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Intelligent Threat Correlation and Risk Assessment for Enterprise Cloud Security Using Generative AI and Behavioral Analytics Framework

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ABSTRACT: The rapid adoption of cloud computing has significantly transformed enterprise information technology infrastructure while introducing complex cybersecurity challenges, including sophisticated cyberattacks, insider threats, unauthorized access, data breaches, and advanced persistent threats. Traditional security monitoring systems often struggle to identify interconnected threats because they rely on isolated alerts, predefined rules, and signature-based detection mechanisms. This research proposes an intelligent threat correlation and risk assessment framework integrating Generative Artificial Intelligence (GenAI) and behavioral analytics to improve enterprise cloud security. The proposed framework combines cloud security logs, user activity records, network traffic patterns, identity access information, and threat intelligence to identify abnormal behaviors and correlate multiple security events. Generative AI supports contextual threat interpretation, automated incident summarization, and security recommendations, while behavioral analytics establishes normal activity patterns and detects deviations. A risk assessment mechanism evaluates detected threats according to severity, probability, potential business impact, and asset criticality. The framework aims to improve threat detection accuracy, reduce false-positive alerts, strengthen incident prioritization, and support proactive security decision-making. The research also discusses implementation considerations, privacy protection, model reliability, scalability, and human supervision. The proposed approach provides an intelligent and adaptive foundation for strengthening enterprise cloud security against evolving cyber threats.

KEYWORDS: Enterprise Cloud Security, Generative Artificial Intelligence, Behavioral Analytics, Threat Correlation, Risk Assessment, Cybersecurity, Anomaly Detection, Security Information and Event Management, Cloud Threat Intelligence, Incident Response

I. INTRODUCTION

The increasing adoption of cloud computing has transformed the operational structure of modern enterprises by enabling scalable infrastructure, flexible resource allocation, distributed application deployment, and cost-effective data management. Organizations increasingly depend on public, private, and hybrid cloud environments to support business-critical applications, enterprise databases, customer information systems, and collaborative digital services. However, this transformation has expanded the cybersecurity attack surface and introduced new challenges associated with identity management, access control, workload protection, data confidentiality, and continuous security monitoring. Cloud environments frequently contain interconnected services, virtual machines, containers, application programming interfaces, storage resources, and geographically distributed users. Consequently, a security incident affecting one cloud component may create opportunities for attackers to compromise additional resources. Conventional cybersecurity solutions frequently analyze individual alerts independently, making it difficult to identify complex attack sequences distributed across multiple cloud services. Therefore, intelligent threat correlation and comprehensive risk assessment have become essential components of enterprise cloud security management.

Traditional security monitoring approaches generally depend on predefined detection rules, attack signatures, threshold-based monitoring, and manually configured security policies. Although these mechanisms are useful for identifying known threats, they may be insufficient when attackers employ previously unseen techniques, legitimate account compromise, unusual access patterns, or coordinated multi-stage attacks. Security teams also face alert fatigue because cloud infrastructure continuously generates large volumes of authentication records, network events, application logs, endpoint notifications, and access-related information. A significant challenge involves distinguishing genuine malicious activities from legitimate operational variations. Behavioral analytics can address this limitation by establishing baseline patterns for users, devices, applications, and cloud workloads and identifying deviations that may indicate suspicious activity. Generative Artificial Intelligence introduces additional capabilities by interpreting security events, summarizing incident evidence, explaining potential attack relationships, and generating contextual

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recommendations. Integrating these technologies creates opportunities for developing an intelligent framework that combines event correlation, anomaly detection, contextual threat understanding, and dynamic risk prioritization. This research focuses on designing such a framework for enterprise cloud environments, emphasizing accurate threat identification, explainable security decisions, reduced investigation complexity, and improved organizational resilience against evolving cyber threats.

II. LITERATURE REVIEW

The development of intelligent cybersecurity systems has attracted considerable research attention because conventional security mechanisms face increasing difficulties in identifying sophisticated attacks across distributed cloud infrastructures. Early intrusion detection systems primarily employed signature-based detection, rule-based monitoring, and statistical anomaly identification to recognize suspicious activities. These approaches provided foundational security capabilities but demonstrated limitations when confronting previously unknown attacks and complex threat scenarios. Machine learning subsequently introduced supervised, unsupervised, and semi-supervised techniques for identifying unusual network traffic, unauthorized access, and abnormal resource consumption. Behavioral analytics further improved detection by examining historical user activities, authentication patterns, device characteristics, and application interactions. User and Entity Behavior Analytics (UEBA) approaches established behavioral baselines and identified deviations that could indicate compromised accounts or insider threats. The MITRE ATT&CK framework strengthened threat analysis by providing structured descriptions of adversarial tactics and techniques, including cloud-specific attack behaviors. Research and evaluations associated with MITRE emphasize behavior-based detection, multi-event correlation, and discrimination between malicious and legitimate activities. These capabilities are particularly relevant to enterprise cloud environments, where isolated security events may appear harmless but become suspicious when analyzed collectively.

