UNIFIED CYBER THREAT DETECTION AND INCIDENT MANAGEMENT SYSTEM

A report submitted in partial fulfillment of the requirements for the Degree

Bachelor of Technology

In

COMPUTER SCIENCE AND ENGINEERING (Cyber Security)

By

P. Aditya Sriram

2111CS040005

Under the esteemed guidance of

Dr. G. Anand Kumar

Head of the Department

Cyber Security

Department of Computer Science & Engineering (Cyber Security) School of Engineering

MALLA REDDY UNIVERSITY

Maisammaguda, Dulapally, Hyderabad, Telangana 500100, 2025

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(Telangana State Private Universities Act No.13 of 2020 and G.O.Ms.No.14, Higher Education (UE) Department)

Department of Computer Science & Engineering (Cyber Security)

CERTIFICATE

This is to certify that the project report entitled **"UNIFIED CYBER THREAT DETECTION AND INCIDENT MANAGEMENT SYSTEM",** submitted by **P. Aditya Sriram(2111CS040005)** towards the partial fulfilment for the award of **Bachelor's Degree in Cybersecurity** from the **Department of Computer Science and Engineering, Malla Reddy University, Hyderabad**, is a record of bonafide work done by him/ her. The results embodied in the work are not submitted to any other University or Institute for award of any degree or diploma

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DECLARATION

We hereby declare that the project report entitled "**UNIFIED CYBER THREAT DETECTION AND INCIDENT MANAGEMENT SYSTEM**" has been carried out by us and this work has been submitted to the **Department of Computer Science and Engineering (Cyber Security), Malla Reddy University, Hyderabad** in partial fulfilment of the requirements for the award of degree of Bachelor of Technology. We further declare that this project work has not been submitted in full or part for the award of any other degree in any other educational institutions.

Place:

Date:

P. Aditya Sriram

2111CS040005

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ABSTRACT

The **UNIFIED CYBER THREAT DETECTION AND INCIDENT MANAGEMENT SYSTEM** is a comprehensive cybersecurity solution designed to enhance an organization's security posture using **Wazuh**, it collects and analyzes log and event data from various sources, including network devices, endpoints, cloud environments, and applications. As cyber threats become more advanced, organizations require proactive security measures to detect and stop attacks before they cause harm. This system leverages machine learning, correlation rules, and threat intelligence to identify suspicious activities, investigate incidents, and automate responses, significantly reducing security risks. Deployed within a Security Operations Center (SOC), it enables security teams to continuously monitor threats, detect vulnerabilities, and respond swiftly to potential cyberattacks. Its automated incident response mechanisms ensure rapid containment of security breaches, minimizing damage, downtime, and operational disruptions. The system also helps organizations comply with industry regulations and security standards. With real-time security insights, forensic investigation tools, and compliance reporting, it strengthens an organization's ability to prevent, detect, and respond to cyber threats effectively. This powerful solution bridges the gap between threat detection, incident response, and compliance management, making it an indispensable component of modern cyber defense strategies.

Contents

Chapter 1

Introduction

1.1 Problem Definition & Description

Problem Definition:

In today's rapidly evolving digital landscape, organizations face increasing cyber threats like malware attacks, brute force attempts, and unauthorized access. Many lack the resources for unified threat detection and incident response systems, resulting in delayed responses and gaps in security monitoring. The need for a cost-effective, comprehensive, and centralized security solution is critical.

Problem Description:

This project aims to develop a Unified Cyber Threat Detection and Incident Management System using Wazuh SIEM. The system will focus on real-time threat detection, alert generation, and incident response, particularly for Windows environments. By simulating various attack scenarios—such as malware execution, brute force attacks, and file integrity violations—the system will be validated through custom test cases.

Key Features:

- **Real-Time Detection**: Continuous monitoring for threats like brute force attacks, malware, and unauthorized access.
- **Incident Management**: Automated alert generation and response workflows.
- **Unified Monitoring**: Centralized platform for security event management.
- **Test Cases**: Custom scenarios to validate system effectiveness.

Goals:

- Provide accurate threat detection and timely incident response.
- Centralize monitoring for improved visibility and faster action.
- Implement test cases simulating real-world cyberattacks to ensure system reliability.

1.2 Objectives of the Project:

1) **Develop a Unified Cybersecurity System**: Create a system using Wazuh SIEM to detect, manage, and respond to security threats in real-time.
2) **Monitor Windows Hosts**: Focus on monitoring Windows-based environments for various cyber threats like malware, brute force attacks, and unauthorized access.
3) **Incident Management**: Implement an effective incident management workflow to handle detected threats and prioritize response based on severity.
4) **Test Case Implementation**: Design and execute test cases
5) **Centralized Security Monitoring**: Integrate multiple security functions into one unified platform for better visibility and quicker threat response.
6) **Automation and Reporting**: Automate threat detection, alert generation, and create detailed reports for further analysis and proactive defense.
7) **Cost-Effective Solution**: Provide a scalable, open-source cybersecurity solution for organizations, reducing the need for expensive tools.

1.3 Scope of the Project:

1) **Threat Detection on Windows Hosts:** The project will focus on detecting cyber threats (e.g., malware, brute force attacks, privilege escalation) primarily on Windows environments using Wazuh SIEM.

2) **Real-Time Monitoring and Incident Management:** The system will provide continuous monitoring, real-time alerts, and automated incident management workflows to mitigate threats efficiently.

3) **Custom Test Cases:** Various test cases, such as brute force attacks on RDP, malware execution, and unauthorized access, will be implemented to evaluate the system's effectiveness.

4) **Centralized Security Management:** The project aims to provide a unified platform to

centralize security monitoring and incident management across multiple hosts and networks.

5) **Scalability:** The system will be scalable, allowing organizations to monitor and manage

6) **Automation and Reporting:** The project will incorporate automation for threat detection and response while providing detailed reporting and dashboards for security analysis.

7) **Cross-Platform Compatibility:** While the primary focus is on Windows hosts, the system will be adaptable for monitoring other platforms (Linux, macOS) if required.

8) **Cost-Effective Solution:** The project will utilize open-source tools (Wazuh) to provide a cost-effective cybersecurity solution for organizations with limited resources.

1.3 Wazuh:

Wazuh is a free, open-source security information and event management (SIEM) platform that provides comprehensive threat detection, monitoring, and incident response capabilities. It integrates with various systems to centralize the collection and analysis of security events, making it a powerful tool for identifying and managing cyber threats.

Key Features of Wazuh:

1. **Intrusion Detection**: Monitors systems for signs of malicious activity such as unauthorized access, malware infections, or suspicious network traffic.
2. **Log Analysis**: Collects and analyzes logs from multiple sources, identifying potential security incidents and generating alerts based on predefined or custom rules.
3. **File Integrity Monitoring**: Tracks changes to critical system files, helping detect unauthorized modifications that could indicate a security breach or tampering.
4. **Vulnerability Detection**: Identifies known vulnerabilities in systems and applications, allowing proactive mitigation of potential risks.
5. **Incident Response**: Facilitates the handling of security incidents by generating alerts, categorizing threats, and providing real-time insights into potential breaches.

6. **Scalability**: Designed to scale across different environments, Wazuh can monitor multiple platforms (Windows, Linux, macOS, etc.) and handle large-scale deployments.
7. **Compliance**: Helps organizations meet regulatory compliance requirements by providing reports and monitoring tools that address security standards such as GDPR, HIPAA, and PCI-DSS.
8. **Dashboards and Reporting**: Wazuh provides user-friendly dashboards for visualizing security events and generating detail reports to support analysis and decision-making.

Chapter 2

System Analysis

2.1 Existing System:

Splunk Enterprise Security: Splunk Enterprise Security is a SIEM platform that collects and analyzes data from diverse sources to provide real-time visibility into security events. It offers advanced analytics, correlation, and threat intelligence capabilities to detect and respond to security threats effectively.

McAfee Enterprise Security Manager (ESM): McAfee ESM is a SIEM solution that collects, correlates, and analyzes security event data from across the organization's IT infrastructure. It provides real-time threat detection, incident response, and compliance reporting features.

LogRhythm NextGen SIEM Platform: LogRhythm offers a NextGen SIEM platform that combines log management, security analytics, and threat intelligence to detect and respond to advanced cyber threats. It provides centralized monitoring, automated incident response, and compliance reporting capabilities.

ArcSight Enterprise Security Manager (ESM): ArcSight ESM is a SIEM solution that helps organizations detect and respond to security threats in real-time. It collects and analyzes security event data from diverse sources, correlates events to identify potential threats, and provides actionable insights for incident response.

Literature Survey:

[1] Smith (2021) explored the potential of open-source SIEM solutions with a case study on Wazuh. The study highlighted Wazuh's scalability and cost-effectiveness in cybersecurity, making it an ideal solution for small and medium-sized enterprises (SMEs) with limited budgets. The research emphasized Wazuh’s ability to detect various types of threats, including malware, brute force attacks, and unauthorized access.

[2] Johnson and Lee (2022) provided a comparative analysis of automated incident response in SIEM platforms, focusing on Wazuh and Splunk. The study found that while Splunk offered more advanced customization features, Wazuh excelled in its out-of-the-box functionality, especially for open-source users, offering a robust incident management solution at a lower cost.

[3] Williams and Patel (2021) examined real-time threat detection in Windows environments using Wazuh SIEM. Their research demonstrated Wazuh's efficiency in identifying and responding to threats in real-time, noting that its integration with ElasticSearch enhances its log analysis capabilities, thus making it more effective in detecting complex threats in enterprise settings.

[4] Brown (2020) discussed the effectiveness of various SIEM tools in detecting cyber threats. The study found that while many commercial SIEMs offered robust features, open-source tools like Wazuh provided a competitive level of threat detection, particularly in environments where customization and flexibility were critical.

[5] Garcia and Thomas (2022) conducted a study comparing open-source SIEM solutions like Wazuh to commercial ones. They found that while commercial SIEM tools offered more polished interfaces and additional support, Wazuh’s open-source nature allowed for extensive customization and integration, making it a viable alternative in budget-constrained environments.

[6] Clark and Harris (2021) focused on file integrity monitoring and incident response using Wazuh SIEM. The study found that Wazuh’s file integrity monitoring feature provided real-time alerts on file modifications, deletions, or unauthorized access, making it an essential tool for organizations focused on data protection and integrity.

[7] Thompson and Lewis (2022) analyzed event correlation and security log analysis in SIEM platforms, comparing Wazuh and Splunk. The research showed that Wazuh’s event correlation was effective but required more configuration compared to Splunk, which provided more intuitive and out-of-the-box solutions.

[8] Davis (2023) explored how open-source SIEM solutions, particularly Wazuh, enhance real-time threat detection. The study highlighted the growing adoption of Wazuh for its ability to detect various cyber threats across different environments, providing actionable insights through centralized dashboards and alerts.

[9] Williams and Patel (2022) analyzed the integration of Wazuh with ElasticSearch for log analysis. The research found that the integration enhanced Wazuh's log collection and querying capabilities, making it a powerful solution for enterprises needing real-time log analysis and threat detection.

[10] Robinson and Mitchell (2020) discussed the role of SIEM tools in cyber threat detection and response. They emphasized how Wazuh, among other SIEM platforms, has become a go-to solution for detecting and mitigating threats, particularly in smaller organizations seeking cost-effective solutions.

[11] Garcia (2021) focused on Wazuh as an open-source SIEM solution for real-time security monitoring. The research showed that Wazuh offered comparable features to commercial solutions, such as real-time threat detection, log management, and alert generation, making it a popular choice for budget-conscious organizations.

[12] Harris and Lee (2020) conducted a comparative study on SIEM solutions in Windows environments. They found that Wazuh offered superior integration with Windows systems for detecting malware and other threats, while commercial solutions provided more comprehensive enterprise-level security features.

[13] Thompson and Robinson (2021) examined SIEM architecture for real-time threat detection, comparing Wazuh and Splunk. Their research found that while Splunk offered better enterprise support, Wazuh provided flexible and scalable architecture, allowing organizations to tailor their security monitoring solutions to specific needs.

[14] Davis and Brown (2021) discussed real-time malware detection in Windows environments using SIEM. The study found that Wazuh effectively detected malware in real-time and provided actionable alerts, making it a key tool for enhancing security in

Windows-based systems.

[15] Lewis and Patel (2022) conducted a case study on security event monitoring with Wazuh, highlighting how its centralized monitoring capabilities improved visibility into network activity and provided real-time alerts for faster incident response.

[16] Robinson and Mitchell (2021) explored the use of SIEM tools for cyber threat detection, with insights on Wazuh's capabilities. The research showed that Wazuh's open-source nature and flexibility made it an appealing solution for organizations looking for customizable and scalable security monitoring systems.

[17] Clark and Johnson (2022) analyzed SIEM solutions in cloud environments, comparing Wazuh and Splunk. They concluded that Wazuh's open-source nature provided significant cost advantages in cloud deployments, but it required more manual configurations compared to Splunk's cloud-native features.

[18] Harris (2021) discussed the role of open-source solutions in cybersecurity threat detection, focusing on Wazuh's ability to provide real-time monitoring and alerting capabilities across diverse environments.

[19] Garcia and Lee (2023) studied event monitoring and security threat detection using Wazuh SIEM. The research highlighted how Wazuh's integration with cloud-based platforms and ElasticSearch improved log collection, analysis, and threat detection capabilities in real-time.

[20] Mitchell and Thomas (2021) conducted a comparative study of SIEM platforms in incident management, concluding that while commercial solutions offered more enterprise-grade features, open-source platforms like Wazuh provided a cost-effective and customizable alternative suitable for smaller organizations.

2.2 Proposed System:

The proposed system is a Unified Cyber Threat Detection and Incident Management System built using Wazuh SIEM, designed to offer real-time threat detection, automated incident response, and centralized security monitoring. This system will focus on detecting and

managing security events specifically in Windows environments, while also being adaptable for other platforms if needed. The project aims to provide a cost-effective, open-source alternative to traditional SIEM solutions, such as Splunk Enterprise Security, McAfee Enterprise Security Manager, LogRhythm NextGen SIEM, and ArcSight Enterprise Security Manager.

Key Features of the Proposed System:

1. **Real-Time Threat Detection**: Continuously monitor systems for suspicious activities like unauthorized access, malware infections, and privilege escalations.

2. **Centralized Security Management**: Collect and analyze security events from multiple sources, providing a unified view of all security activities across the organization.

3. **Automated Incident Response**: Automatically generate alerts, classify threats, and initiate incident management workflows based on the severity of the detected events.

4. **Custom Test Cases**: Implement custom test cases, such as detecting brute force attacks on RDP, malware execution, and file integrity violations, to validate the system's effectiveness.

5. **Compliance Reporting**: Provide detailed reporting tools to ensure the system aligns with compliance standards such as GDPR, HIPAA, and PCI-DSS.

6. **Scalability**: The system will be scalable to allow monitoring across multiple Windows machines and other platforms, ensuring its applicability for both small and large infrastructures.

