Architectural Framework for Threat Intelligence Integration with SIEM and SOAR in Hybrid CloudSecurity Environments

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Abstract

This paper presents an architectural framework for integrating threat intelligence with Security Information and Event Management (SIEM) and Security Orchestration, Au- tomation, and Response (SOAR) systems in multi-cloud, hybrid cloud, and on-premises security environments. The proposed architecture aims to enhance threat detection, incident response, and automation by combining threat intelligence feeds with SIEM and SOAR capabilities. Experimental results indicate a significant improvement in response times and threat visibility, offering a novel approach to managing security threats effectively across different infrastructure models.

Keywords: Threat Intelligence, SIEM, SOAR, Multi-Cloud, Hybrid Cloud, On-Premises, Security, Incident Response, Au- tomation

I. INTRODUCTION

The adoption of cloud computing has revolutionized the way organizations manage and process data, providing un- precedented scalability, flexibility, and cost savings [1]. Pub- lic cloud platforms such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP) have enabled organizations to rapidly deploy and manage their in- frastructure without the need for significant upfront investment [2]. However, many organizations also maintain on-premises infrastructure or adopt a hybrid approach that combines on- premises systems with public or private clouds, leading to complex security requirements. The shift to multi-cloud and hybrid cloud environments introduces additional security challenges, particularly in the detection and mitigation of threats across diverse, distributed infrastructure [1].

Cloud and hybrid environments are characterized by multi- tenancy, elasticity, and a shared responsibility model, which complicates the implementation of traditional security mea- sures [1]. Attack surfaces expand rapidly as organizations leverage various cloud services and integrate them with exist- ing on-premises infrastructure, making it difficult to maintain comprehensive visibility and control over potential vulnerabilities. Threat actors are increasingly exploiting misconfigu- rations, weak access controls, and vulnerabilities in cloud and on-premises services to launch attacks such as data breaches, denial of service (DoS), and advanced persistent threats (APT)[3].

Security Information and Event Management (SIEM) sys- tems have become a cornerstone for monitoring security events, providing real-time insights through log aggregation, correlation, and analytics across multi-cloud, hybrid, and on- premises environments [4]. SIEM solutions are adept at col- lecting vast amounts of data from disparate sources, normal- izing it, and generating alerts for suspicious activities [4]. However, SIEM systems alone can struggle with the volume of alerts, which often leads to alert fatigue and delayed response times [7]. On the other hand, Security Orchestration, Automa- tion, and Response (SOAR) platforms complement SIEM by automating repetitive tasks, standardizing response workflows, and enhancing the efficiency of security operations [5]. SOAR platforms allow security teams to focus on critical incidents by reducing manual intervention and ensuring consistent incident handling [11].

Despite their individual capabilities, SIEM and SOAR sys- tems can benefit immensely from the integration of threat intelligence, which provides context to emerging threats and helps anticipate potential attacks [3]. Threat intelligence refers to evidence-based knowledge about existing or emerging threats, including indicators of compromise (IoCs), tactics, techniques, and procedures (TTPs) used by threat actors [12]. By integrating threat intelligence, SIEM systems can enrich security alerts with actionable context, enabling more accurate threat detection and prioritization [8]. SOAR platforms, in turn, can leverage threat intelligence to automate playbooks for threat mitigation, ensuring timely and informed responses [5].

Threat intelligence integration with SIEM and SOAR allows security teams to enrich alerts with real-world insights, thereby prioritizing incidents that pose the highest risk [8]. This integration provides a more holistic view of the threat land- scape, enabling proactive threat hunting and improving situa- tional awareness across multi-cloud, hybrid, and on-premises environments [12]. By effectively combining threat intelligence with SIEM and SOAR, security can be significantly enhanced—facilitating faster response times, reducing false positives, and improving overall incident response efficacy [3]. Moreover, integrating these systems helps address the challenges of scalability and complexity by enabling auto- mated responses that adapt to evolving threats across different infrastructure models [6].