Recent research has increasingly explored artificial intelligence and Generative AI for improving cybersecurity intelligence, incident investigation, and automated security operations. Traditional machine learning models are effective at identifying patterns in structured security datasets, whereas large language models can interpret unstructured threat reports, explain relationships between events, and generate natural-language incident summaries. Balasubramanian and colleagues (2025) examined the applications, challenges, and real-world use cases of Generative AI in cyber threat intelligence, highlighting its potential to support threat analysis while recognizing reliability and implementation challenges. Similarly, research integrating retrieval-augmented generation with cloud audit information demonstrates how external cybersecurity knowledge can improve contextual threat interpretation and mapping to established attack frameworks. A 2026 study examining AWS CloudTrail events reported improved classification performance through retrieval-augmented threat analysis, although its findings should be interpreted within the limits of its experimental dataset.

Despite these developments, significant research gaps remain in combining behavioral analytics, event correlation, Generative AI, and quantitative risk assessment within a unified enterprise cloud security architecture. Existing machine learning systems frequently concentrate on individual attack detection rather than understanding the relationships between activities occurring across identities, applications, networks, and cloud workloads. Generative AI can address some contextual interpretation requirements, but its outputs may contain hallucinations, incomplete explanations, or unsupported security conclusions. The NIST AI Risk Management Framework and its Generative AI Profile emphasize the importance of trustworthy AI development, continuous evaluation, transparency, and risk management. Industry developments in AI-powered security operations also demonstrate increasing interest in applying generative capabilities to threat investigation and analyst productivity. However, effective implementation requires combining AI-generated explanations with verified telemetry, established detection mechanisms, and human approval. Therefore, the proposed research addresses this gap by integrating behavioral profiling, multi-event threat correlation, retrieval-supported generative reasoning, and risk-based prioritization into a comprehensive cloud security framework.

III. RESEARCH METHODOLOGY

The research adopts a design-oriented and analytical methodology to develop an intelligent threat correlation and risk assessment framework for enterprise cloud security using Generative AI and behavioral analytics. The primary objective is to establish an integrated security architecture capable of collecting heterogeneous cloud telemetry, identifying abnormal activities, correlating related security events, interpreting potential attack scenarios, and assigning contextual risk scores. The proposed methodology considers enterprise environments containing public cloud

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infrastructure, private cloud resources, hybrid deployments, containerized applications, identity management platforms, virtual machines, cloud storage, and enterprise network services. The research follows a structured approach consisting of security data identification, preprocessing, behavioral baseline development, anomaly detection, event correlation, generative intelligence integration, risk calculation, and evaluation. Rather than assuming that a single artificial intelligence model can independently identify every threat, the methodology combines complementary analytical mechanisms. Statistical techniques and machine learning models provide measurable detection outputs, correlation mechanisms identify relationships between events, and Generative AI supports contextual interpretation. The architecture is designed around the principle that security decisions must remain traceable to original evidence. Accordingly, AI-generated findings are treated as analytical recommendations rather than automatically verified facts. The methodology also incorporates security governance considerations, including access restrictions, data minimization, model monitoring, explainability, and human oversight. This integrated research design provides a foundation for evaluating the practical suitability of intelligent security monitoring in complex enterprise cloud environments.