Benefits of the Proposed System:

- **Improved Security Monitoring**: Real-time monitoring and detection of threats

ensure timely identification and response to cyberattacks.

- **Enhanced Incident Management**: Automating the incident response process minimizes response time, reduces manual intervention, and mitigates security risks.

- **Unified Platform**: The centralized approach simplifies security management, eliminating the need to use multiple, disconnected tools.

- **Lower Costs**: Using open-source Wazuh reduces licensing and operational costs, making it an ideal solution for organizations with limited budgets.

2.3 Software & Hardware Requirements:

2.3.1 Hardware Requirements

- System processor - Quad-core (minimum)
- Hard Disk – 250 GB (minimum)
- Ram – 8 GB (minimum)

2.3.2 Software Requirements

- **Host Environment**: Windows 10/11 (for testing and implementation)
- **Wazuh Server**: Linux-based distribution

2.4 Feasibility Study:

2.4.1 Technical Feasibility

The Unified Cyber Threat Detection and Incident Management System using Wazuh SIEM is technically feasible due to the following factors:

1. **Availability of Open-Source Tools**: Wazuh is an open-source platform, which makes it cost-effective and easily customizable to meet the project's needs. Supporting components like Elasticsearch, Kibana, and Filebeat are also open-source and widely adopted.

2. **Cross-Platform Support**: Wazuh supports multiple operating systems, including Windows, Linux, and macOS. This ensures seamless integration with the Windows environment, where the test cases will be deployed, and enables future scalability to other platforms.

3. **Existing Integration**: Wazuh has built-in integration with **Elasticsearch** and **Kibana** for data storage, analysis, and visualization. These components provide a strong foundation for log management, security event correlation, and dashboard creation, reducing the need for additional development.

4. **Customizable Test Cases**: Wazuh allows for the development of custom rules and alerts. This flexibility enables the creation of specific test cases for detecting brute force attacks, malware execution, and unauthorized access, ensuring the system is adaptable to various security scenarios.

5. **Scalable Infrastructure**: The project can be implemented using a scalable architecture. Wazuh's server-agent model allows for monitoring multiple hosts, and the system can scale up as the infrastructure grows without significant performance degradation.

6. **Minimal Hardware Requirements**: Wazuh's resource requirements are moderate, and it can run effectively on commodity hardware, making it feasible to deploy in a typical organization or lab setting without the need for specialized hardware.

7. **Ease of Deployment**: Wazuh provides comprehensive documentation and community support, which facilitates easy installation, configuration, and troubleshooting. The server and agents can be deployed without extensive technical expertise, making the system accessible for students and IT professionals alike.

8. **Automation Capabilities**: Wazuh's built-in automation features, such as automated threat detection and incident response, further streamline operations.

2.4.2 Robustness & Reliability

The Unified Cyber Threat Detection and Incident Management System using Wazuh SIEM is designed to ensure high levels of robustness and reliability. Wazuh provides real-time threat detection by continuously monitoring systems and collecting security event data, enabling swift identification of potential security incidents such as malware infections, brute force attacks, and unauthorized access. Its event correlation and analysis capabilities allow for the detection of complex attack patterns by analyzing logs from multiple sources, thus enhancing detection accuracy and reducing false positives. The centralized management architecture ensures reliable monitoring and incident response across multiple hosts and networks, offering seamless coordination from a single platform. Wazuh's built-in fault tolerance, automated alerting system, and robust incident management workflows ensure the system remains operational, even under high volumes of security events. Furthermore, the platform's scalability allows it to grow with organizational needs, maintaining its reliability as the infrastructure expands. Overall, Wazuh's ability to handle diverse security scenarios with minimal downtime ensures a dependable solution for continuous cyber threat detection and management.

2.4.3 Economic Feasibility

The Unified Cyber Threat Detection and Incident Management System using Wazuh SIEM is economically feasible due to its open-source nature, which eliminates the need for expensive software licensing fees associated with traditional SIEM platforms. Wazuh and its supporting components, such as Elasticsearch and Kibana, are freely available, significantly reducing the initial investment required for software. Additionally, the hardware requirements are moderate and can be met using existing infrastructure or affordable commodity hardware, further lowering costs. Compared to proprietary SIEM solutions like Splunk, McAfee, or ArcSight, Wazuh provides similar functionality at a fraction of the cost, making it an ideal choice for organizations with limited budgets. The system's scalability ensures that organizations can start small and expand as needed without requiring costly upgrades. Moreover, the platform's automation features reduce the need for large security teams, cutting down on operational and labor costs. Given these factors, the implementation of this project is not only economically viable but also cost-effective in the long term, providing significant savings while delivering robust cybersecurity capabilities.

2.4.4 Operational Feasibility

The Unified Cyber Threat Detection and Incident Management System using Wazuh SIEM is operationally feasible due to its user-friendly architecture, ease of deployment, and comprehensive support for security monitoring. Wazuh provides a centralized, web-based dashboard that simplifies the management of security events, making it accessible even to users with limited cybersecurity expertise. The system's real-time alerting and automated incident response capabilities ensure that security teams can respond to threats efficiently without needing constant manual oversight. Wazuh integrates smoothly into Windows environments through its agent-server model, allowing seamless communication between hosts and the central server. The platform’s scalability ensures that it can accommodate the needs of small to large infrastructures, while also offering detailed documentation and community support to guide users through the deployment, configuration, and operational stages. Additionally, its automated features, such as real-time log analysis, threat detection, and compliance reporting, reduce the operational burden on security personnel. These factors make the system highly feasible for day-to-day operations in a variety of organizational settings.

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2.4.5 Legal and Compliance Feasibility

The Unified Cyber Threat Detection and Incident Management System using Wazuh SIEM is legally and compliance-wise feasible, as it adheres to major cybersecurity regulations and standards. Wazuh supports compliance with frameworks such as GDPR, HIPAA, PCI-DSS, and SOX, providing built-in compliance modules that help organizations meet regulatory requirements by monitoring, logging, and reporting on security events. The system can generate compliance reports automatically, making it easier for organizations to demonstrate adherence to industry standards and data protection laws. Wazuh’s open-source nature also ensures that there are no legal concerns regarding proprietary software usage or licensing. Additionally, the use of encryption and secure communication protocols ensures that the system complies with data privacy and security requirements, safeguarding sensitive information during threat detection and incident management processes. By enabling organizations to maintain legal and regulatory compliance, Wazuh offers a reliable, compliant cybersecurity solution

Chapter 3

Architectural Design

3.1 Modules Design

3.1.1 Data Pre-processing

In the **Unified Cyber Threat Detection and Incident Management System** using **Wazuh SIEM**, data pre-processing is a critical step to ensure that the raw security event data collected from various sources is transformed into a format suitable for analysis. This process involves several stages, including:

1. **Data Collection**: The Wazuh agents collect raw logs from Windows hosts and other connected systems, including event logs, file changes, network traffic, and system activity.

2. **Data Cleansing**: Raw logs often contain irrelevant or duplicate information. The data cleansing step removes unnecessary log entries, filters out noise, and ensures that only meaningful security events are retained for analysis.

3. **Normalization**: Collected data comes in different formats depending on the source (e.g., Windows logs, network logs, application logs). Normalization converts all data into a standardized format, making it easier to analyze and correlate events across different sources.

4. **Log Parsing**: The logs are parsed into structured formats, allowing for the extraction of key information such as IP addresses, timestamps, file paths, user accounts, and event types, which are essential for threat detection and incident response.

5. **Enrichment**: This step enhances the raw data by adding additional context, such as mapping IP addresses to geographic locations or cross-referencing data with threat intelligence feeds to identify known malicious activity.

6. **Correlation**: Pre-processed data is then correlated across multiple data sources to identify patterns and detect complex attack scenarios that may involve multiple steps or systems.

By performing data pre-processing, the system ensures that the incoming security event data is cleaned, structured, and enriched, making it ready for accurate analysis, threat detection, and incident management. This step improves the overall efficiency and effectiveness of the cybersecurity system.

3.2 Data Collection and Integration

In the Unified Cyber Threat Detection and Incident Management System using Wazuh SIEM, Data Collection and Integration are crucial processes that enable the system to gather security-related information from various sources and integrate it into a unified platform for analysis and threat detection.

1. **Data Collection**:
    - Wazuh agents are installed on Windows hosts and other systems across the network to collect security event data, such as system logs, application logs, and network traffic.
    - The agents monitor critical system activities, including file integrity, process creation, user logins, registry changes, and network connections, gathering real-time data for analysis.
    - Wazuh also supports the collection of data from cloud environments, databases, and third-party applications, ensuring comprehensive security visibility.
2. **Integration with External Systems**:
    - The collected logs are sent to the **Wazuh Server**, which integrates them into a centralized data store.
    - Wazuh integrates with **Elasticsearch** for indexing and storing logs, and **Kibana** is used to visualize and explore the security data.
    - The platform can integrate with external **threat intelligence feeds** to enrich the data with information about known vulnerabilities, malicious IP addresses, or suspicious domains, enhancing the ability to detect sophisticated attacks.

- Wazuh supports integration with other security tools and services, such as **firewalls**, **intrusion detection systems (IDS)**, and **endpoint protection platforms**, to provide a holistic view of the security landscape.

Through effective data collection and integration, Wazuh ensures that all relevant security events are captured, centralized, and prepared for analysis, providing comprehensive coverage and enabling real-time detection of cyber threats across an organization's infrastructure.

3.3 Analyzing

In the **Unified Cyber Threat Detection and Incident Management System** using **Wazuh SIEM**, the **analyzing** phase plays a pivotal role in detecting, identifying, and responding to potential security threats. Once data has been collected and integrated from various sources, the system proceeds with the following analysis steps:

1. **Log Parsing and Normalization**: The raw security event data collected from Windows hosts and other sources is parsed and normalized into a structured format, ensuring consistency across different types of logs (e.g., application logs, network logs, system logs). This makes it easier to extract meaningful information, such as user activities, IP addresses, and timestamps.

2. **Threat Detection**: Wazuh uses a set of predefined rules and custom rules to detect suspicious activity, such as unauthorized access attempts, malware execution, privilege escalation, or brute-force attacks. The platform continuously analyzes the incoming data for anomalies or patterns that may indicate a security breach.

3. **Event Correlation**: By correlating security events across multiple data sources, Wazuh can detect multi-step attacks that may span across different systems or time periods. This helps identify complex attack scenarios that would otherwise go unnoticed if events were analyzed in isolation.

4. **Behavioral Analysis**: Wazuh also uses behavioral analysis techniques to track the normal behavior of systems, applications, and users. Any deviation from these baselines (e.g., unusual file access, abnormal login times) is flagged for further investigation as it could signal a potential threat.

5. **Risk Assessment**: Each detected event is analyzed in terms of its severity and potential impact on the system. Wazuh categorizes incidents based on risk levels, allowing security teams to prioritize high-risk threats and respond promptly to critical security issues.

6. **Real-Time Alerts**: When a threat or anomaly is detected, Wazuh generates real-time alerts that notify security personnel of the issue. The alerts include details about the nature of the threat, affected systems, and recommended response actions. Alerts can also trigger automated responses to mitigate the threat immediately.

Through continuous log analysis, event correlation, and behavioral monitoring, the system effectively detects, analyzes, and escalates security incidents, providing a proactive defense mechanism against cyber threats. This comprehensive analysis ensures the organization's

3.4 Project Architecture

3.4.1 Complete architecture

- The Wazuh architecture is based on agents, running on the monitored endpoints, that forward security data to a central server. Agentless devices such as firewalls, switches, routers, and access points are supported and can actively submit log data via Syslog, SSH, or using their API. The central server decodes and analyzes the incoming information and passes the results along to the Wazuh indexer for indexing and storage.

- The Wazuh indexer cluster is a collection of one or more nodes that communicate with each other to perform read and write operations on indices. Small Wazuh deployments, which do not require processing large amounts of data, can easily be handled by a single-node cluster. Multi-node clusters are recommended when there are many monitored endpoints, when a large volume of data is anticipated, or when high

availability is required.

- For production environments, it is recommended to deploy the Wazuh server and Wazuh indexer to different hosts. In this scenario, Filebeat is used to securely forward Wazuh alerts and archived events to the Wazuh indexer cluster (single-node or multi-node) using TLS encryption.

- The diagram below represents a Wazuh deployment architecture. It shows the solution components and how the Wazuh server and the Wazuh indexer nodes can be configured as clusters, providing load balancing and high availability.

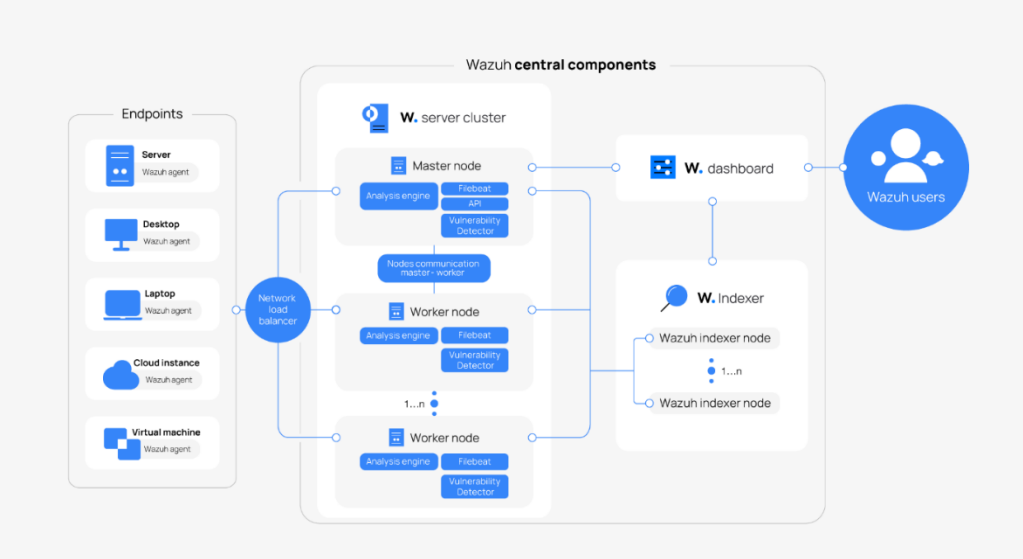


Fig. 1 Complete Architecture

Wazuh agent - Wazuh server communication:

The Wazuh agent continuously sends events to the Wazuh server for analysis and threat detection. To start shipping this data, the agent establishes a connection with the server service for agent connection, which listens on port 1514 by default (this is configurable). The Wazuh server then decodes and rule-checks the received events, utilizing the analysis engine. Events that trip a rule are augmented with alert data such as rule ID and rule name. Events can be spooled to one or both of the following files, depending on whether or not a rule is tripped:

- The file /var/ossec/logs/archives/archives.json contains all events whether they tripped a rule or not.
- The file /var/ossec/logs/alerts/alerts.json contains only events that tripped a rule with

high enough priority (the threshold is configurable).

The Wazuh messages protocol uses AES encryption by default, with 128 bits per block and 256-bit keys. Blowfish encryption is optional.