In this paper, we propose an architectural framework that integrates threat intelligence with SIEM and SOAR in multi- cloud, hybrid cloud, and on-premises security environments, addressing the limitations of existing solutions and offering a robust approach to proactive threat management. The proposed framework aims to enhance the efficiency and effectiveness of security operations by providing a seamless flow of infor- mation between threat intelligence, SIEM, and SOAR com- ponents. Through this integration, organizations can achieve better visibility, faster detection, and automated response ca- pabilities, ultimately improving their overall security posture in diverse environments.

II. RELATED WORK

The integration of threat intelligence with SIEM and SOAR systems has been a subject of considerable research interest in recent years. Several studies have highlighted the importance of leveraging threat intelligence to improve threat detection and incident response capabilities [3]. For instance, Bernardi et al. [3] present an approach for integrating threat intelligence feeds with SIEM systems to enhance the detection of advanced persistent threats (APT). Similarly, Smith and Kumar [5] explore the use of SOAR platforms to automate the response process by using threat intelligence to enrich incidents and trigger appropriate playbooks.

Despite the growing interest in this area, there are still sig- nificant gaps in the current solutions. Many existing SIEM and SOAR implementations lack the ability to effectively correlate threat intelligence with security events in real time, leading to delayed detection and response [11]. Moreover, the integration of threat intelligence often results in an overwhelming number of alerts, contributing to alert fatigue and inefficiencies in security operations [7].

Another challenge identified in the literature is the complex- ity of integrating disparate data sources and maintaining the quality and relevance of threat intelligence feeds. Narayanan and Singh [8] point out that the effectiveness of threat in- telligence depends heavily on the accuracy, timeliness, and contextual relevance of the data. However, ensuring that the threat intelligence being used is actionable and not outdated remains a major hurdle for organizations [9].

In this paper, we address these challenges by proposing an integrated architectural framework that combines threat intelligence with SIEM and SOAR in multi-cloud, hybrid cloud, and on-premises environments. Our approach aims to bridge the gap between data aggregation, threat correlation, and automated response, providing a more efficient and scal- able solution for comprehensive security.

III.PROPOSED ARCHITECTURE AND METHODOLOGY

The proposed architecture for integrating threat intelligence with SIEM and SOAR in multi-cloud, hybrid cloud, and on- premises environments consists of several key components, each playing a crucial role in the overall security workflow. This section describes the components involved, includingdata ingestion, threat intelligence correlation, automation, and incident response mechanisms, and how they interact to forma cohesive security solution.

A. System Overview

The proposed system integrates SIEM, SOAR, and threat intelligence sources to provide a comprehensive solution for multi-cloud, hybrid cloud, and on-premises security. The archi- tecture comprises several core components: the data ingestion layer, threat intelligence processing engine, SIEM platform, SOAR system, and automated response mechanisms. Each of these components interacts with others to facilitate real-time threat detection, analysis, and response. Public cloud platformssuch as AWS, Azure, and GCP, as well as on-premises data centers, serve as the primary infrastructure environments fromwhich security data is ingested and processed.