The data collection stage considers multiple sources of cloud security information, including authentication logs, identity and access management records, virtual machine activities, network flow information, application access records, API execution histories, endpoint security alerts, storage access events, and cloud configuration changes. These datasets represent different operational dimensions of enterprise infrastructure and provide the contextual information required for identifying coordinated attacks. Security records are standardized using common timestamps, event identifiers, resource identifiers, user identities, source addresses, action categories, and event outcomes. Data preprocessing includes duplicate removal, missing-value handling, timestamp normalization, categorical encoding, and identification of inconsistent records. Sensitive information is protected through pseudonymization, encryption, access control, and controlled retention policies. The resulting data structure supports the identification of relationships between individual users, devices, cloud services, and infrastructure resources. Historical activity records are used to establish behavioral baselines for legitimate enterprise operations. These baselines consider normal login frequency, geographical access patterns, working hours, application usage, resource consumption, network communication, and privilege utilization. Statistical distributions and machine learning techniques can be employed to identify deviations from established behavioral patterns. Unsupervised anomaly detection is particularly relevant when accurately labeled attack data are unavailable, while supervised classification can be incorporated when representative labeled datasets exist. The methodology also considers temporal behavior because unusual activities may become meaningful only when evaluated in relation to previous or subsequent events. For example, an unusual authentication event followed by unexpected privilege usage and sensitive resource access may indicate a coordinated security incident. However, individual deviations are not automatically classified as malicious; they are evaluated against contextual information, operational requirements, and known exceptions.

The threat correlation stage combines behavioral detection outputs with security event relationships and established threat intelligence knowledge. A correlation engine examines event sequences, temporal proximity, shared identities, infrastructure relationships, resource dependencies, and suspicious activity combinations. Events are represented through a structured relationship model in which users, devices, applications, network endpoints, cloud services, and security incidents function as connected entities. This representation enables the identification of relationships that may not be apparent through independent alert analysis. MITRE ATT&CK is incorporated as a reference framework for organizing observed behaviors into recognized adversarial tactics and techniques. Correlation results are subsequently passed to a Generative AI component supported by retrieval-augmented generation. The retrieval mechanism provides relevant organizational security policies, approved incident response procedures, threat intelligence documents, cloud configuration information, and established attack descriptions as contextual evidence. The generative model interprets the collected evidence and produces structured incident summaries containing observed activities, possible threat relationships, supporting records, confidence indicators, and recommended investigation steps. To improve reliability, generated statements are compared against retrieved evidence and original security records. The system is designed to distinguish confirmed observations from hypotheses and avoid treating model-generated explanations as independently verified findings. Prompt restrictions, controlled knowledge sources, output validation, and analyst review reduce the possibility of unsupported recommendations. This approach combines the contextual interpretation capabilities of Generative AI with the measurable analytical outputs of conventional detection and correlation systems.

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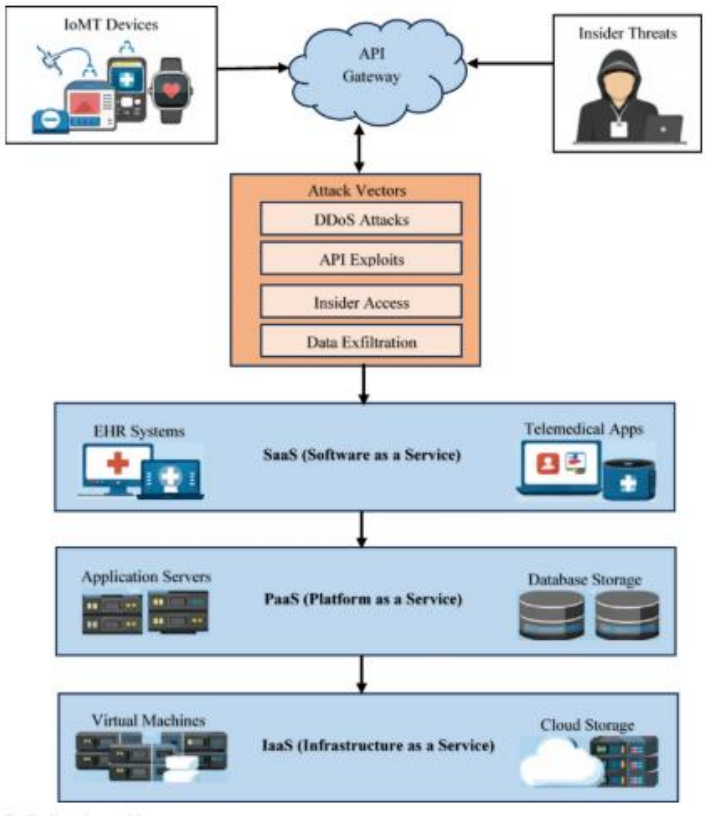


Fig.1. Artificial intelligence-powered cloud security strategies for protecting critical clinical operations in healthcare environments