Wazuh server - Wazuh indexer communication

- The Wazuh server uses Filebeat to securely transmit alert and event data to the Wazuh indexer via TLS encryption. Filebeat monitors output data from the Wazuh server and forwards it to the Wazuh indexer, which listens on port 9200/TCP by default. Once indexed, you can analyze and visualize the data through the Wazuh dashboard.

- The Vulnerability Detection module updates the vulnerability inventory. It also generates alerts, providing insights into system vulnerabilities.

- The Wazuh dashboard queries the Wazuh RESTful API (by default listening on port 55000/TCP on the Wazuh server) to display configuration and status-related information of the Wazuh server and agents. It can also modify agents or server configuration settings through API calls. This communication is encrypted with TLS and authenticated with a username and password.

Archival data storage

Both alerts and non-alert events are stored in files on the Wazuh server, in addition to being sent to the Wazuh indexer. These files can be written in JSON format (.json), or plain text format (.log). These files are daily compressed and signed using MD5, SHA1, and SHA256 checksums. The directory and filename structure is as follows:

root@wazuh-manager:/var/ossec/logs/archives/2022/Jan# ls -l

Output:

total 176
-rw-r----- 1 wazuh wazuh 234350 Jan 2 00:00 ossec-archive-01.json.gz
-rw-r----- 1 wazuh wazuh   350 Jan 2 00:00 ossec-archive-01.json.sum
-rw-r----- 1 wazuh wazuh 176221 Jan 2 00:00 ossec-archive-01.log.gz
-rw-r----- 1 wazuh wazuh   346 Jan 2 00:00 ossec-archive-01.log.sum

```
-rw-r----- 1 wazuh wazuh 224320 Jan  2 00:00 ossec-archive-02.json.gz
-rw-r----- 1 wazuh wazuh    350 Jan  2 00:00 ossec-archive-02.json.sum
-rw-r----- 1 wazuh wazuh 151642 Jan  2 00:00 ossec-archive-02.log.gz
-rw-r----- 1 wazuh wazuh    346 Jan  2 00:00 ossec-archive-02.log.sum
-rw-r----- 1 wazuh wazuh 315251 Jan  2 00:00 ossec-archive-03.json.gz
-rw-r----- 1 wazuh wazuh    350 Jan  2 00:00 ossec-archive-03.json.sum
-rw-r----- 1 wazuh wazuh 156296 Jan  2 00:00 ossec-archive-03.log.gz
-rw-r----- 1 wazuh wazuh    346 Jan  2 00:00 ossec-archive-03.log.sum
```

- Rotation and backups of archive files are recommended according to the storage capacity of the Wazuh server. By using cron jobs, you can easily manage to keep only a specific time window of archive files locally on the server, for example, last year or the last three months.
- On the other hand, you may choose to dispense with storing archive files and simply rely on the Wazuh indexer for archive storage. This alternative might be preferred if you run periodic Wazuh indexer snapshot backups and/or have a multi-node Wazuh indexer cluster with shard replicas for high availability. You could even use a cron job to move snapshotted indices to a final data storage server and sign them using MD5, SHA1, and SHA256 hashing algorithms.

3.4.2 Data Flow /Process Flow Diagram

The diagram below represents the Wazuh components and data flow.

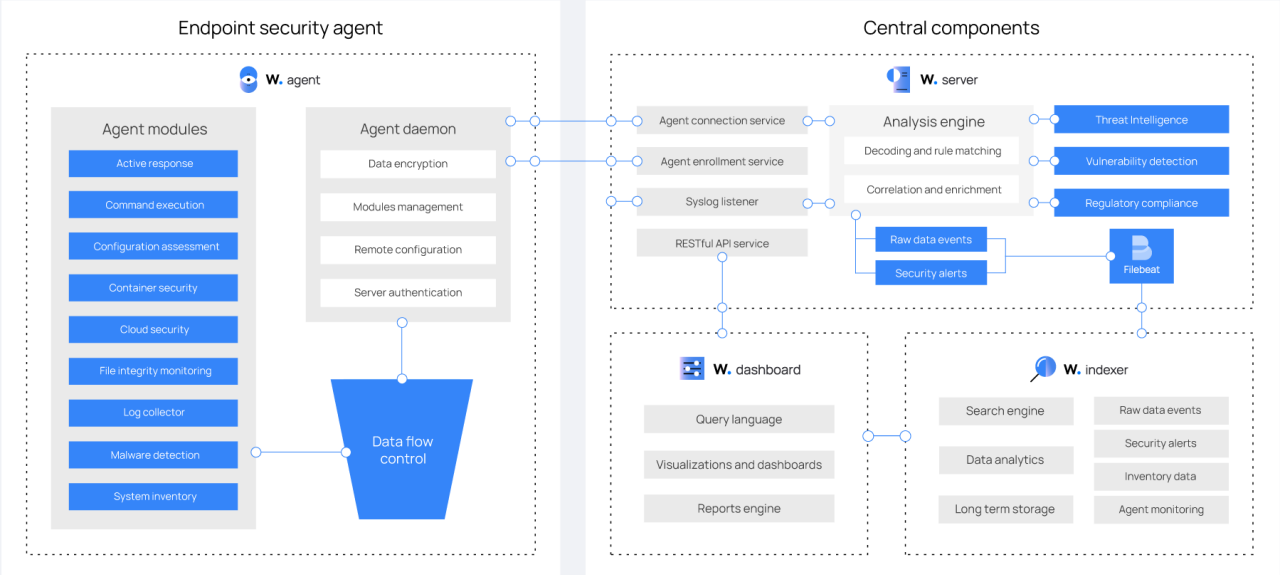


Fig. 2 Data Flow & Process Flow Diagram

The Wazuh platform provides XDR and SIEM features to protect your cloud, container, and server workloads. These include log data analysis, intrusion and malware detection, file integrity monitoring, configuration assessment, vulnerability detection, and support for regulatory compliance.

The Wazuh solution is based on the Wazuh agent, which is deployed on the monitored endpoints, and on three central components: the Wazuh server, the Wazuh indexer, and the Wazuh dashboard.

- The Wazuh indexer is a highly scalable, full-text search and analytics engine. This central component indexes and stores alerts generated by the Wazuh server.

- The Wazuh server analyzes data received from the agents. It processes it through decoders and rules, using threat intelligence to look for well-known indicators of compromise (IOCs). A single server can analyze data from hundreds or thousands of agents, and scale horizontally when set up as a cluster. This central component is also used to manage the agents, configuring and upgrading them remotely when necessary.

- The Wazuh dashboard is the web user interface for data visualization and analysis. It includes out-of-the-box dashboards for threat hunting, regulatory compliance (e.g., PCI DSS, GDPR, CIS, HIPAA, NIST 800-53), detected vulnerable applications, file integrity monitoring data, configuration assessment results, cloud infrastructure monitoring events, and others. It is also used to manage Wazuh configuration and to

monitor its status.

- Wazuh agents are installed on endpoints such as laptops, desktops, servers, cloud instances, or virtual machines. They provide threat prevention, detection, and response capabilities. They run on operating systems such as Linux, Windows macOS, Solaris, AIX, and HP-UX.

In addition to agent-based monitoring capabilities, the Wazuh platform can monitor agent-less devices such as firewalls, switches, routers, or network IDS, among others. For example, a system log data can be collected via Syslog, and its configuration can be monitored through periodic probing of its data, via SSH or through an API

3.4.3 Use Case Diagram

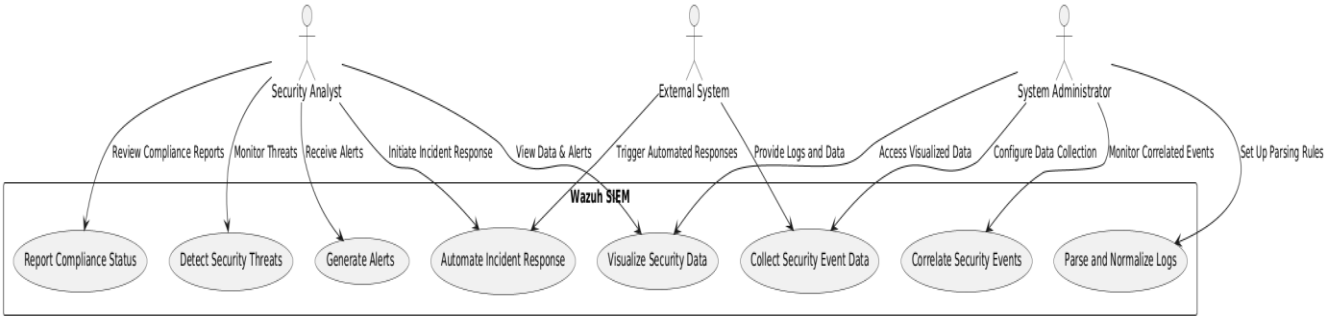


Fig. 3 Use Case Diagram

The **Use Case Diagram** for the **Unified Cyber Threat Detection and Incident Management System** using **Wazuh SIEM** depicts the key actors and their interactions with the system. The primary actors involved are the **Security Analyst**, **System Administrator**, and an **External System** that provides log data and integrates with Wazuh.

Actors:

1. **Security Analyst**: This actor is responsible for monitoring threats, receiving alerts, and initiating incident response actions. They interact with the system to analyze detected threats, view security event visualizations, and ensure compliance reporting.
2. **System Administrator**: The System Administrator configures the data collection settings, sets up log parsing rules, and monitors event correlations. They are responsible for ensuring that the system collects logs from various hosts and devices and processes them efficiently. They also review visualized security data and event correlations.
3. **External System**: External systems, such as network devices, firewalls, or other logging tools, provide raw data and logs to the Wazuh system. They also trigger automated responses when certain predefined security events or thresholds are met.

Use Cases:

1. **Collect Security Event Data**: Wazuh collects logs and security events from various hosts, including Windows systems, external network devices, and cloud environments. The data is centralized in Wazuh for further analysis.
2. **Parse and Normalize Logs**: The system parses the raw logs and normalizes the data into a structured format, making it consistent and ready for analysis. Parsing rules can be customized based on the system's requirements.
3. **Detect Security Threats**: Wazuh continuously monitors the incoming data for potential threats by applying predefined or custom rules. This process detects anomalies, malicious activities, or any suspicious behavior.
4. **Generate Alerts**: When a threat is detected, the system generates real-time alerts that notify the Security Analyst of the incident. Alerts include details of the detected threat, such as affected systems, severity, and timestamps.
5. **Visualize Security Data**: The system provides dashboards and visualizations that allow security teams to view log data, correlated events, threat patterns, and historical security incidents. Kibana is typically used to render these visualizations.
6. **Automate Incident Response**: Wazuh can trigger automated responses based on predefined rules or detected threats. These responses could include blocking an IP address, terminating a process, or alerting system admins for further action.
7. **Report Compliance Status**: Wazuh generates compliance reports based on security events and system configurations. These reports help organizations meet compliance requirements like GDPR, HIPAA, or PCI-DSS by documenting security-related activities.
8. **Correlate Security Events**: The system correlates events from multiple sources to identify complex attack patterns. This helps in detecting sophisticated multi-stage attacks that might span across different hosts or networks.

3.4.4 Activity Diagram

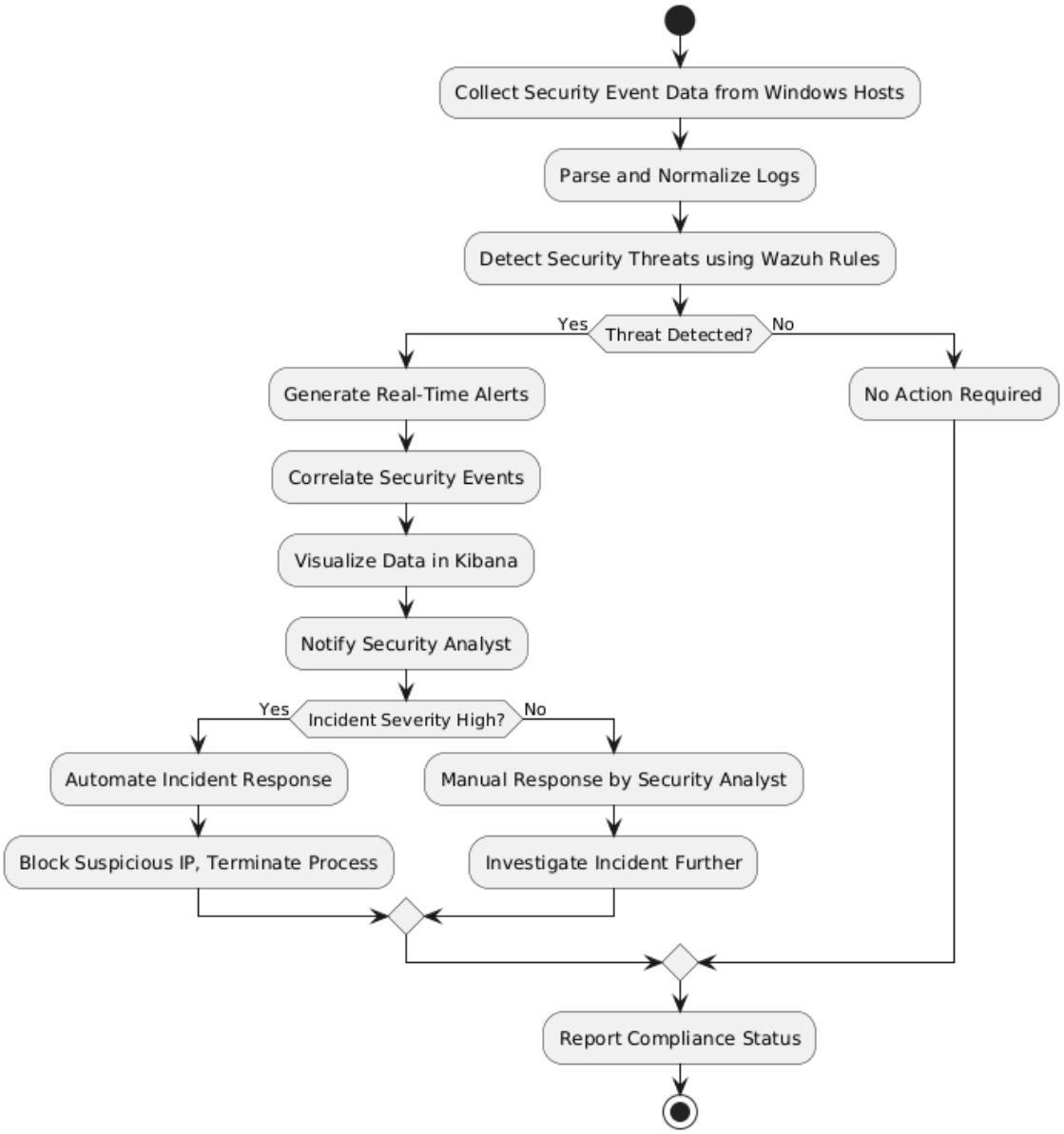


Fig. 4 Activity Diagram

Description of the Activity Diagram:

1. **Collect Security Event Data**: The system collects security logs and event data from various sources, including Windows hosts and other systems.
2. **Parse and Normalize Logs**: The collected data is parsed and normalized into a structured format to ensure uniformity across all log types.
3. **Detect Security Threats**: Wazuh SIEM applies predefined rules to detect suspicious activities or anomalies within the security data.
4. **Threat Detected?**: A decision point checks whether a security threat has been detected.
    - **Yes**:
        - If a threat is detected, the system generates real-time alerts.
        - Correlates the event with other logs to identify the severity or nature of the threat.
        - The data is visualized in the Kibana dashboard for monitoring.
        - The Security Analyst is notified for further actions.
        - **Incident Severity High?**: Another decision point checks if the incident severity is high.
            - **Yes**: The system initiates automated incident response, such as blocking a suspicious IP or terminating a malicious process.
            - **No**: The Security Analyst manually investigates the incident and decides on the response.
    - **No**: If no threat is detected, the system takes no further action.
5. **Report Compliance Status**: The system generates compliance reports based on security activities and incidents, ensuring that the organization meets regulatory requirements.

