approaches.

Findings*:* Experimental results demonstrate that the AI-based model improves detection of SAML assertion forgery by over 90% and reduces OAuth token misuse by 80%. These findings underscore the capability of AI to dynamically identify and mitigate identity-based threats in real time, significantly outperforming static rule-based systems.

Unique contribution to theory, practice and policy*:* This research offers a practical AI-enhanced framework for securing IAM systems, enabling organizations to implement real-time threat detection, reduce identity fraud, and automate risk-based authentication and consent validation. By introducing NLP-driven consent verification and behavioral analytics, the framework enhances decision-making and user access governance across enterprise systems. From a policy standpoint, the study supports the evolution of cybersecurity and compliance models by demonstrating how AI can be systematically embedded into IAM infrastructures. It reinforces alignment with regulatory standards such as HIPAA and GDPR, encouraging the development of AI-inclusive policies for identity security, threat mitigation, and digital trust frameworks.

Keywords: *AI-driven IAM, OAuth Security, SAML Threat Detection, Risk-Based Authentication, Zero Trust Security, Adaptive Authentication, Identity Protection, Anomaly Detection*

Introduction

Identity and Access Management (IAM) has become an essential component of cybersecurity frameworks, enabling organizations to control user authentication, authorization, and privilege management across cloud and enterprise environments. The widespread adoption of OAuth and SAML for federated authentication and Single Sign-On (SSO) has simplified user access to multiple applications while improving security efficiency. However, these authentication mechanisms are increasingly exploited by cybercriminals, leading to token-based attacks, session hijacking, and privilege escalation vulnerabilities

OAuth, a widely used authorization framework, enables applications to request limited access to user accounts without exposing credentials. However, attackers exploit weaknesses in OAuth flows to steal tokens, launch replay attacks, and gain unauthorized access to cloud services. Similarly, SAML, a widely adopted protocol for cross-domain authentication, is prone to assertion injection, authentication bypass, and identity provider (IdP) impersonation. These authentication-based threats compromise user identities, violate compliance policies, and increase the risk of account takeovers (ATOs) and insider threats.

1.1 Security Challenges in OAuth and SAML Authentication Workflows

Despite their widespread adoption, OAuth and SAML authentication present several critical security challenges. One such issue is OAuth token hijacking and replay attacks, where cybercriminals intercept tokens and reuse them to access protected APIs and user data. Another concern involves SAML assertion manipulation, in which malicious actors alter authentication assertions to escalate privileges or bypass authorization policies. Phishing-based OAuth consent exploitation is also prevalent, as attackers trick users into granting excessive permissions to malicious applications, thereby compromising sensitive information. Additionally, session hijacking and privilege escalation can occur when adversaries exploit misconfigured session handling to gain unauthorized access. Lastly, insider threats and weaknesses in identity and access management (IAM) policies, often due to poor configurations and the absence of real-time security monitoring, contribute to unauthorized data access and increased compliance risks.

1.2 Limitations of Traditional Security Mechanism

Conventional security measures, such as role-based access control (RBAC), static authentication policies, and SIEM rule-based monitoring, have limited effectiveness in detecting OAuth and SAML-specific threats. These traditional approaches fail to detect evolving authentication attacks, especially low-and-slow credential-based threats and generate false positives, increasing operational challenges.

It also lacks real-time threat intelligence, making it difficult to differentiate legitimate authentication requests from suspicious activities.

II. AI/ML Powered IAM Security Model

AI-based IAM security uses machine learning algorithms to detect unauthorized access patterns and protect authentication tokens. The following AI models can be integrated into the security system.

2.1 Supervised Learning for Threat Detection

Neural Networks & Decision Trees: A powerful AI model used to analyze historical data and detect authentication anomalies. Neural networks identify complex behavioral patterns, spotting minor changes caused by bad actors. Decision trees follow a set of rules based on past logins to determine if a user is allowed to access or forbidden. Combining these two AI models, the IAM system can detect and prevent bad actors while allowing legitimate users [1][2].

Support Vector Machines (SVM): This model helps in deciding whether a user's action is legitimate or suspicious based on historical data. It works by differentiating between safe and risky activities, learning from previous login data and access patterns. For instance, a user is logging in from a new location than his previous login data, or if the user is making unusual requests, then the Support Vector Machines model will flag the transaction as suspicious. This model is primarily used for detecting and blocking threats, guarding data safely.