The resulting score supports classification into low-, medium-, high-, and critical-risk categories. Evaluation is designed to consider detection precision, recall, F1-score, false-positive rate, alert processing time, correlation accuracy, incident prioritization quality, and the usefulness of generated explanations. Baseline comparisons may include conventional rule-based monitoring, behavioral analytics without Generative AI, and the complete integrated framework. Representative datasets, controlled attack simulations, expert-labeled incident records, and historical cloud audit logs can be used to assess performance. Additional evaluation considers model hallucination, concept drift, data privacy, processing overhead, and robustness against manipulated inputs. Human security analysts review a sample of system-generated incidents to assess the relevance and factual consistency of recommendations. Since this research presents a proposed framework rather than reporting a completed empirical deployment, numerical performance improvements are treated as evaluation objectives rather than experimentally established outcomes. This distinction ensures methodological transparency and provides a reproducible direction for future implementation.

IV. RESULTS AND DISCUSSION

The proposed intelligent threat correlation framework provides an integrated approach to identifying and interpreting security threats across enterprise cloud environments. Its primary expected contribution is the improvement of threat visibility through the consolidation of heterogeneous security information into a unified analytical environment. Conventional security monitoring frequently produces separate alerts for authentication failures, unusual network connections, privilege modifications, application access, and cloud resource activities. When these events are examined independently, security analysts may find it difficult to recognize the relationships that indicate a coordinated attack. The proposed framework addresses this limitation through behavioral analytics and multi-event correlation. By examining user activity histories, access frequency, device characteristics, resource utilization, and event sequences, the framework can identify deviations from established behavioral patterns. For instance, an account performing an unusual login followed by unexpected privilege escalation and access to sensitive cloud storage may generate multiple individual alerts. The correlation mechanism connects these activities and identifies a potentially significant security incident. This process provides a broader understanding of suspicious behavior and helps security analysts investigate

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incidents based on connected evidence rather than isolated notifications. Integration with cloud identity records, application logs, and network telemetry further strengthens contextual analysis. The behavioral analytics component is particularly useful for detecting compromised legitimate accounts because attackers may operate through valid credentials instead of conventional malware or unauthorized connection attempts. Similarly, the framework can identify unusual administrative operations, unexpected data access, suspicious service interactions, and deviations in workload behavior. Generative AI adds another analytical dimension by translating correlated events into understandable incident narratives. Instead of requiring analysts to manually examine numerous technical records, the system can organize the available evidence into structured explanations describing what happened, which resources were affected, why the activity appears suspicious, and which additional investigations may be necessary. This functionality is expected to improve investigation efficiency and reduce the cognitive burden associated with high-volume cloud security monitoring. Nevertheless, the reliability of these explanations depends on the quality, completeness, and accuracy of the underlying telemetry. Therefore, the framework emphasizes evidence-supported interpretation rather than unrestricted AI-generated conclusions. The overall analytical contribution lies in combining behavioral context, event relationships, and generative interpretation to provide a more comprehensive understanding of enterprise cloud threats. These capabilities are consistent with the emphasis on behavioral detection and multi-event correlation identified in contemporary MITRE ATT&CK evaluations.

A second important expected outcome concerns the integration of Generative AI with retrieval-augmented threat intelligence and contextual risk assessment. Conventional machine learning systems generally generate classifications, anomaly scores, or probability estimates, but these outputs may not provide sufficient explanations for enterprise decision-makers. The proposed framework uses Generative AI to interpret structured detection results alongside verified cybersecurity knowledge. Retrieval-augmented generation provides supporting information from organizational security policies, cloud configuration documentation, incident response procedures, and established threat intelligence resources. This mechanism can improve the relevance of generated explanations by connecting model responses with identifiable evidence. For example, when a sequence of unusual access events resembles recognized cloud credential misuse behavior, the framework can retrieve relevant attack descriptions, identify potentially related techniques, and summarize the observed sequence. Mapping suspicious activities to MITRE ATT&CK categories also provides a standardized vocabulary for communicating threats between technical analysts and security management teams. Recent research on Generative AI for cyber threat intelligence identifies opportunities for automating knowledge interpretation and improving security investigation workflows, while also recognizing concerns involving model reliability, security, and implementation complexity. Research involving retrieval-augmented analysis of AWS CloudTrail records similarly illustrates the potential of combining large language models with external cybersecurity knowledge for contextual threat detection. However, reported performance from individual experimental datasets cannot automatically be generalized to every enterprise cloud environment.