3.1.1 Sequence Diagram

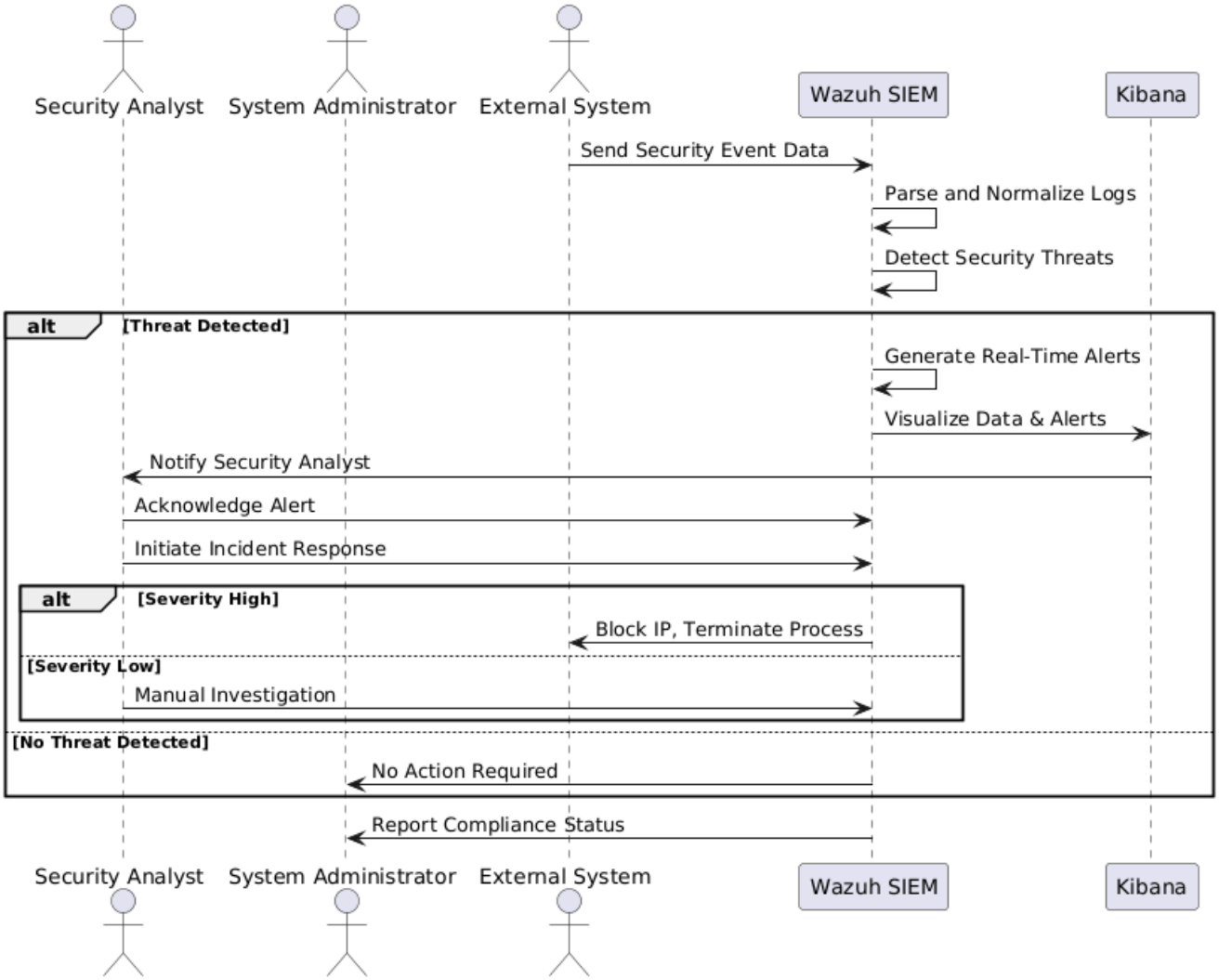


Fig. 3.2.5 Sequence Diagram

Description of the Sequence Diagram:

1. **External System Sends Security Event Data**: The external system, which could be a firewall, server, or any other device, sends its logs and event data to Wazuh for processing.
2. **Wazuh Parses and Normalizes Logs**: Wazuh parses the incoming data to ensure uniformity, making it easier to analyze and detect threats.
3. **Wazuh Detects Security Threats**: Wazuh applies security rules to the normalized data to detect any potential threats.
4. **Threat Detected?**: If a threat is detected, the following actions take place:
    - Wazuh generates real-time alerts based on the detected threat.
    - Wazuh sends the alert and data to **Kibana** for visualization, allowing for graphical representation of security events.
    - Kibana notifies the **Security Analyst** of the detected threat.
5. **Security Analyst Response**:
    - The Security Analyst acknowledges the alert and initiates an incident response.
    - If the incident severity is high, Wazuh takes automated actions (e.g., blocking IP, terminating malicious processes).
    - If the severity is low, the Security Analyst manually investigates the incident further.
6. **No Threat Detected**: If no threat is detected, no action is required, and the **System Administrator** is informed.
7. **Compliance Reporting**: Wazuh generates and sends compliance reports to the **System Administrator**, ensuring the organization is meeting security and regulatory requirements.

This **Sequence Diagram** outlines the step-by-step interactions between the system's components,

Chapter 4

Implementation & Testing

4.1 Sample Code

sudo -i

ip a

Configuration files

All components included in this virtual image are configured to work out-of-the-box, without the need to modify any settings. However, all components can be fully customized. These are the configuration files locations:

- Wazuh manager: **/var/ossec/etc/ossec.conf**
- Wazuh indexer: **/etc/wazuh-indexer/opensearch.yml**
- Filebeat-OSS: **/etc/filebeat/filebeat.yml**
- Wazuh dashboard:
    - **/etc/wazuh-dashboard/opensearch_dashboards.yml**
    - **/usr/share/wazuh-dashboard/data/wazuh/config/wazuh.yml**

Preparing the upgrade

In case Wazuh is installed in a multi-node cluster configuration, repeat the following steps for every node.

1. Ensure you have added the Wazuh repository to every Wazuh indexer, server, and dashboard node before proceeding to perform the upgrade actions.Import the GPG key.
   # rpm --import https://packages.wazuh.com/key/GPG-KEY-WAZUH

2. Add the repository.
   echo -e '[wazuh]\ngpgcheck=1\ngpgkey=https://packages.wazuh.com/key/GPG-KEY-WAZUH\nenabled=1\nname=EL-$releasever - Wazuh\nbaseurl=https://packages.wazuh.com/4.x/yum/\nprotect=1' | tee /etc/yum.repos.d/wazuh.repo

d

Stop the Filebeat and Wazuh dashboard services if installed in the node.

- **systemctl stop filebeat**
- **systemctl stop wazuh-dashboard**

Upgrading the Wazuh indexer

The Wazuh indexer cluster remains operational throughout the upgrade. The rolling upgrade process allows nodes to be updated one at a time, ensuring continuous service availability and minimizing disruptions. The steps detailed in the following sections apply to both single-node and multi-node Wazuh indexer clusters.

Preparing the Wazuh indexer cluster for upgrade

Perform the following steps on any of the Wazuh indexer nodes replacing <WAZUH_INDEXER_IP_ADDRESS>, <USERNAME>, and <PASSWORD>.

1. Disable shard replication to prevent shard replicas from being created while Wazuh indexer nodes are being taken offline for the upgrade.

```
curl -X PUT "https://<WAZUH_INDEXER_IP_ADDRESS>:9200/_cluster/settings" \
-u <USERNAME>:<PASSWORD> -k -H "Content-Type: application/json" -d '
{
  "persistent": {
    "cluster.routing.allocation.enable": "primaries"
  }
}'
```

2. Perform a flush operation on the cluster to commit transaction log entries to the index.

```
curl -X POST "https://<WAZUH_INDEXER_IP_ADDRESS>:9200/_flush" -u
<USERNAME>:<PASSWORD> -k
```

3. Run the following command on the Wazuh manager node(s) if running a single-node Wazuh indexer cluster.

```
systemctl stop wazuh-manager
```

Upgrading the Wazuh indexer nodes

Perform the following steps on each Wazuh indexer node to upgrade them. Upgrade nodes with the cluster_manager role last to maintain cluster connectivity among online nodes.

- Stop the Wazuh indexer service.
  systemctl stop wazuh-indexer

- Upgrade the Wazuh indexer to the latest version.
  yum upgrade wazuh-indexer

- Restart the Wazuh indexer service.
  systemctl daemon-reload
  systemctl enable wazuh-indexer
  systemctl start wazuh-indexer

- Run the following command on the Wazuh manager node(s) to start the Wazuh manager service if you stopped it earlier.
  systemctl start wazuh-manager

Steps to Install Wazuh Agent on Kali Linux

1. Update Your Kali Linux

Before installing the Wazuh agent, update your system to ensure you have the latest package lists and software updates.

sudo apt update && sudo apt upgrade -y

2. Import Wazuh GPG Key

To allow your system to trust the Wazuh packages, add the Wazuh GPG key:

curl -s https://packages.wazuh.com/key/GPG-KEY-WAZUH | sudo apt-key add –

3. Add Wazuh Repository

Add the Wazuh repository to your Kali Linux system by running:

echo "deb https://packages.wazuh.com/4.x/apt/ stable main" | sudo tee

/etc/apt/sources.list.d/wazuh.list

4. Update Package List

After adding the Wazuh repository, update your package list to recognize the new Wazuh packages:

sudo apt update

5. Install the Wazuh Agent

Now, you can install the Wazuh agent by running the following command:

sudo apt install wazuh-agent -y

6. Configure the Wazuh Agent

After installation, the Wazuh agent needs to be configured to communicate with the Wazuh server.

- Open the Wazuh agent configuration file:

sudo nano /var/ossec/etc/ossec.conf

- In the <client> section, modify the <address> tag to point to the Wazuh manager's IP address:

```
<client>
  <server>
    <address>WAZUH_MANAGER_IP</address>
    <port>1514</port> <!-- Default port for communication -->
  </server>
</client>
```

Replace **WAZUH_MANAGER_IP** with the IP address of your Wazuh manager/server.

7. Enable and Start the Wazuh Agent

After configuring the agent, enable and start the Wazuh agent service:

sudo systemctl daemon-reload

sudo systemctl enable wazuh-agent

sudo systemctl start wazuh-agent

8. Verify Wazuh Agent Status

Check if the Wazuh agent is running correctly:

sudo systemctl status wazuh-agent

The output should indicate that the service is **active** and running.

9. Connect the Agent to the Wazuh Manager

Once the agent is installed and configured, the Wazuh manager will automatically start receiving logs from the agent.

You can monitor the logs on the **Kibana** dashboard to ensure the agent is working correctly.

Additional Commands:

- **Restart the Wazuh Agent**:
  sudo systemctl restart wazuh-agent
- **Stop the Wazuh Agent**:
  sudo systemctl stop wazuh-agent

Detecting and removing malware using VirusTotal integration:

Wazuh uses the integrator module to connect to external APIs and alerting tools such as VirusTotal. In this use case, you use the Wazuh File Integrity Monitoring (FIM) module to monitor a directory for changes and the VirusTotal API to scan the files in the directory. Then, configure Wazuh to trigger an active response script and remove files that VirusTotal detects as malicious. We test this use case on Ubuntu and Windows endpoints. You need a VirusTotal API key in this use case to authenticate Wazuh to the VirusTotal API.

Configuration for the Windows endpoint:

Perform the following steps to configure Wazuh to monitor near real-time changes in the /Downloads directory. These steps also install the necessary packages and create the active response script to remove malicious files.

1. Search for the <syscheck> block in the Wazuh agent C:\Program Files (x86)\ossec-agent\ossec.conf file. Make sure that <disabled> is set to no. This enables the Wazuh FIM module to monitor for directory changes.

2. Add an entry within the <syscheck> block to configure a directory to be monitored in near real-time. In this use case, you configure Wazuh to monitor the C:\Users\<USER_NAME>\Downloads directory.

3. Replace the <USER_NAME> variable with the appropriate user name:
   <directories realtime="yes">C:\Users\<USER_NAME>\Downloads</directories>

4. Download the Python executable installer from the official Python website.

5. Run the Python installer once downloaded. Make sure to check the following boxes:
   - Install launcher for all users
   - Add Python 3.X to PATH (This places the interpreter in the execution path)

6. Once Python completes the installation process, open an administrator PowerShell terminal and use pip to install PyInstaller:
   - **pip install pyinstaller**
   - **pyinstaller --version**

You use Pyinstaller here to convert the active response Python script into an executable application that can run on a Windows endpoint.