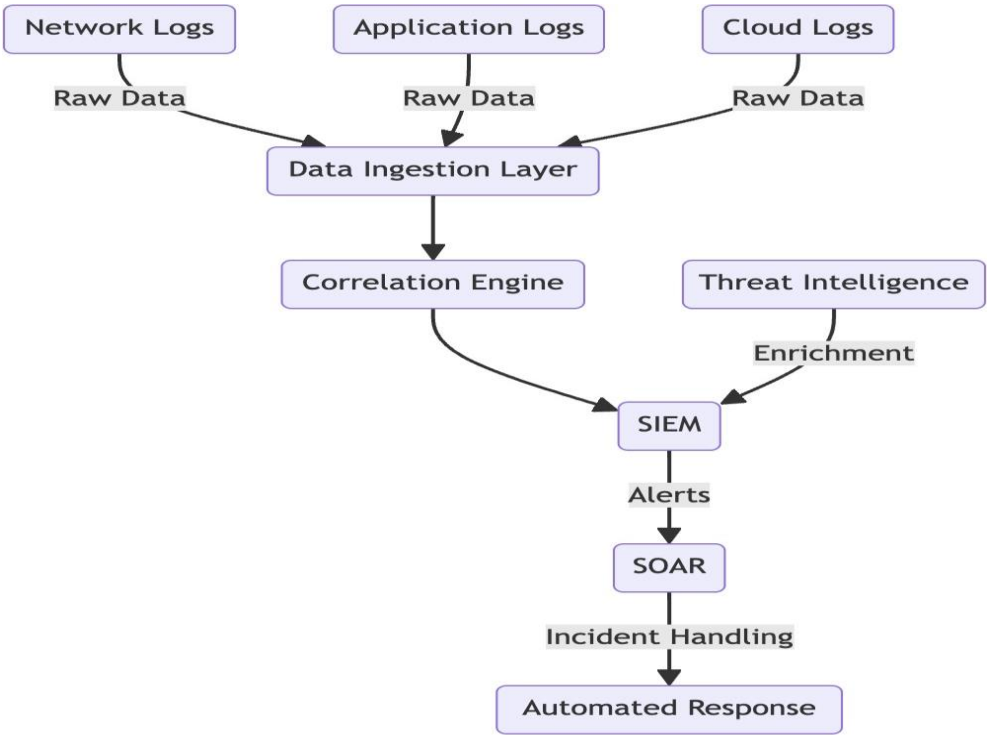

Fig. 1. System Overview of SIEM, SOAR, and Threat Intelligence Integration

B. Data Flow

The data flow begins with the ingestion of raw security data from various sources, such as cloud services, network logs, and application logs hosted on public cloud platforms (e.g., AWS, Azure, GCP) and on-premises environments [9]. This data is then correlated with threat intelligence feeds to identify potential threats and generate actionable alerts [3]. The SIEM system is responsible for aggregating and normalizing this data [4], while the SOAR platform automates response actions based on predefined playbooks [5]. Threat intelligence is used at multiple stages to enrich alerts, prioritize incidents, and guide automated responses across all infrastructure types [8].