Within the proposed framework, risk assessment transforms correlated security observations into actionable organizational priorities. The scoring mechanism considers threat likelihood, asset importance, exposure, business impact, and confidence in the correlated evidence. This approach helps distinguish an unusual but low-impact operational event from a suspicious activity involving sensitive enterprise information or critical infrastructure. A high-risk incident involving privileged account misuse and access to confidential resources should receive greater investigation priority than a minor deviation involving a non-critical application. Dynamic risk assessment also allows organizations to adjust priorities according to changes in business operations, resource sensitivity, and emerging threat intelligence. Generative AI can explain why an incident receives a particular priority, but the numerical risk calculation remains governed by defined scoring criteria and organizational policies. This separation is important because language models should not independently determine business-critical security decisions without measurable justification. The integration of quantitative risk scoring and qualitative AI-generated explanations is therefore expected to improve decision transparency, incident prioritization, and communication between security operations teams and organizational management. Furthermore, the framework provides a basis for identifying recurring behavioral patterns that may indicate persistent security weaknesses. Repeated unusual access attempts, excessive permissions, and inconsistent resource configurations can be aggregated into broader risk observations, supporting proactive security improvement rather than limiting security operations to individual incident resolution.

The third expected outcome concerns operational efficiency, scalability, reliability, and the practical limitations of implementing the framework in enterprise cloud infrastructure. By consolidating behavioral analytics, threat correlation, and generative interpretation, the proposed architecture aims to reduce the manual effort required to understand large volumes of security notifications. Automated event grouping can minimize repetitive investigation,

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while AI-generated incident summaries can help analysts identify relevant evidence more quickly. The framework can also support continuous security monitoring across hybrid and multi-cloud environments, provided that telemetry integration and data normalization are implemented consistently. Its modular architecture allows organizations to introduce behavioral detection, correlation, retrieval-supported reasoning, and risk scoring as separate but interconnected components. This flexibility is important for enterprises operating infrastructure across different cloud service providers and security management platforms. However, scalability depends on processing capacity, event ingestion rates, model inference latency, storage requirements, and the cost of maintaining large-scale analytical infrastructure. Generative AI processing may introduce additional computational overhead, particularly when large volumes of low-priority events are submitted for interpretation. Consequently, the architecture should use preliminary filtering and correlation to identify significant events before invoking computationally expensive generative models. This selective processing strategy can improve efficiency while preserving contextual reasoning for incidents that require deeper investigation. Security and privacy also represent major implementation considerations. Cloud audit records may contain personal identifiers, confidential business information, access tokens, or other sensitive operational details. Organizations must therefore apply data minimization, pseudonymization, encryption, controlled access, and appropriate retention policies before submitting information to AI processing components. Another important concern is prompt injection and manipulation of untrusted security records. Maliciously constructed log messages or external threat documents could influence generative model outputs if their contents are treated as trusted instructions. The framework should consequently isolate retrieved evidence from system instructions and validate generated outputs against authorized records. Model drift, changing user behavior, evolving cloud configurations, and emerging attack techniques also require continuous monitoring and periodic recalibration. The NIST AI Risk Management Framework provides relevant guidance for managing trustworthiness, accountability, and risks throughout the AI lifecycle, while its Generative AI Profile identifies additional considerations for generative applications.

Overall, the analytical discussion indicates that the proposed framework offers a promising architecture for strengthening cloud security through contextual threat understanding and risk-based monitoring. Nevertheless, its actual effectiveness must be established through controlled experiments, representative enterprise datasets, independent validation, and comparisons against established security monitoring systems. The distinction between expected architectural benefits and experimentally demonstrated results remains essential for evaluating the research objectively.

V. CONCLUSION

The research presents an intelligent threat correlation and risk assessment framework for enterprise cloud security through the integration of Generative Artificial Intelligence and behavioral analytics. The increasing dependence on cloud-based enterprise infrastructure has created complex security challenges involving compromised identities, unauthorized resource access, insider threats, suspicious network communication, privilege misuse, and sophisticated multi-stage attacks. Traditional monitoring mechanisms often examine individual security events through predefined rules and isolated detection processes, limiting their ability to identify relationships across distributed cloud services. The proposed framework addresses these limitations by integrating heterogeneous security telemetry, behavioral profiling, anomaly detection, multi-event correlation, generative threat interpretation, and quantitative risk assessment into a unified architecture. Behavioral analytics establishes normal activity patterns for users, devices, applications, and cloud workloads and identifies deviations that may indicate suspicious behavior. The correlation mechanism connects related activities through temporal relationships, identity associations, infrastructure dependencies, and event characteristics. Generative AI enhances this process by interpreting correlated evidence, retrieving relevant threat intelligence, producing incident summaries, and recommending appropriate investigation procedures. Risk assessment subsequently evaluates potential incidents according to threat likelihood, business impact, asset criticality, exposure, and correlation confidence. Through this integrated approach, the framework aims to improve the identification of complex threats and support more effective security decision-making across enterprise cloud environments. Its central contribution is not simply the application of Generative AI to cybersecurity, but the combination of established behavioral detection techniques with contextual generative reasoning and evidence-based risk prioritization. This design provides a structured foundation for moving enterprise security operations from isolated alert monitoring toward intelligent, context-aware threat investigation. It also supports the communication of technical security findings in a more understandable form, enabling security analysts and organizational decision-makers to assess threats according to their potential operational and business consequences.