7. Create an active response script remove-threat.py to remove a file from the Windows endpoint:

```
#!/usr/bin/python3
# Copyright (C) 2015-2022, Wazuh Inc.
# All rights reserved.

import os
import sys
import json
import datetime

if os.name == 'nt':
    LOG_FILE = "C:\\Program Files (x86)\\ossec-agent\\active-response\\active-responses.log"
else:
    LOG_FILE = "/var/ossec/logs/active-responses.log"
```

```
ADD_COMMAND = 0
DELETE_COMMAND = 1
CONTINUE_COMMAND = 2
ABORT_COMMAND = 3

OS_SUCCESS = 0
OS_INVALID = -1

class message:
    def __init__(self):
        self.alert = ""
        self.command = 0

def write_debug_file(ar_name, msg):
    with open(LOG_FILE, mode="a") as log_file:
        log_file.write(str(datetime.datetime.now().strftime('%Y/%m/%d
%H:%M:%S')) + " " + ar_name + ": " + msg +"\n")

def setup_and_check_message(argv):

    # get alert from stdin
    input_str = ""
    for line in sys.stdin:
        input_str = line
        break


    try:
        data = json.loads(input_str)
    except ValueError:
        write_debug_file(argv[0], 'Decoding JSON has failed, invalid input format')
        message.command = OS_INVALID
        return message
```

```
    message.alert = data

    command = data.get("command")

    if command == "add":
        message.command = ADD_COMMAND
    elif command == "delete":
        message.command = DELETE_COMMAND
    else:
        message.command = OS_INVALID
        write_debug_file(argv[0], 'Not valid command: ' + command)

    return message


def send_keys_and_check_message(argv, keys):

    # build and send message with keys
    keys_msg = json.dumps({"version": 1,"origin":{"name": argv[0],"module":"active-response"},"command":"check_keys","parameters":{"keys":keys}})

    write_debug_file(argv[0], keys_msg)

    print(keys_msg)
    sys.stdout.flush()

    # read the response of previous message
    input_str = ""
    while True:
        line = sys.stdin.readline()
        if line:
            input_str = line
            break
```

```
    # write_debug_file(argv[0], input_str)

    try:
        data = json.loads(input_str)
    except ValueError:
        write_debug_file(argv[0], 'Decoding JSON has failed, invalid input format')
        return message

    action = data.get("command")

    if "continue" == action:
        ret = CONTINUE_COMMAND
    elif "abort" == action:
        ret = ABORT_COMMAND
    else:
        ret = OS_INVALID
        write_debug_file(argv[0], "Invalid value of 'command'")

    return ret

def main(argv):

    write_debug_file(argv[0], "Started")

    # validate json and get command
    msg = setup_and_check_message(argv)

    if msg.command < 0:
        sys.exit(OS_INVALID)

    if msg.command == ADD_COMMAND:
        alert = msg.alert["parameters"]["alert"]
        keys = [alert["rule"]["id"]]
```

```
        action = send_keys_and_check_message(argv, keys)

        # if necessary, abort execution
        if action != CONTINUE_COMMAND:

            if action == ABORT_COMMAND:
                write_debug_file(argv[0], "Aborted")
                sys.exit(OS_SUCCESS)
            else:
                write_debug_file(argv[0], "Invalid command")
                sys.exit(OS_INVALID)

        try:
            file_path                                                    =
msg.alert["parameters"]["alert"]["data"]["virustotal"]["source"]["file"]
            if os.path.exists(file_path):
                os.remove(file_path)
            write_debug_file(argv[0], json.dumps(msg.alert) + " Successfully removed
threat")
        except OSError as error:
            write_debug_file(argv[0], json.dumps(msg.alert) + "Error removing threat")



    else:
        write_debug_file(argv[0], "Invalid command")

    write_debug_file(argv[0], "Ended")

    sys.exit(OS_SUCCESS)

if __name__ == "__main__":
    main(sys.argv)
```

8. Convert the active response Python script remove-threat.py to a Windows executable

application. Run the following PowerShell command as an administrator to create the executable:

pyinstaller -F \path_to_remove-threat.py

Take note of the path where pyinstaller created remove-threat.exe.

9. Move the executable file remove-threat.exe to the C:\Program Files (x86)\ossec-agent\active-response\bin directory.

10. Restart the Wazuh agent to apply the changes. Run the following PowerShell command as an administrator:

Restart-Service -Name wazuh

Wazuh server:

Perform the following steps on the Wazuh server to configure the VirusTotal integration. These steps also enable and trigger the active response script whenever a suspicious file is detected.

1. Add the following configuration to the /var/ossec/etc/ossec.conf file on the Wazuh server to enable the VirusTotal integration. Replace <YOUR_VIRUS_TOTAL_API_KEY> with your VirusTotal API key. This allows to trigger a VirusTotal query whenever any of the rules in the FIM syscheck group are triggered:

```
<ossec_config>
  <integration>
    <name>virustotal</name>
    <api_key><YOUR_VIRUS_TOTAL_API_KEY></api_key> <!-- Replace with your VirusTotal API key -->
    <group>syscheck</group>
    <alert_format>json</alert_format>
  </integration>
</ossec_config>
```

Note

The free VirusTotal API rate limits requests to four per minute. If you have a premium VirusTotal API key, with a high frequency of queries allowed, you can add more rules besides these two. You can configure Wazuh to monitor more directories besides C:\Users\<USER_NAME>\Downloads.

Append the following blocks to the Wazuh server /var/ossec/etc/ossec.conf file. This enables Active Response and trigger the remove-threat.exe executable when the VirusTotal query returns positive matches for threats:

```
<ossec_config>
  <command>
    <name>remove-threat</name>
    <executable>remove-threat.exe</executable>
    <timeout_allowed>no</timeout_allowed>
  </command>

  <active-response>
    <disabled>no</disabled>
    <command>remove-threat</command>
    <location>local</location>
    <rules_id>87105</rules_id>
  </active-response>
</ossec_config>
```

Add the following rules to the Wazuh server /var/ossec/etc/rules/local_rules.xml file to alert about the Active Response results.

```
<group name="virustotal,">
  <rule id="100092" level="12">
     <if_sid>657</if_sid>
     <match>Successfully removed threat</match>
     <description>$(parameters.program) removed threat located at $(parameters.alert.data.virustotal.source.file)</description>
  </rule>
```

```
  <rule id="100093" level="12">
    <if_sid>657</if_sid>
    <match>Error removing threat</match>
    <description>Error removing threat located at
$(parameters.alert.data.virustotal.source.file)</description>
  </rule>
</group>
```

2. Restart the Wazuh manager to apply the configuration changes:

```
$ sudo systemctl restart wazuh-manager
```

Attack emulation:

1. Follow the next steps to temporarily turn off real-time Microsoft Defender antivirus protection in Windows Security:
    a. Click on the **Start** menu and type Windows Security to search for that app.
    b. Select the **Windows Security app** from results, go to **Virus & threat protection**, and under **Virus & threat protection settings** select **Manage settings**.
    c. Switch **Real-time protection** to **Off**.

2. Download an EICAR test file to the C:\Users\<USER_NAME>\Downloads directory on the Windows endpoint.

```
Invoke-WebRequest -Uri https://secure.eicar.org/eicar.com.txt -OutFile eicar.txt
cp .\eicar.txt C:\Users\<USER_NAME>\Downloads
```

This triggers a VirusTotal query and generates an alert. In addition, the active response script automatically removes the file.

4.2 Execution Flow for the Unified Cyber Threat Detection and Incident Management System using Wazuh SIEM

The execution flow for this project involves a series of steps where data is collected, analyzed, and security threats are detected. It integrates Wazuh agents, Wazuh server, and a centralized SIEM platform (Wazuh with Kibana) for real-time threat monitoring and incident response.

Here's the step-by-step execution flow:

1. **Log Generation (Source Systems):**
    - Security event logs are generated by different endpoints such as Windows hosts, Linux systems, network devices, databases, and other critical infrastructure components.
    - These logs include information about system activities, user access, failed login attempts, and other security events.
2. **Log Collection (Wazuh Agents):**
    - Wazuh agents are installed on the endpoint systems (like Kali Linux, Windows, etc.).
    - These agents collect system logs, application logs, and security events from the source systems.
    - The collected logs are forwarded to the Wazuh Server for further processing.
3. **Log Parsing and Normalization:**
    - The Wazuh server parses and normalizes the collected logs to ensure they are structured and consistent.
    - Parsing rules are applied to extract relevant fields from the logs (such as IP addresses, usernames, event types).
    - Normalization allows Wazuh to analyze data from various sources in a uniform format.
4. **Threat Detection and Correlation:**
    - The parsed logs are processed by Wazuh’s detection engine, which applies predefined security rules and machine learning algorithms.
    - Wazuh correlates these events with historical data to detect anomalies, potential security threats, and suspicious activities (e.g., multiple failed login attempts, unauthorized access).

5. **Alert Generation:**
    - When a threat or anomaly is detected, Wazuh generates an alert.
    - The alerts contain detailed information about the threat, including its severity, event type, and affected systems.

6. **Alert Visualization (Kibana Dashboard):**
    - Wazuh integrates with Kibana to provide a visual representation of the security events and alerts.
    - Security analysts can view real-time data on the Kibana dashboard, including graphs, charts, and dashboards, for easy monitoring of threats and incidents.
7. **Incident Response:**
    - Based on the alert severity, incident response actions can be initiated.
    - Automated responses, such as blocking malicious IP addresses or killing suspicious processes, are triggered for high-severity threats.
    - For less severe alerts, security analysts investigate the incidents manually, using the detailed logs and alerts available in Kibana.
8. **Compliance Reporting:**
    - Wazuh generates compliance reports to help organizations adhere to security regulations and industry standards (e.g., GDPR, HIPAA).
    - These reports include information about security events, incidents, and the actions taken to resolve them.
9. **Continuous Monitoring:**
    - The system continuously monitors logs from all endpoints, ensuring ongoing protection against threats.
    - The Wazuh server updates security rules and threat detection algorithms to adapt to emerging threats and vulnerabilities.

Summary of Execution Flow:

1. Log Generation (Source Systems)
2. Log Collection (Wazuh Agents)
3. Log Parsing and Normalization (Wazuh Server)
4. Threat Detection and Correlation (Wazuh Detection Engine)
5. Alert Generation
6. Alert Visualization (Kibana Dashboard)

7. Incident Response (Automated/Manual Actions)
8. Compliance Reporting
9. Continuous Monitoring

Test Cases:

1.1.1 Test Case 1:

System: Wazuh SIEM

Scenario: Test Data Ingestion and Processing

Steps:

1. Install the Wazuh agent on a Windows host system.
2. Generate a sample log file containing different types of events (e.g., system logs, user access logs, security alerts).
3. Configure the Wazuh agent to collect logs from the Windows host and send them to the Wazuh server.
4. Verify that the logs are successfully ingested and parsed by Wazuh SIEM.
5. Ensure that the events are categorized correctly and mapped to appropriate security rules in the Wazuh dashboard.

Expected Result:

1. All events from the sample log file are successfully ingested and processed by the Wazuh SIEM.
2. Events are categorized correctly, and rules are triggered as expected.
3. Security alerts are generated and displayed on the Wazuh dashboard.

1.1.2 Test Case 2:

System: Wazuh SIEM

Scenario: Log Collection from Multiple Sources

Steps:

1. Install Wazuh agents on multiple systems (e.g., Windows host, Linux server, network device).
2. Configure each agent to collect logs from its respective system and forward them to the Wazuh server.
3. Verify that the Wazuh server is receiving logs from all configured sources.

4. Check if logs are parsed and normalized correctly for each source type.
5. Monitor the system to ensure that there are no delays or missed logs in the data collection process.

Expected Result:

1. Logs from all sources are successfully collected and forwarded to the Wazuh server.
2. Logs are parsed and normalized properly, regardless of source type.
3. Wazuh SIEM displays real-time data without missing any logs from the sources.

1.1.3 Test Case 3:

System: Wazuh SIEM

Scenario: Threat Detection and Alert Generation

Steps:

1. Generate a security event (e.g., a brute force attack or failed login attempts) on the Windows host system.
2. Verify that the Wazuh agent collects this event and sends it to the Wazuh server.
3. Ensure that the Wazuh detection engine applies the correct rules and detects the threat.
4. Confirm that Wazuh generates an alert for the detected security threat.
5. Review the details of the generated alert in the Wazuh dashboard.

Expected Result:

1. The security event is collected and processed by the Wazuh SIEM.
2. The threat is detected by the Wazuh rules and appropriate alerts are generated.
3. Alerts contain relevant information about the threat, such as IP address, event type, and timestamps.

1.1.4 Test Case 4:

System: Wazuh SIEM with VirusTotal API integration

Scenario: Testing the integration of VirusTotal with Wazuh for analyzing and detecting malicious files.

Steps:

1. **Configure VirusTotal API Key in Wazuh:**
    - Obtain a VirusTotal API key from the VirusTotal website.
    - Add the API key in the Wazuh manager configuration under the virustotal

module.

- Ensure that VirusTotal integration is enabled in the Wazuh configuration file.

2. **Upload a Sample Suspicious File for Testing:**
    - Place a sample suspicious file (e.g., a file known to be flagged as malware by VirusTotal) in the monitored directory for Wazuh.
    - Ensure that the file triggers an event to be analyzed by Wazuh.

3. **Check Wazuh Manager Logs:**
    - Verify that Wazuh detects the suspicious file and sends a request to VirusTotal for analysis using the configured API key.
    - Confirm that the VirusTotal API response is logged in Wazuh, providing a verdict on the file.
4. **Verify Alerts in Wazuh:**
    - Check the Wazuh dashboard to ensure that an alert is generated for the suspicious file.
    - Verify that the alert includes VirusTotal analysis results, including the file hash, detection ratio, and any malware classification provided by VirusTotal.
5. **Simulate a Non-malicious File Upload:**
    - Upload a file that is known to be safe (not flagged by VirusTotal).
    - Confirm that Wazuh performs the VirusTotal analysis, and no alerts are generated for this file.
6. **Monitor API Request Limits:**
    - Ensure that the VirusTotal API integration respects the request limits defined by the VirusTotal API plan.
    - Check the logs for any API rate limit warnings or errors when multiple files are uploaded for analysis within a short time.

Expected Results:

1. Wazuh successfully sends the sample suspicious file hash to VirusTotal for analysis.
2. The VirusTotal API response is received and logged by Wazuh.
3. Wazuh generates alerts for files identified as malicious by VirusTotal, with detailed analysis in the alert.
4. No false positive alerts are generated for safe files during the test.
5. The VirusTotal API rate limit is not exceeded, or appropriate warnings are logged

when the limit is reached.

Extra Test Cases:

Test Case 1: Brute Force Attack Detection

- **Objective**: Verify that Wazuh detects and logs brute force attempts on an SSH service.
- **Steps**:
    1. Set up an SSH service on a test server.
    2. Use Hydra to attempt a brute force login on the SSH service.

    hydra -l root -P /usr/share/wordlists/rockyou.txt ssh://<IP_ADDRESS>

    3. Monitor Wazuh's alerts and logs for detection.
    4. Check if the brute force detection rule is triggered.
- **Expected Result**:
    - Wazuh should generate an alert for multiple failed login attempts.
    - Logs should show the source IP, number of attempts, and blocked IP if applicable.

Test Case 2: Malware Detection

- **Objective**: Test Wazuh's ability to detect malware execution or installation.
- **Steps**:
    1. Download and execute a sample malware (e.g., EICAR test file) on a test machine.

    curl -o eicar.com http://www.eicar.org/download/eicar.com

    2. Execute the file or place it in a directory where malware is detected.
    3. Monitor Wazuh for malware detection and alert generation.
- **Expected Result**:
    - Wazuh should generate an alert for the malware.
    - The alert should contain the file name, path, and any associated hash values .

Test Case 3: Privilege Escalation Detection

- **Objective**: Validate that Wazuh detects privilege escalation attempts, such as sudo use or modifying sensitive system files.
- **Steps**:

1. Simulate a privilege escalation by switching to the root user via sudo or su.
2. Monitor Wazuh for any alerts indicating privilege escalation.

- **Expected Result**:
  - Wazuh should generate an alert when sudo or su commands are used.
  - Alerts should contain details of the user performing the action and the command executed.