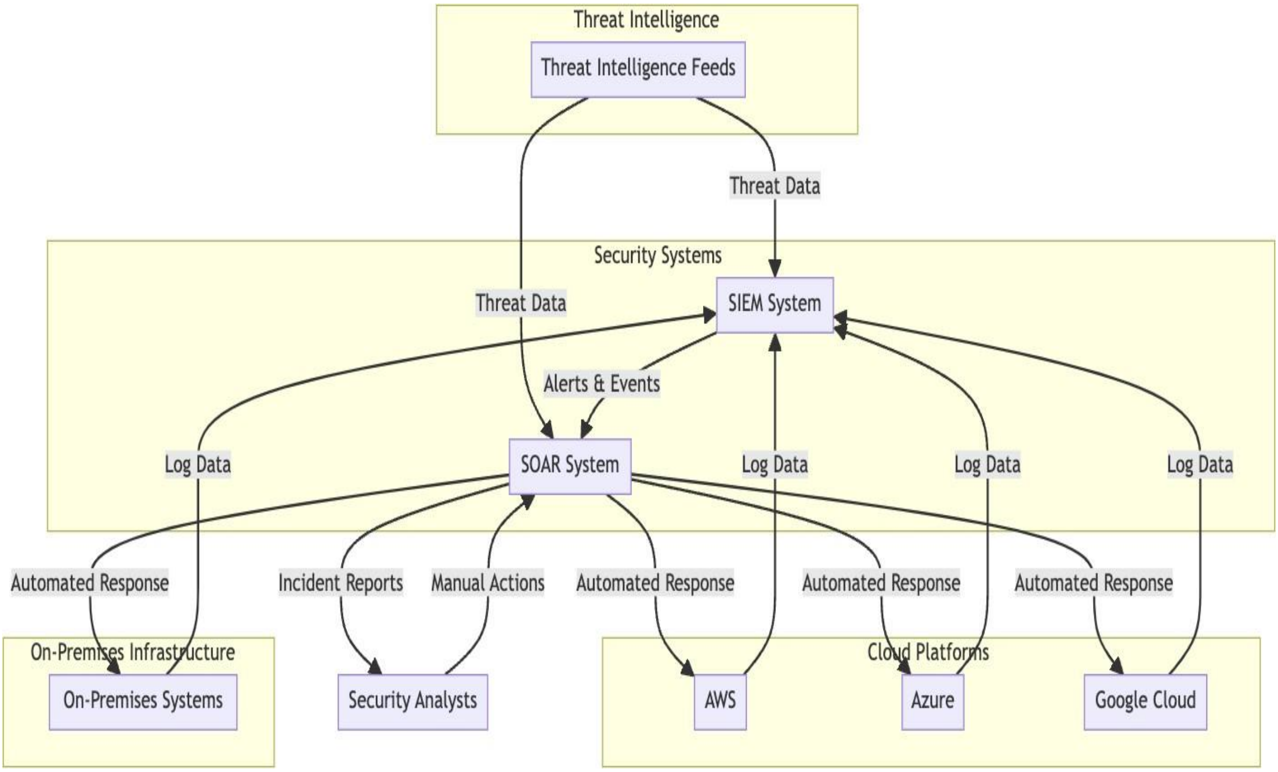

Fig. 2. Data Flow in SIEM, SOAR, and Threat Intelligence Integration

C. Log Collection Architecture

Log collection is a critical component in the proposed architecture, serving as the foundation for effective threat detection and analysis [9]. The log collection architecture is responsible for collecting security data from various sources, including cloud platforms, network devices, applications, and on-premises infrastructure [4].

Components of Log Collection Architecture:

- Log Agents: Deployed across different environments to collect logs from cloud platforms, on-premises systems, and network devices. These agents can be configured to collect different types of logs, such as system logs, security logs, and application logs [9].
- Log Forwarders: Responsible for forwarding the col- lected logs to the centralized log aggregation system. Log forwarders ensure that the data is transmitted securely and efficiently to the aggregation point [4].
- Log Aggregation System: A centralized system where all logs are collected, normalized, and stored. This sys- tem is critical for providing a unified view of security data and is often implemented using technologies like Elasticsearch or a cloud-native logging service [9].

- Normalization and Parsing: Logs are normalized and parsed to ensure consistency and compatibility with the SIEM system. This process involves converting logs into a standardized format that can be analyzed and correlated[4].
- Security Data Lake: The aggregated and normalized logs are stored in a security data lake, which acts asa repository for long-term storage and analysis. This data lake can be queried for threat hunting, compliance reporting, and retrospective analysis [9].