The proposed framework also highlights the importance of reliability, explainability, privacy protection, scalability, and human supervision when implementing AI-driven cybersecurity systems. Although Generative AI can improve incident

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interpretation and reduce the effort associated with manual security analysis, its outputs may contain unsupported conclusions, incomplete explanations, or misleading recommendations. Therefore, the framework maintains a distinction between verified security observations, machine-generated anomaly indicators, and AI-generated interpretations. Retrieval-augmented generation, structured threat intelligence, evidence validation, and controlled prompts provide mechanisms for improving the consistency of generated findings. The inclusion of MITRE ATT&CK supports standardized threat classification and improves the communication of observed adversarial behaviors. Furthermore, quantitative risk scoring ensures that incident prioritization is based on identifiable security factors rather than relying exclusively on natural-language model judgments. The methodology provides an evaluation direction based on precision, recall, F1-score, false-positive rates, processing latency, correlation accuracy, and analyst assessment. Since the framework is proposed conceptually, its expected advantages should not be interpreted as experimentally verified performance improvements. Practical validation using real-world cloud audit records, representative attack scenarios, and expert-reviewed security incidents is necessary to establish its effectiveness. The research ultimately demonstrates that integrating behavioral analytics and Generative AI can provide a valuable direction for developing adaptive enterprise cloud security architectures. By combining continuous monitoring, contextual interpretation, intelligent event correlation, and business-oriented risk assessment, organizations can strengthen their capacity to understand and respond to evolving cybersecurity threats. The proposed architecture offers a foundation for future research into trustworthy AI-enabled security operations and more proactive enterprise cloud risk management.

VI. FUTURE WORK

Future research should focus on implementing and experimentally validating the proposed framework within realistic enterprise cloud environments. A practical prototype can be developed by integrating cloud audit services, identity management records, network monitoring systems, Security Information and Event Management platforms, and behavioral analytics engines. Representative datasets from public cloud environments can be combined with controlled attack simulations to evaluate the detection of compromised accounts, privilege misuse, unusual data access, and coordinated multi-stage threats. Future investigations should compare the proposed architecture with traditional rule-based detection, standalone machine learning systems, and behavioral analytics without Generative AI. Performance evaluation should include detection accuracy, false-positive reduction, event correlation quality, incident investigation time, processing latency, and computational cost. Additional research can explore graph neural networks, transformer-based behavioral models, and retrieval-augmented language models to improve the identification of relationships across complex cloud security events. Federated learning may also provide opportunities for collaborative threat intelligence development without requiring organizations to centralize sensitive operational records. Such developments could improve adaptability across multi-cloud environments while maintaining organizational control over confidential information.

Another important direction involves developing trustworthy, explainable, and continuously adaptive AI security mechanisms. Future systems should incorporate model monitoring, adversarial robustness testing, prompt injection resistance, evidence provenance, and mechanisms for detecting hallucinated security recommendations. Human-in-the-loop validation should remain an essential component when incidents involve critical infrastructure, sensitive business information, or potentially disruptive response actions. Research should also investigate autonomous response capabilities under strictly defined authorization policies, including approval requirements, rollback mechanisms, and comprehensive audit trails. Dynamic risk assessment can be extended through business continuity indicators, regulatory requirements, vulnerability intelligence, and changing asset criticality. Additional studies should examine how behavioral baselines adapt to employee role changes, seasonal operational patterns, workload migration, and evolving enterprise architectures. Finally, developing standardized evaluation datasets and reproducible benchmarking procedures will help researchers compare different AI-driven cloud security approaches. These improvements could establish a more reliable foundation for intelligent, explainable, privacy-preserving, and proactive enterprise cloud security systems

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