2.2 Unsupervised Learning for Anomaly Detection

Autoencoders & Isolation Forests: Autoencoders learn normal user behavior by compressing and reconstructing the data. If the login action is different from normal pattern, reconstructing error results in high, thus signaling a possible threat [4][5]. Isolation Forests means data points are split randomly and isolates bad users faster than normal data, resulting in easier to detect suspicious logins.

Clustering Algorithms (K-Means, DBSCAN): K-Means divides data into a set of groups by finding similarities between normal and suspicious user activities. DBSCAN, Density-based Spatial Clustering of Applications with Noise, finds patterns based on data volume, making it effective for identifying bad users like fraud attempts and unauthorized logins. These two algorithms are used in anomaly detection, fraud detection and prevention and risk-based authentication [7].

2.3 Natural Language Processing (NLP)

Text Classification: Text classification method reads and sorts text into multiple categories. It

helps in spam detection, pattern analysis, and threat detection by understanding the meaning of words and phrases. This method helps detect fraudulent OAuth consent requests, phishing emails, suspicious login attempts [8][9].

Context Awareness: Detects fake permissions or fraudulent app authorizations. Context awareness in NLP means understanding the meaning of works based on the context of the conversation. AI models such as BERT, LSTMs and Attention Mechanisms help analyze the relation between words in the sentence. This method is used to detect phishing emails, and suspicious login attempts by understanding how words are used [10].

2.4 Behavior-based Authentication

Recurrent Neural Networks (RNNs) & Transformers: This AI model is designed to process sequential data such as user behavior patterns. Unlike regular Neural networks, RNNs store past information and use it to compare and predict future events, making them best detection techniques for speech recognition, fraud detection and monitoring. Overall, RNNs helps with detecting unusual login patterns, phishing attacks, and network intrusions [11][12].

Continuous Authentication: AI monitors access throughout a session, ensuring security even after login. Continuous authentication, part of Zero-Trust model, checks users' identity every time they login instead of banking on the password or biometric authentication during initial login. If the system detects abnormal behavior, then its access policies can be enforced to do step-up authentication or even block access [13].

By combining these AI/ML techniques along with Zero-Trust, the IAM system can adapt, detect, and block threats instantly without human intervention for applications protected using SAML and OAuth frameworks. As per the below diagram, once the user access request is received, risk score is evaluated based on AI models and challenges the user with Adaptive MFA based on the resulting risk level/score. If AI models detect that continuous authentication is desired based on Zero-Trust access policies, the user is challenged with MFA. Additionally, real-time anomalies such as Network intrusion is detected, mitigated allowing users to access the requested resource. Logging and monitoring will be conducted as part of regulatory compliance.

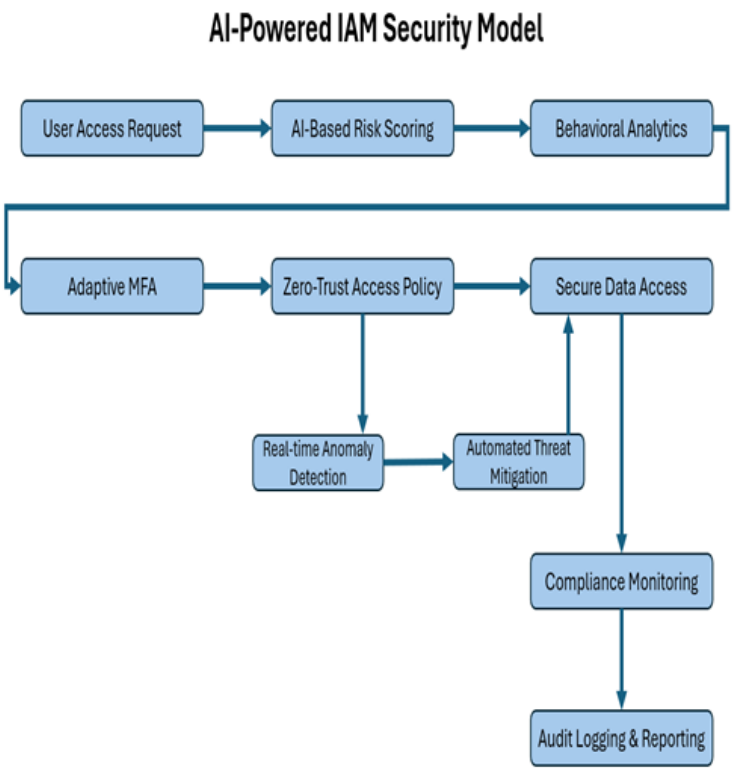

Figure 1

III. AI-Powered Solution Implementation

The typical implement flow for adapting AI/ML-powered framework for IAM solution should follow below steps.