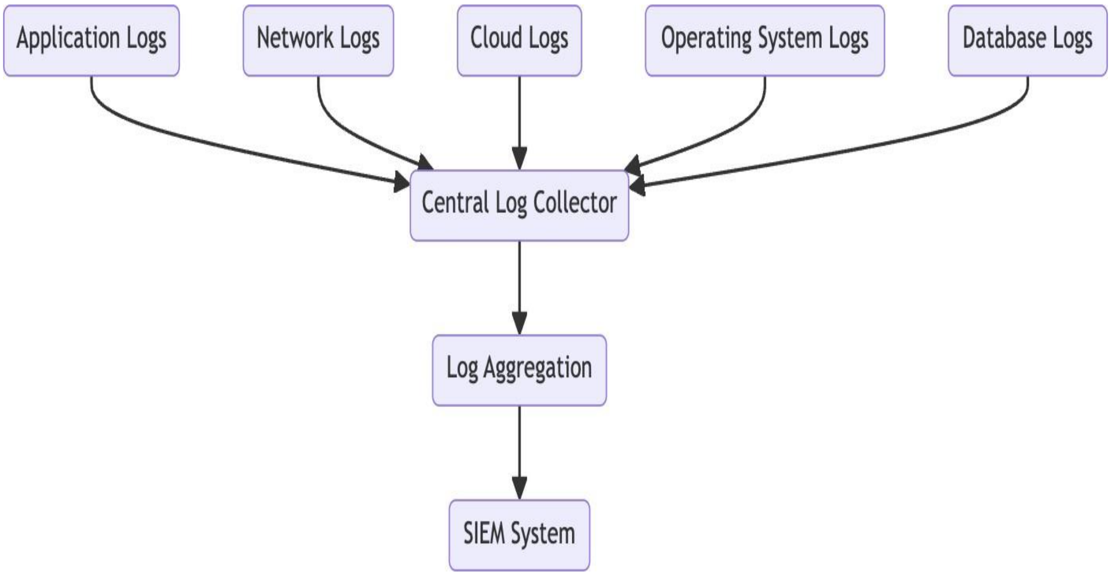

Fig. 3. Log Collection Architecture for SIEM Integration

D. Threat Intelligence Architecture

Threat intelligence is an essential part of the proposed security framework, providing actionable insights that enhancethe detection and mitigation of security threats [8]. The threat intelligence architecture integrates with both SIEM and SOAR systems to improve the accuracy of threat detection and automate response activities [3].

Components of Threat Intelligence Architecture:

- Threat Intelligence Feeds: External and internal sourcesthat provide information on known threats, such as In- dicators of Compromise (IoCs), tactics, techniques, and procedures (TTPs) of threat actors [12].
- Threat Intelligence Platform (TIP): A centralized plat- form for managing and aggregating threat intelligence data. The TIP integrates with external threat feeds and allows analysts to enrich alerts with contextual informa- tion [8].
- Threat Data Correlation Engine: This engine correlatesthreat intelligence data with the ingested security data to identify matches and potential threats. It integrates with the SIEM system to enhance alert generation [3].
- Automated Threat Enrichment: The automated enrich- ment process adds contextual information to alerts, such as threat actor profiles, IoCs, and known vulnerabilities, which helps prioritize incidents and streamline response actions [8].
- Integration with SOAR: The enriched threat intelligenceis passed to the SOAR platform, which uses the datato trigger automated response actions through predefined playbooks [5].

E. Components

SIEM Internal Architecture: The SIEM platform consists of several internal components that work together to collect, analyze, and respond to security events [4]:

- Data Collection Agents: Agents deployed across various environments collect raw security data, including logs, network traffic, and application events. These agents can be installed on cloud platforms (e.g., AWS, Azure, GCP) or on-premises environments [9].
- Log Aggregation and Storage: Collected data is ag- gregated and stored in a centralized data lake. This data can come from cloud infrastructure logs, network traffic data, or application logs, depending on the organization's architecture [9].
- Normalization Engine: The normalization engine stan- dardizes raw security data into a consistent format that can be analyzed and correlated. This process ensures compatibility between different log formats and enables seamless data analysis [4].
- Correlation Engine: The correlation engine identifies patterns in the normalized data to detect potential security threats. It uses predefined rules, machine learning models, and threat intelligence to correlate related events and generate alerts for suspicious activities [3].