Test Case 4: File Integrity Monitoring (FIM)

- **Objective**: Test Wazuh's File Integrity Monitoring (FIM) capabilities by making changes to sensitive files.
- **Steps**:
  1. Configure Wazuh to monitor files in /etc/ (e.g., /etc/passwd).
  2. Modify the file content or permissions.

  sudo echo "testuser:x:1001:1001::/home/testuser:/bin/bash" >> /etc/passwd
  3. Monitor Wazuh for alerts indicating file changes.
- **Expected Result**:
  - Wazuh should generate an alert indicating that a monitored file has been modified.
  - The alert should contain the file name, time of modification, and the user responsible for the change.

Test Case 5: SQL Injection Attack Detection

- **Objective**: Check if Wazuh can detect SQL injection attacks.
- **Steps**:
  1. Deploy a vulnerable web application (e.g., DVWA or OWASP WebGoat).
  2. Simulate an SQL injection attack by sending malicious input in the URL or form fields. Example:

  http://<IP_ADDRESS>/vulnerable_page?id=1' OR '1'='1
  3. Monitor Wazuh for SQL injection alerts.
- **Expected Result**:
  - Wazuh should generate an alert when an SQL injection attempt is detected.
  - The alert should include details of the request and the payload.

Test Case 6: Network Scanning Detection

- **Objective**: Verify that Wazuh can detect network scanning (reconnaissance) activity.
- **Steps**:
    1. Run a network scanning tool like nmap on a network to scan for open ports.

    nmap -sS <IP_ADDRESS>

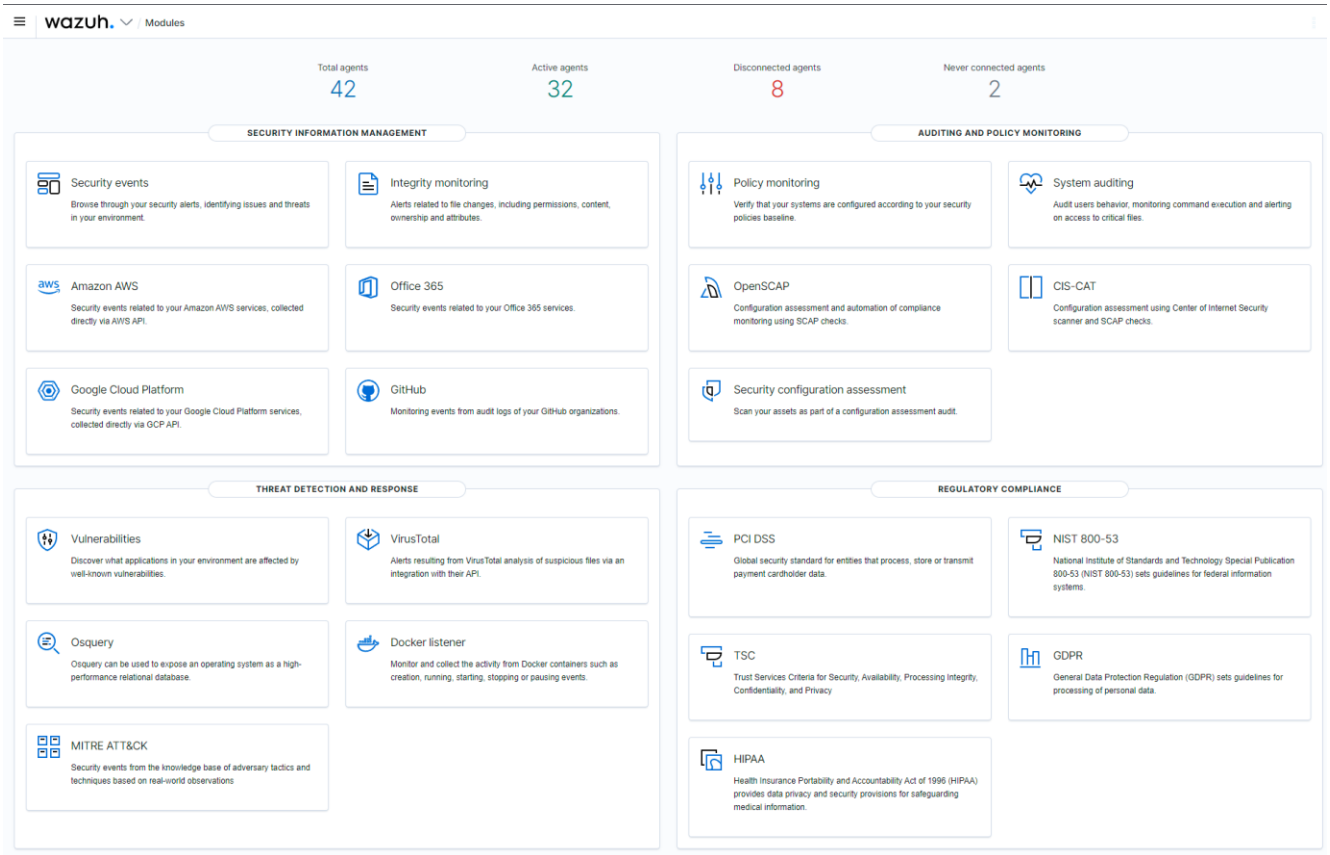
    2. Monitor Wazuh for alerts that indicate scanning activity.
- **Expected Result**:
    - Wazuh should generate alerts indicating suspicious scanning activity.
    - Alerts should contain the source and target IP addresses, the type of scan, and the ports scanned.

Chapter 5

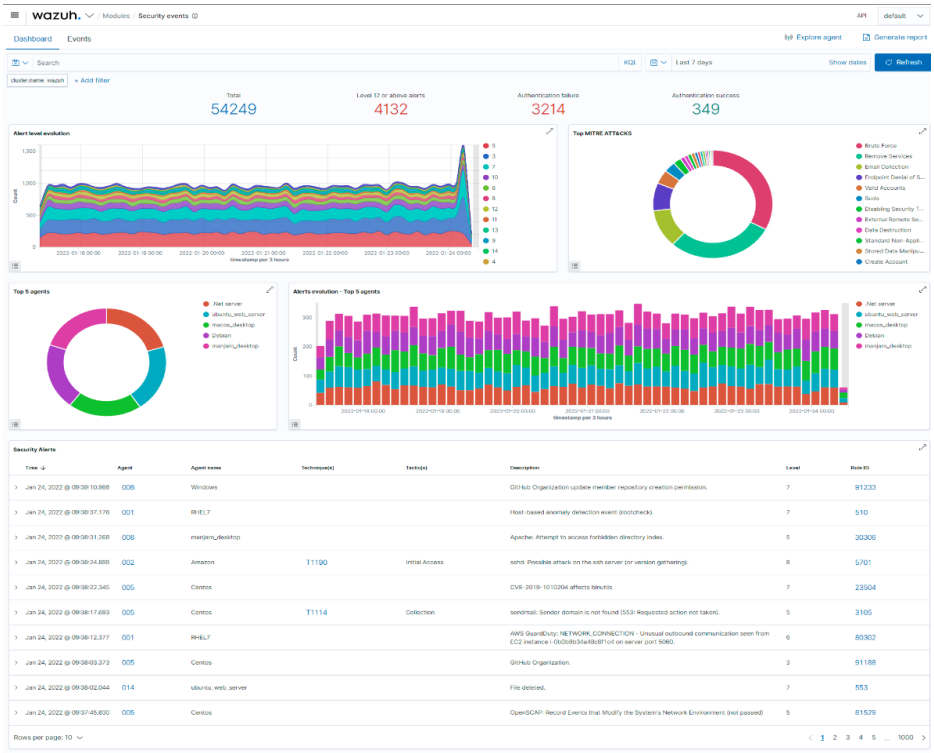
Results

WUI (Wazuh User Interface):

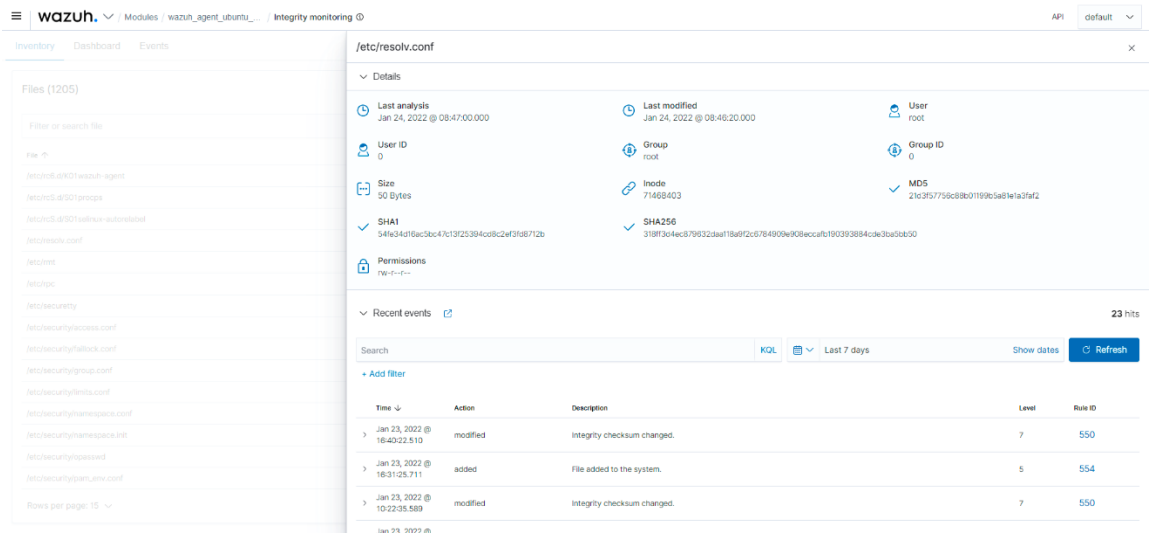
The Wazuh WUI provides a powerful user interface for data visualization and analysis. This interface can also be used to manage Wazuh configuration and to monitor its status.