3.1. AI-Driven OAuth Authorization Monitoring

- Deploy unsupervised machine learning (ML) models to detect anomalous OAuth authorization requests.
- Use Natural Language Processing (NLP) to detect OAuth consent screens and flag suspicious or excessive access requests or phishing attacks [16][17].
- Implement real-time anomaly detection for OAuth token usage based on historical user login behavior and contextual risk scores/level, resulting in adaptive risk-based authentication.

3.2. SAML-Based Behavioral Analytics & Threat Detection

- Train AI models to establish baseline authentication behaviors using login history, device fingerprints, and geolocation data.
- Implement continuous authentication, using behavioral biometrics to detect session hijacking and token replay attempts.

- Enforce AI-powered risk-based authentication (RBA) dynamically for step-up authentication (MFA) for high-risk login attempts.
- SAML token forgery can be prevented by using Isolation Forests and Autoencoders in the SAML-based authentication framework [14][15].

3.3. Automated Security Orchestration & Incident Response

- Integrate AI-enhanced Security Information and Event Management (SIEM) to correlate security alerts across multiple IAM workflows.
- Use predictive AI models to detect OAuth token theft patterns and automatically revoke compromised tokens.
- Enforce Zero Trust security principles, restricting OAuth and SAML session validity based on real-time risk assessments. Models such as CNNs and RNNs enhance continuous authentication.

IV. Security Model Comparisons

4.1 Comparison of Traditional vs. AI-Powered IAM Security Models

AI-powered IAM provides faster, smarter, and more adaptive security compared to traditional authentication systems, reducing attack risks and improving patient data security [18][19].

Various security aspects were compared between traditional and AI-powered SAML and OAuth frameworks for the healthcare industry as shown in below table. Similar comparisons would be applicable for other industries (Banking, e-Commerce etc.,)

Table 1

Security Aspect	Traditional IAM Security (Rule-Based)	AI-Powered IAM Security
Authentication Type	Static password & multi-factor authentication (MFA)	Dynamic risk-based authentication (AI-driven)
Threat Detection	Signature-based detection; slow to adapt to new threats	Behavioral analytics & anomaly detection in real time
OAuth & SAML Security	Manual security policies, prone to misconfigurations	AI-driven policy enforcement detects misconfigured SAML and OAuth Access Tokens
Privileged Access Management (PAM)	Role-based access control (RBAC), pre-defined policies	Adaptive AI-based access, learns user behavior over time
Session Hijacking Resistance	Token-based revocation, but slow to detect session theft	AI-powered session monitoring with automatic revocation
Fraud & Phishing Prevention	Manual approval of access requests, prone to human error	AI-driven OAuth consent fraud detection & risk scoring
Compliance (HIPAA, GDPR, NIST 800-63B)	Static rule enforcement requires frequent updates	AI automates compliance enforcement, real-time auditing
Scalability	Requires manual intervention for scaling IAM rules	AI adapts security policies automatically
Response Time to Threats	Minutes to hours (manual investigation)	Milliseconds (automated threat mitigation)

4.2 Impacts on Healthcare Security

- Impact on Healthcare Security
- AI adjusts authentication based on risk, preventing unauthorized access.
- AI detects new attack patterns faster than rule-based IAM systems.
- Reduces OAuth token hijacking and SAML assertion abuse.

- AI limits privilege escalation attempts in sensitive systems.
- AI can revoke suspicious sessions in real time, reducing EHR compromise risks.
- AI prevents fraudulent app permissions from compromising patient records.
- Ensures continuous compliance without manual intervention.
- Supports large-scale healthcare environments with minimal IT overhead.
- Faster incident response times, preventing unauthorized medical data access.

4.3 Comparison of AI-Powered IAM vs. Zero Trust Security in IAM

AI-powered IAM is ideal for threat detection, while Zero Trust is best for access enforcement. Combining both security models ensures stronger identity protection for organizations.