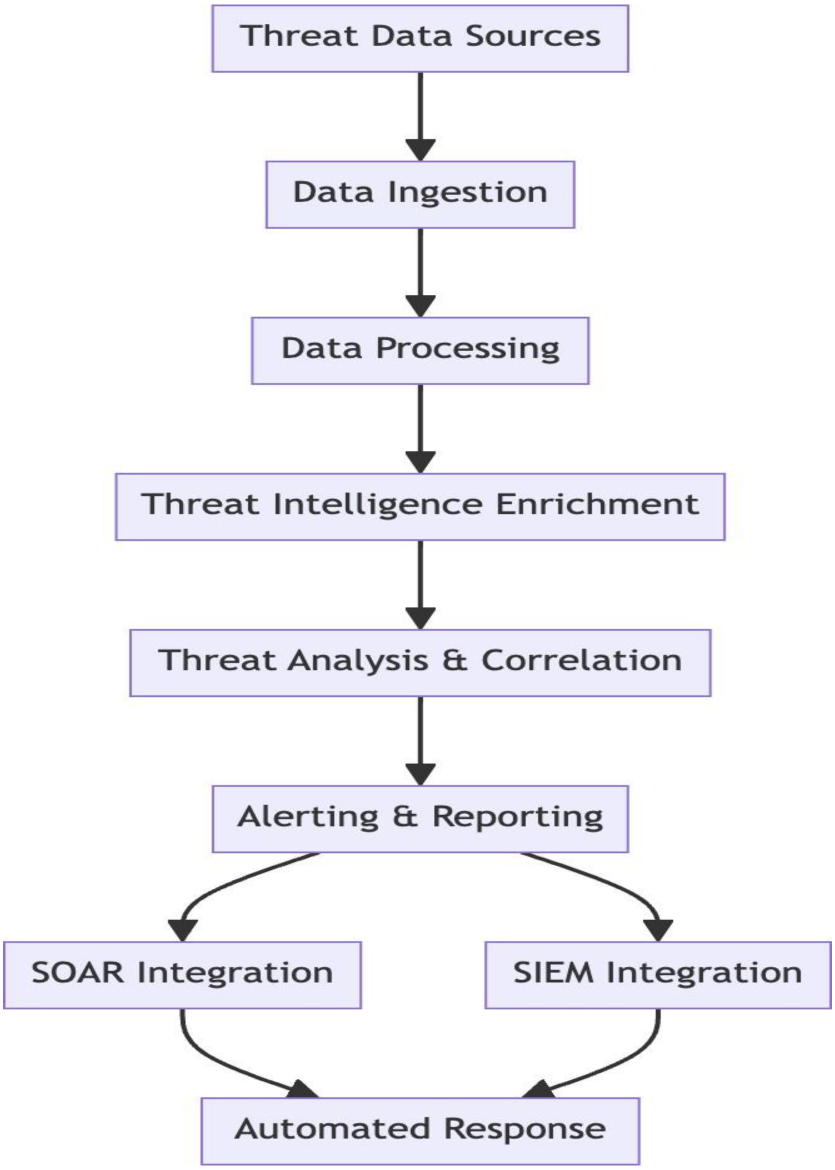

Fig. 4. Threat Intelligence Architecture for Integration with SIEM and SOAR

- Integration Connectors: Connectors provide seamless integration with other security tools, including firewalls, SIEM platforms, threat intelligence sources, and ticketing systems. These connectors ensure that the SOAR platform can communicate and act across different components of the security infrastructure [11].
- Case Management: The case management module al- lows analysts to manage incidents as cases, tracking theirstatus and associated artifacts. It facilitates collaboration among analysts to ensure incidents are investigated and resolved efficiently [5].
- Incident Enrichment Module: This module enhances incident data by automatically pulling information from threat intelligence feeds, user databases, and asset inven- tories. The enriched data provides analysts with a deeper context regarding an alert, improving decision-making during incident response [8].
- Automation Scripts: SOAR systems use scripts to exe- cute specific actions automatically, such as blocking IP addresses, disabling compromised accounts, or isolating affected endpoints. Automation scripts are crucial in reducing response times and mitigating threats beforethey escalate [5].
- Orchestration Layer: The orchestration layer manages the coordination of multiple tools involved in the response process, ensuring that different security components work together effectively to respond to incidents [11].

F. Integration Mechanisms

The integration between threat intelligence, SIEM, and SOAR is achieved through APIs, data connectors, and work- flow automation. Threat intelligence feeds are ingested intothe SIEM platform, where they are used to enrich security alerts. The enriched alerts are then forwarded to the SOAR system, which triggers automated response playbooks basedon the threat context.