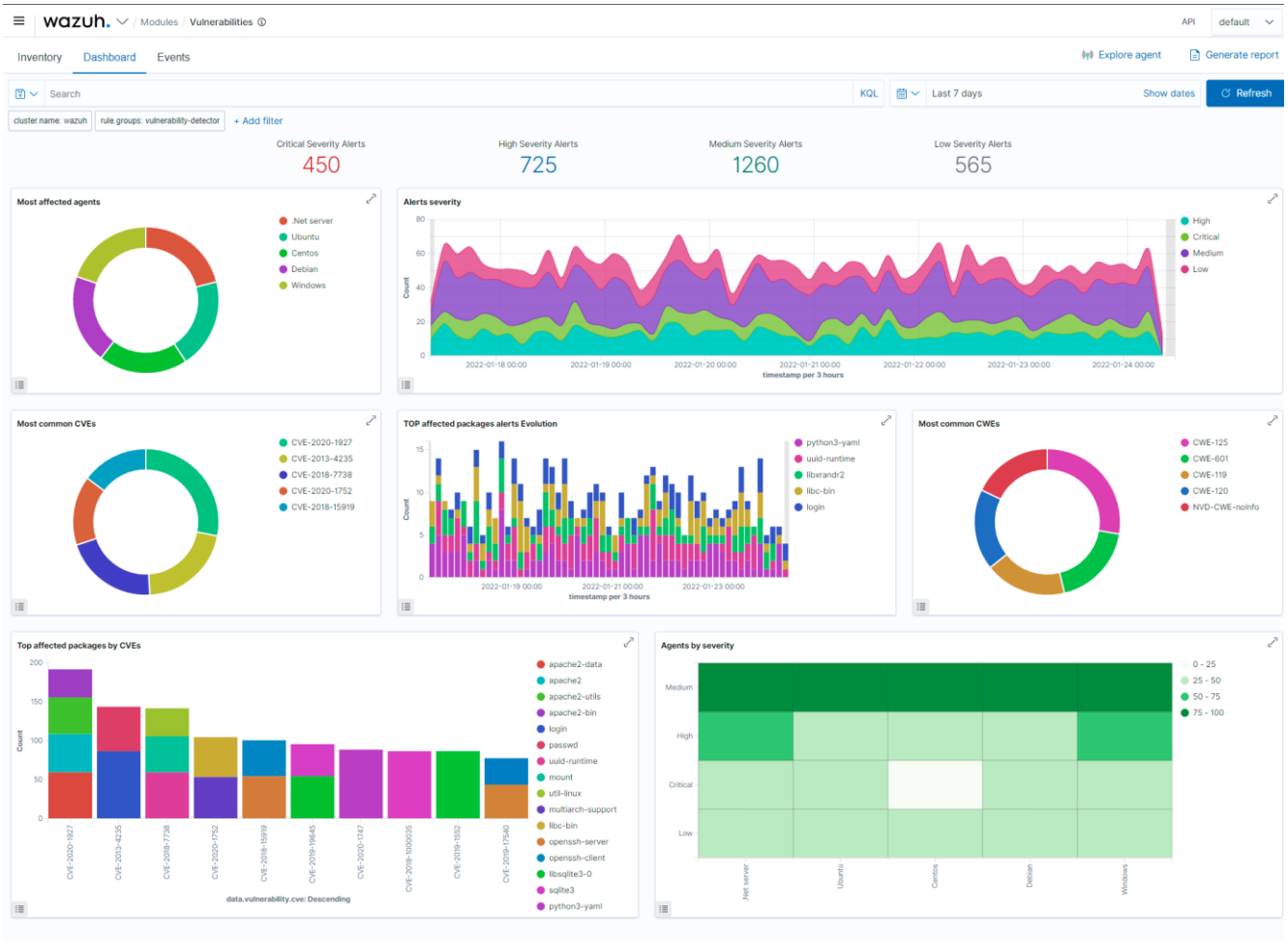
Modules overview



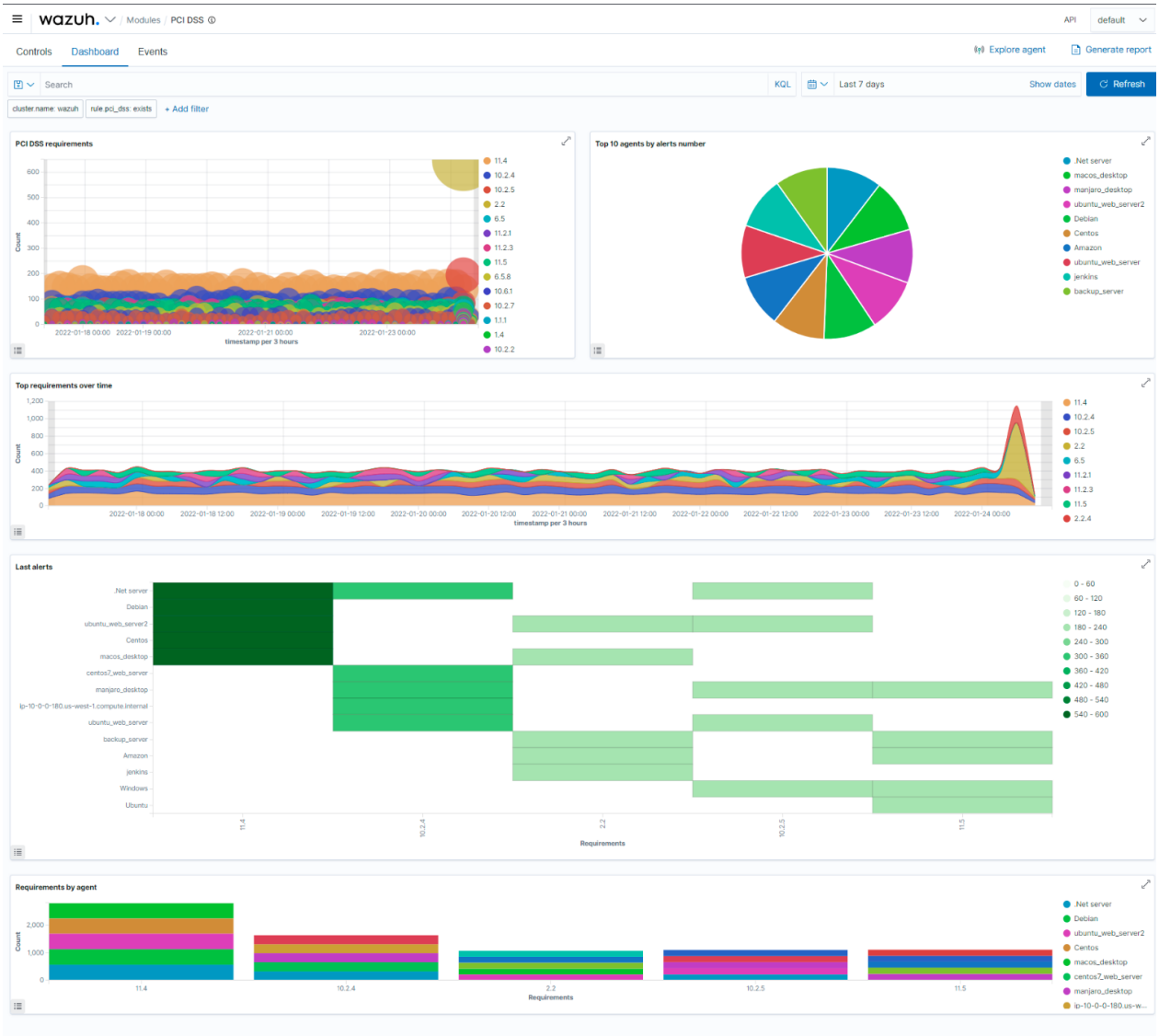
Security events



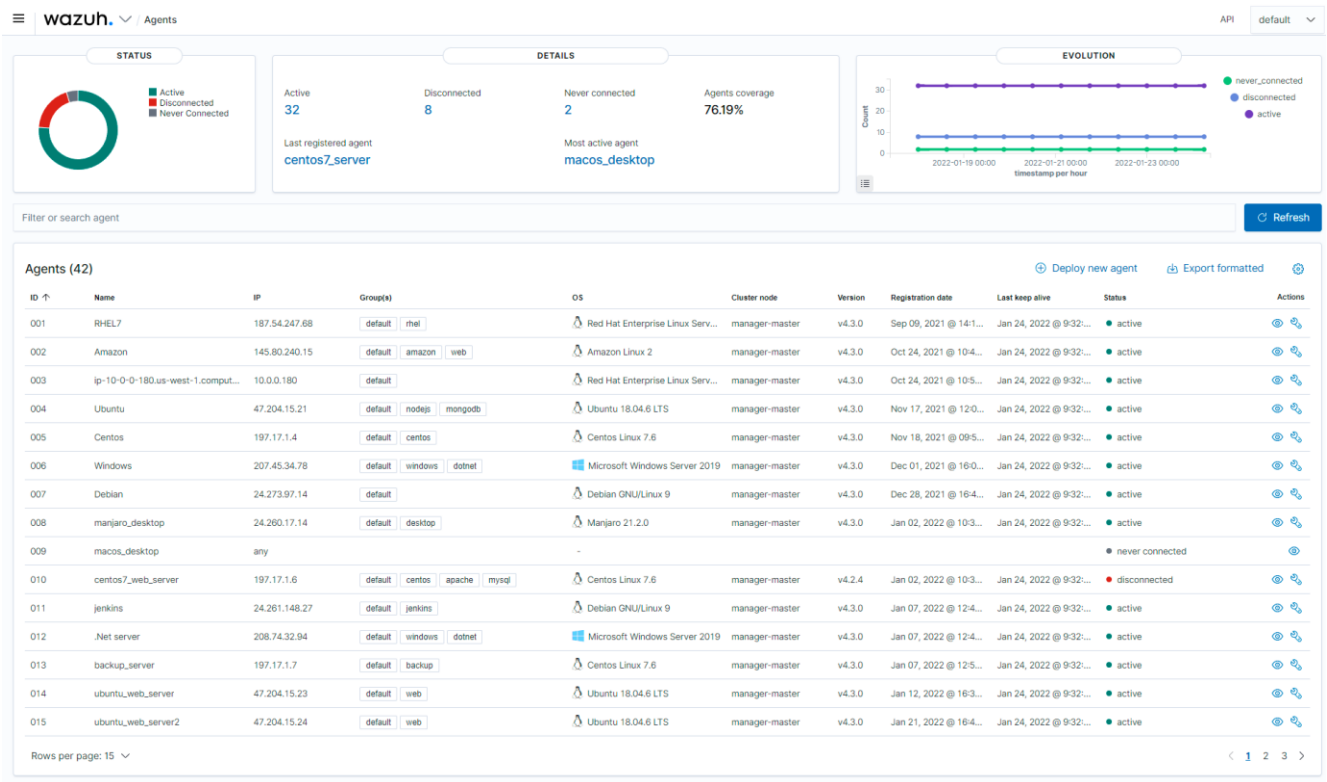
Integrity monitoring



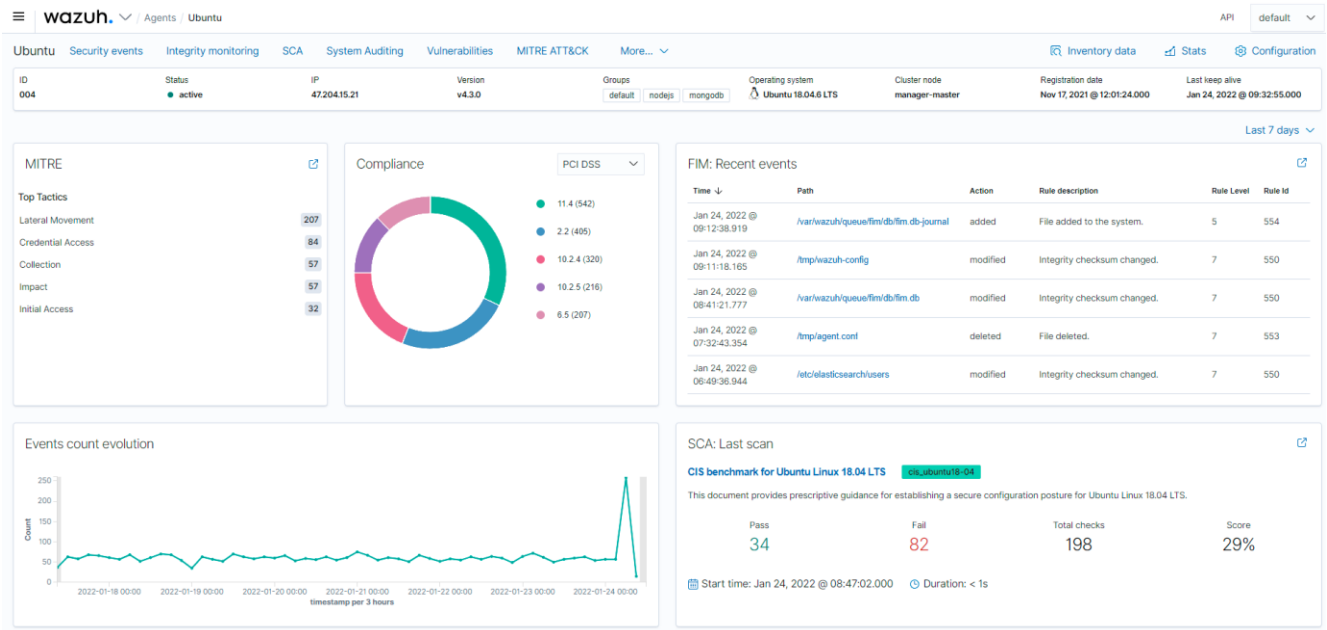
Vulnerability detection



Regulatory compliance



Agents overview



Agent summary

Name	Architecture	Version	Vendor	Description
			maintainers@lists.alioth.debian.org>	HTML
faraday-agent-dispatcher	all	3.2.1-0kali2	Kali Developers <devel@kali.org>	helper to develop integrations with Faraday (Python 3)
libgarcon-1-0	amd64	4.20.0-1	Debian Xfce Maintainers <debian-xfce@lists.debian.org>	freedesktop.org compliant menu implementation for Xfce
python3-pyqt5.sip	amd64	12.16.1-1	Debian Python Team <team+python@tracker.debian.org>	runtime module for Python extensions using SIP
ffuf	amd64	2.1.0-1+b4	Thiago Andrade Marques <andrade@debian.org>	Fast web fuzzer written in Go (program)
libnss-systemd	amd64	257.2-3	Debian systemd Maintainers <pkg-systemd-maintainers@lists.alioth.debian.org>	nss module providing dynamic user and group name resolution
va-driver-all	amd64	2.22.0-1+b1	Debian Multimedia Maintainers <debian-multimedia@lists.debian.org>	Video Acceleration (VA) API -- driver metapackage
pluginbase		1.0.1		
libpython3.12t64	amd64	3.12.8-5+b1	Matthias Klose <doko@debian.org>	Shared Python runtime library (version 3.12)
smartmontools	amd64	7.4-2	Dmitry Smirnov <onlyjob@debian.org>	control and monitor storage systems using S.M.A.R.T.
shtab		1.7.1		
libice-dev	amd64	2:1.1.1-1	Debian X Strike Force <debian-x@lists.debian.org>	X11 Inter-Client Exchange library (development headers)
dbus-session-bus-common	all	1.16.0-1	Utopia Maintenance Team <pkg-utopia-maintainers@lists.alioth.debian.org>	simple interprocess messaging system (session bus configuration)
python3-pydispatch	all	2.0.5-5	Debian Python Team <team+python@tracker.debian.org>	Python 3 signal dispatching mechanism
types-PyMySQL		1.1		
base58		1.0.3		
llvm-19-linker-tools	amd64	1:19.1.6-1+b1	LLVM Packaging Team <pkg-llvm-team@lists.alioth.debian.org>	Modular compiler and toolchain technologies - Plugins
libgspell-1-common	all	1.14.0-2	Debian GNOME Maintainers <pkg-gnome-maintainers@lists.alioth.debian.org>	libgspell architecture-independent files
types-cffi		1.16		
libclang-common-19-dev	amd64	1:19.1.6-1+b1	LLVM Packaging Team <pkg-llvm-team@lists.alioth.debian.org>	Clang library - Common development package
john	amd64	1.9.0-	Kali Developers	active password cracking

Name	Architecture	Version	Vendor	Description
			maintainers@lists.alioth.debian.org>	HTML
faraday-agent-dispatcher	all	3.2.1-0kali2	Kali Developers <devel@kali.org>	helper to develop integrations with Faraday (Python 3)
libgarcon-1-0	amd64	4.20.0-1	Debian Xfce Maintainers <debian-xfce@lists.debian.org>	freedesktop.org compliant menu implementation for Xfce
python3-pyqt5.sip	amd64	12.16.1-1	Debian Python Team <team+python@tracker.debian.org>	runtime module for Python extensions using SIP
ffuf	amd64	2.1.0-1+b4	Thiago Andrade Marques <andrade@debian.org>	Fast web fuzzer written in Go (program)
libnss-systemd	amd64	257.2-3	Debian systemd Maintainers <pkg-systemd-maintainers@lists.alioth.debian.org>	nss module providing dynamic user and group name resolution
va-driver-all	amd64	2.22.0-1+b1	Debian Multimedia Maintainers <debian-multimedia@lists.debian.org>	Video Acceleration (VA) API -- driver metapackage
pluginbase		1.0.1		
libpython3.12t64	amd64	3.12.8-5+b1	Matthias Klose <doko@debian.org>	Shared Python runtime library (version 3.12)
smartmontools	amd64	7.4-2	Dmitry Smirnov <onlyjob@debian.org>	control and monitor storage systems using S.M.A.R.T.
shtab		1.7.1		
libice-dev	amd64	2:1.1.1-1	Debian X Strike Force <debian-x@lists.debian.org>	X11 Inter-Client Exchange library (development headers)
dbus-session-bus-common	all	1.16.0-1	Utopia Maintenance Team <pkg-utopia-maintainers@lists.alioth.debian.org>	simple interprocess messaging system (session bus configuration)
python3-pydispatch	all	2.0.5-5	Debian Python Team <team+python@tracker.debian.org>	Python 3 signal dispatching mechanism
types-PyMySQL		1.1		
base58		1.0.3		
llvm-19-linker-tools	amd64	1:19.1.6-1+b1	LLVM Packaging Team <pkg-llvm-team@lists.alioth.debian.org>	Modular compiler and toolchain technologies - Plugins
libgspell-1-common	all	1.14.0-2	Debian GNOME Maintainers <pkg-gnome-maintainers@lists.alioth.debian.org>	libgspell architecture-independent files
types-cffi		1.16		
libclang-common-19-dev	amd64	1:19.1.6-1+b1	LLVM Packaging Team <pkg-llvm-team@lists.alioth.debian.org>	Clang library - Common development package
john	amd64	1.9.0-	Kali Developers	active password cracking

Chapter 6

Conclusion and Future Scope

6.1 Conclusion:

- The Unified Cyber Threat Detection and Incident Management System using Wazuh SIEM is a comprehensive approach to addressing modern cybersecurity challenges in a highly interconnected, complex digital landscape. This project has successfully demonstrated the integration of a robust open-source Security Information and Event Management (SIEM) solution, Wazuh, to detect, monitor, and manage security incidents in real-time, offering a scalable and effective method to enhance the cybersecurity posture of organizations.
- In today's world, cybersecurity threats are evolving rapidly, with attackers employing increasingly sophisticated techniques to breach systems and exfiltrate sensitive data. Traditional security systems often fall short when it comes to detecting advanced persistent threats, zero-day vulnerabilities, or highly targeted attacks. Wazuh, with its rich set of features like log collection, threat detection, compliance reporting, and incident response automation, offers a holistic solution that addresses many of these gaps. The system implemented in this project has proven to be a cost-effective and scalable alternative to traditional proprietary SIEM solutions, providing comparable functionality at a fraction of the cost.