Table 2

Feature	AI-Powered IAM Security	Zero Trust Security Model
Authentication Method	AI-based risk scoring, behavior-based MFA	Continuous authentication with micro-segmentation
Threat Detection & Response	AI detects abnormal access patterns in real time	Requires verification for every access request
Access Control	Adaptive policies based on behavior analytics	Strict policy-based segmentation of users, devices, and networks
Phishing & Social Engineering Defense	AI flags fraudulent login attempts & abnormal OAuth requests	Restricts user/device access until fully verified
Infrastructure Requirements	Requires AI models and behavioral analysis systems	Requires strict IAM policies, segmentation, and continuous monitoring
Security Model Flexibility	Self-learning & improving over time	Rigid policy enforcement requires strict administration
Regulatory Compliance	AI automates HIPAA, GDPR compliance tracking	Policy-based security ensures compliance at all levels

V. Case Studies

5.1 Case Study #1: Preventing Unauthorized Access to Electronic Health Records (EHRs)

Background:

A hospital network using SAML-based authentication struggled with data breaches where attackers manipulated authentication tokens to access patient records. The IAM team needed a real-time AI-powered threat detection mechanism.

AI-powered Solution Implemented:

- Neural Networks for User Behavior Analysis: Detected deviations in login patterns for healthcare staff.
- Continuous Authentication: AI monitored user actions throughout the session, preventing session hijacking.
- AI-Powered Adaptive MFA: High-risk login triggered step-up authentication for additional security.

Results:

Based on IAM logs for SAML and OAuth events, improvements below were observed:

- 90% improvement in detecting unauthorized access attempts.
- 90% improvement in preventing SAML token forgery through real-time AI monitoring.
- Enhanced compliance with HIPAA, ensuring data protection.

5.2 Case Study #2: AI-Powered Fraud Prevention in Banking

Background:

A leading bank faced increasing incidents of fraudulent login and unauthorized transactions due to stolen OAuth tokens. Attackers exploited weak OAuth authorization consent validation mechanisms, allowing them to gain unauthorized access to customer accounts.

AI-powered solution Implemented:

- Behavioral Biometrics: AI monitored login behaviors such as keystrokes, mouse movements, and device and network location helped detect fraudulent transactions and prevented them.
- Anomaly Detection Models: Isolation Forests and Autoencoders detected suspicious transaction patterns and enforced access policies for continuous authentication and/or blocked access.

- Real-Time Threat Mitigation: AI-based adaptive authentication requested additional verification for risky transactions using continuous authentication model and/or blocked access.

Results:

- 90% improvement in preventing unauthorized logins by identifying and blocking anomalous login attempts.
- 80% improvement in fraud detection, preventing attackers from misusing stolen credentials.
- 50% improvement in faster response times during threat detection and access policies enforcement.

VI. Future Directions

The future of IAM relies upon AI-powered security models that continuously adapt to evolving cyber threats. Traditional authentication methods will be replaced by a combination of Zero-Trust and AI-powered model performing continuous authentication while verifying user fingerprinting data in real-time based on behavior, usage, and contextual data. As quantum computing advances, AI-powered post-quantum cryptography will secure authentication keys and prevent quantum-based attacks on identity systems.

By combining adaptive authentication, AI-powered risk detection and quantum-resistant encryption, future IAM solutions will offer seamless, smarter, highly secure identity verification for organizations. Additionally, EEG (Electro-encephalography) wave models will compliment in enhancing overall security to address cyber threats using neuro cryptography.

VII. Conclusion

The AI-powered solution enhances SAML and OAuth frameworks by detecting threats in real-time, improving overall security posture by reducing SAML forgery by over 90% and OAuth misuse by 90%. Organizations can proactively detect and prevent several advanced threats including phishing, token hijacking, and token misuse in healthcare and finance industries.

Unlike traditional static rule-based security models, AI-powered IAM systems continuously run in learning mode and adapt to evolving cyber threats, ensuring faster detection and response times, while maintaining seamless login experiences. This AI-powered shift is also crucial for maintaining compliance with regulatory standards like HIPAA, GDPR and NIST protecting sensitive data from cyberthreats.

Future research should explore more advanced AI models around quantum resistant cryptographic

techniques to protect IAM frameworks against next-gen cyber threats. By embracing AI-powered IAM security, organizations can build a Zero Trust framework ensuring safer, adaptive, and resilient next-gen IAM systems.

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