- Alerting Module: The alerting module is responsible fornotifying security personnel of detected threats. Alerts can be prioritized based on the severity and potential impact of the threats, enabling security teams to focus on the most critical incidents [7].
- Dashboard and Reporting: The SIEM dashboard pro- vides visualizations of security data and incidents. Re- ports are generated for compliance, audit purposes, andto track the overall security posture of the environment [4].

SOAR Internal Architecture: The SOAR system consists of various internal components designed to orchestrate and automate security responses effectively [5]:

- Playbook Engine: The playbook engine defines and manages automated response workflows, called play- books. Playbooks are configured to trigger specific response actions based on predefined rules or triggeredalerts from the SIEM [5].

IV. CONCLUSION

The proposed architectural framework for integrating threat intelligence with SIEM and SOAR in multi-cloud, hybrid cloud, and on-premises security environments offers signif- icant improvements in threat detection, response time, andoperational efficiency. By leveraging threat intelligence to enrich security alerts and automating response actions through SOAR, the framework addresses key challenges in security, including alert fatigue, scalability, and the need for timely responses. The results demonstrate that the integration of these systems can enhance the overall security posture of diverse environments, providing a robust and scalable solution forproactive threat management.

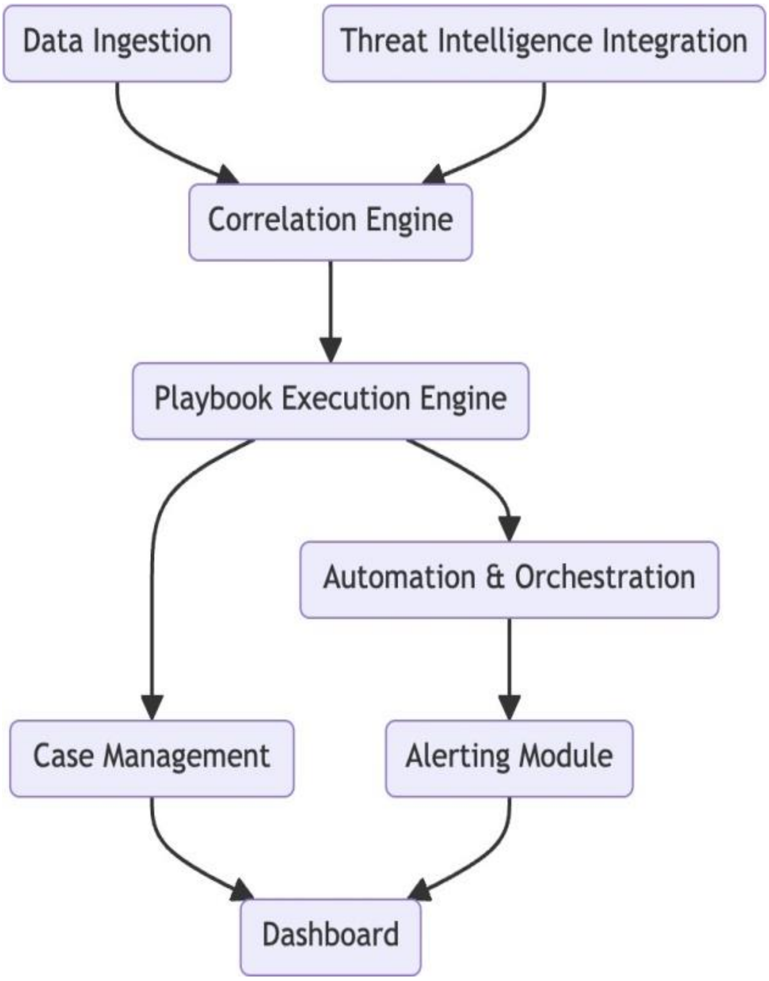
Data Ingestion
Threat Intelligence Integration
Correlation Engine
Playbook Execution Engine
Automation & Orchestration
Case Management
Alerting Module
Dashboard

Fig. 5. Integration Mechanisms for SIEM, SOAR, and Threat Intelligence

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