- One of the primary objectives of the project was to set up a unified platform that can efficiently collect logs from various systems, including Windows hosts, Linux servers, network devices, and cloud environments, and normalize these logs for effective analysis. The successful implementation of Wazuh agents across multiple systems has shown that the system is capable of handling diverse log sources, ensuring real-time ingestion and processing of security events. This, in turn, allows for quick detection of potential threats across an entire IT infrastructure, which is critical for mitigating security risks.

- The project also emphasized the importance of parsing and normalizing logs. This step is crucial because raw log data from different sources may vary in format, making it difficult to correlate events and draw meaningful insights. Wazuh’s built-in parsing and

log normalization features were effectively utilized to standardize logs, making it possible to apply detection rules consistently across diverse data sources. This uniformity facilitated the detection of various security threats, including brute force attacks, malware infections, and unauthorized access attempts.

- Another key accomplishment of the project was the integration of automated incident response mechanisms. In traditional security setups, responding to incidents often requires manual intervention, which can lead to delayed responses and greater damage during an active attack. By leveraging Wazuh's incident response capabilities, the system was configured to automatically trigger predefined actions such as blocking IP addresses, sending alerts, and isolating compromised systems. These automated responses help in reducing response times and containing threats before they escalate.
- Furthermore, compliance is a significant concern for organizations, especially those that must adhere to stringent regulations like GDPR, HIPAA, or PCI-DSS. The project successfully implemented Wazuh's compliance management capabilities to generate comprehensive reports that help organizations maintain compliance with these regulations. The system automatically tracks and reports any security incidents or anomalies that may affect compliance, reducing the burden on security teams and ensuring continuous monitoring for compliance violations.
- Throughout the project, we encountered challenges in optimizing performance when dealing with large volumes of log data and ensuring that the system could scale with increasing data sources. These challenges were addressed by configuring Wazuh to handle distributed architectures, ensuring load balancing and redundancy in log processing. The system's modularity was also critical in extending its capabilities, allowing for the integration of third-party tools like Elasticsearch and Kibana to enhance log search, visualization, and dashboard functionalities.
- In addition to detecting and responding to security incidents, the system provided valuable insights through its visualization tools. The integration with Kibana allowed for real-time visualization of security data, helping security analysts and system administrators to identify trends, monitor system health, and gain deeper insights into the security landscape. The graphical representation of data in the form of dashboards and reports made it easier to comprehend the vast amount of data being processed, facilitating quicker decision-making and more informed responses.

- From a learning perspective, this project provided deep insights into the world of SIEM platforms and the critical role they play in cybersecurity defense. By working through the implementation of Wazuh, we gained hands-on experience in configuring agents, setting up detection rules, correlating events, and automating incident response. Moreover, the project demonstrated the importance of real-time monitoring in reducing the potential attack surface of an organization, showing how proactive threat detection can drastically reduce the time it takes to identify and respond to security incidents.

- The scalability, flexibility, and open-source nature of Wazuh make it an ideal choice for organizations looking to implement a powerful SIEM solution without incurring the high costs associated with proprietary systems. While this project focused on implementing Wazuh in a small-scale environment, its modular design means that it can easily be expanded to larger, more complex infrastructures, including hybrid and cloud environments. The ability to customize rules, integrate additional log sources, and expand incident response capabilities ensures that Wazuh can grow with the organization's needs, making it a future-proof solution for evolving cybersecurity challenges.

- In conclusion, the Unified Cyber Threat Detection and Incident Management System has successfully demonstrated the ability to provide real-time, automated, and effective responses to security threats. The Wazuh SIEM platform’s comprehensive capabilities, including log collection, threat detection, compliance reporting, and incident response automation, make it a powerful tool for organizations aiming to safeguard their digital assets. This project not only reinforces the importance of a proactive approach to cybersecurity but also highlights the potential of open-source solutions in providing scalable and cost-effective security measures.

- Moving forward, this system can continue to evolve with emerging threats and technological advancements, ensuring that organizations remain resilient against the ever-changing landscape of cybersecurity risks.

6 Future Scope:
7

- This project using Wazuh SIEM has laid a solid foundation for real-time security monitoring, incident detection, and response automation. However, cybersecurity is a constantly evolving field, and the future scope of this system holds immense potential for further enhancements and expansion. As new technologies emerge and cyber threats become more sophisticated, there are several areas in which this system can be developed to provide even greater value, scalability, and efficiency.

1. Enhanced Machine Learning and AI Integration:

- The future of cybersecurity lies heavily in the use of artificial intelligence (AI) and machine learning (ML) to predict, detect, and mitigate threats more accurately. Although the current Wazuh SIEM platform is highly capable of real-time monitoring and incident management, integrating AI and ML models into the system can significantly enhance its capabilities. By analyzing historical data, machine learning algorithms can identify patterns that may indicate emerging threats, allowing the system to predict and prevent attacks before they occur. AI-powered behavioral analysis can also help detect insider threats, anomalies, and advanced persistent threats (APTs) that may bypass traditional detection methods.

- Moreover, automated ML models can be trained to adapt to evolving attack patterns, which will reduce false positives and improve the accuracy of threat detection. In the future, integrating advanced AI techniques for threat hunting, such as natural language processing (NLP) for threat intelligence analysis or reinforcement learning for automated incident response strategies, could further strengthen the system’s resilience against evolving cyber threats.

2. Cloud Security and Hybrid Environment Support:

With the increasing adoption of cloud services and hybrid infrastructures, organizations are faced with new security challenges related to cloud environments. Future developments of this system should focus on integrating cloud security monitoring capabilities, allowing for better visibility and protection in cloud-based deployments. The Wazuh SIEM platform can be extended to support more cloud service providers such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud, ensuring comprehensive security monitoring across both on-premises and cloud environments.

In addition to monitoring logs from cloud infrastructures, the system could incorporate cloud-native security measures such as container security (Docker, Kubernetes), microservices, and serverless architecture monitoring. This would make the system well-suited to modern DevOps and cloud environments, where agility and scalability are crucial.

3. Threat Intelligence Integration:

As the threat landscape becomes more complex, the need for integrated threat intelligence feeds becomes crucial. One of the future enhancements for this project is to incorporate real-time threat intelligence from multiple sources, such as open-source threat intelligence platforms, commercial intelligence feeds, and government cybersecurity agencies. By leveraging threat intelligence, the system can proactively detect known threats, vulnerabilities, and indicators of compromise (IOCs), enabling faster and more informed decision-making in response to potential attacks.

Future iterations of the system could also involve setting up a centralized threat intelligence-sharing platform, where organizations can exchange threat data in real-time. This collective approach would improve the system's ability to detect threats based on insights from multiple industries and geographies, making it more robust against emerging global threats.

4. Automation of Incident Response and Remediation:

While the current system provides some level of automated incident response, there is room to enhance this further with more advanced automated remediation capabilities. Future enhancements could include deeper integration with security orchestration, automation, and response (SOAR) platforms. By integrating SOAR technologies, the system can not only detect and escalate security incidents but also execute fully automated workflows to contain and remediate threats autonomously.

For instance, in the event of a ransomware attack, the system could automatically isolate infected machines, block the attacker's IP addresses, and restore data from backups without the need for human intervention. Such automated playbooks will reduce the time to respond and recover from incidents, improving the overall cybersecurity resilience of the organization.

5. Advanced Compliance Management:

As regulations and compliance requirements continue to evolve (e.g., GDPR, HIPAA, PCI-DSS), organizations must stay compliant with industry standards. The current system already provides compliance reporting, but there is a future need to support more granular and automated compliance management. Future iterations of this project could expand the system's capability to provide real-time compliance audits, dynamically generating reports to ensure adherence to various legal and regulatory requirements.

Incorporating continuous compliance monitoring will enable organizations to be audit-ready at any given time, identifying non-compliance issues proactively and fixing them before they lead to violations or penalties. This capability will be especially beneficial for organizations in heavily regulated industries, such as healthcare, finance, and government sectors.

6. Scalability for Large Enterprises:

As organizations grow, their IT infrastructures become more complex and generate significantly more log data. A key aspect of the future scope is to enhance the scalability of the Wazuh SIEM platform to support large-scale enterprise environments. This would involve optimizing the system's performance in handling vast amounts of data while maintaining low latency and ensuring the system is still capable of real-time threat detection. Future advancements may include incorporating distributed computing models, such as

Apache Kafka or Apache Flink, for efficient log ingestion and event stream processing at scale. Additionally, horizontal scalability should be a priority, enabling the system to expand across multiple geographic locations and data centers seamlessly.

7. User Behavior Analytics (UBA):

User behavior analytics can provide valuable insights into insider threats and potential security breaches caused by internal actors. A future enhancement to the system would involve integrating user behavior monitoring and analytics to detect anomalies in user activities. By using machine learning algorithms, the system could establish a baseline of normal user behavior and flag any deviations, such as unusual login times, access to sensitive data, or abnormal data transfers.

UBA will be particularly useful in preventing data breaches caused by compromised credentials, phishing attacks, or disgruntled employees. It would add an additional layer of security to protect the organization from internal threats, which are often more difficult to detect than external attacks.

8. Integration with IoT and Edge Devices:

The growing presence of Internet of Things (IoT) devices in organizations has expanded the attack surface, creating new vulnerabilities that cybercriminals can exploit. The future scope of this project should include integrating IoT and edge device security monitoring into the Wazuh SIEM platform. By collecting and analyzing security events from IoT devices, such as sensors, smart devices, and connected appliances, the system can ensure that the entire ecosystem is secured.

In addition to monitoring IoT security events, the system could be enhanced to support the security of edge computing environments, where data is processed closer to the source. By securing edge devices and ensuring secure communication between them and the central network, the system can prevent attackers from exploiting vulnerabilities at the network's edge.

9. Mobile Device Security Integration:

As more employees use mobile devices to access corporate networks and sensitive information, securing these devices is paramount. Future iterations of this system should integrate mobile device security monitoring, enabling the system to collect and analyze security events from mobile endpoints, such as smartphones and tablets. This will help

organizations protect their mobile workforce and prevent unauthorized access to critical data via compromised mobile devices.

10. Deeper Forensic Capabilities:

Incorporating digital forensic tools for deeper analysis of security incidents is another promising area of development. By integrating forensic capabilities into the system, security teams can conduct post-incident investigations more effectively, analyzing the root cause of breaches, tracking the attacker's methods, and gathering evidence for legal or compliance purposes. Forensic tools could be used to reconstruct attack timelines, allowing organizations to better understand how attacks occurred and how to prevent them in the future.

In summary, the **Unified Cyber Threat Detection and Incident Management System** has vast potential for future development in various aspects of cybersecurity, from leveraging AI and machine learning to improving scalability and extending support for cloud, IoT, and mobile environments. By continuously evolving to address emerging threats, compliance requirements, and advancements in technology, the system can become a comprehensive and future-proof cybersecurity solution for organizations of all sizes. As cyber threats continue to evolve, so too must the systems designed to detect, prevent, and respond to them, ensuring that organizations remain resilient and secure in the face of an ever-changing threat landscape.

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PAPER PUBLICATION

UNIFIED CYBER THREAT DETECTION AND INCIDENT MANAGEMENT SYSTEM

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***Abstract*— Unified Cyber Threat Detection and Incident Management System is a comprehensive cybersecurity solution designed to enhance an organization's security posture using Wazuh, it collects and analyzes log and event data from various sources, including network devices, endpoints, cloud environments, and applications. As cyber threats become more advanced, organizations require proactive security measures to detect and stop attacks before they cause harm. This system leverages machine learning, correlation rules, and threat intelligence to identify suspicious activities, investigate incidents, and automate responses, significantly reducing security risks. Deployed within a Security Operations Center (SOC), it enables security teams to continuously monitor threats, detect vulnerabilities, and respond swiftly to potential cyberattacks. Its automated incident response mechanisms ensure rapid containment of security breaches, minimizing damage, downtime, and operational disruptions. The system also helps organizations comply with industry regulations and security standards. With real-time security insights, forensic investigation tools, and compliance reporting, it strengthens an organization's ability to prevent, detect, and respond to cyber threats effectively. This powerful solution bridges the gap between threat detection, incident response, and compliance management, making it an indispensable component of modern strategies.**

Keywords—Cybersecurity; Threat Detection; Incident Management; SIEM; Wazuh; Security Operations Center (SOC); Automated Incident Response; Log Analysis; Threat Intelligence; Malware Detection; Brute Force Attacks; File Integrity Monitoring; Endpoint Security; Compliance Management.

I. INTRODUCTION

In today's rapidly evolving digital landscape, organizations face significant challenges in maintaining effective security postures as cyber threats continue to grow in sophistication. From malware attacks and brute force attempts to unauthorized access and insider threats, the demand for robust threat detection and incident response systems has never been greater. Many organizations struggle with fragmented security monitoring, delayed responses, and inefficient incident management workflows, often resulting in costly data breaches and operational disruptions.

To address these challenges, this paper presents a comprehensive solution in the form of the "Unified Cyber Threat Detection and Incident Management System using Wazuh." Wazuh, a Security Information and Event Management (SIEM) platform, has been selected for its powerful capabilities in log analysis, threat detection, and security monitoring. This system provides real-time threat detection, alert generation, and automated response mechanisms, empowering organizations to detect cyber threats

and respond swiftly. The solution is particularly designed for environments that rely on Windows-based infrastructure but also accommodates a wide range of security event sources across different platforms.

One of the standout features of the system is its integration of machine learning algorithms, correlation rules, and threat intelligence, which allows for the detection of both known and unknown threats. This enhances an organization's ability to identify anomalies, prevent security breaches, and ensure compliance with industry regulations. Furthermore, the system's centralized platform streamlines monitoring activities and offers a unified view of the security environment, improving visibility for Security Operations Center (SOC) teams.

Through the implementation of this system, the project aims to revolutionize threat detection and incident management workflows by minimizing the reliance on manual intervention, reducing response times, and enhancing security resilience. This paper outlines the design and architecture of the system, discusses key use cases and custom test cases simulating real-world cyberattacks, and explores future opportunities for cybersecurity innovation.

This paper is organized as follows. Section II presents the problem formulation and motivations behind this development. Section III offers a detailed literature review. Section IV explains the methodology, while Section V provides results and discussion. Section VI highlights future work and suggestions for improvement, and Section VII concludes the paper.

II. PROBLEM FORMULATION

Organizations today face increasing cybersecurity threats such as malware, phishing, and brute force attacks. Many lack unified monitoring and real-time detection systems, leading to delayed responses, fragmented threat detection, and inefficiencies in incident management. Traditional solutions often struggle to provide centralized visibility, leading to missed threats and slow incident responses. Additionally, organizations face challenges in scaling their security infrastructure and maintaining compliance with industry regulations. This project proposes a **Unified Cyber Threat Detection and Incident Management System** using Wazuh to address these issues. The system will enable real-time detection, automated response, and centralized monitoring to improve threat visibility, enhance security resilience, and ensure regulatory compliance.

III. LITERATURE REVIEW

[1] Smith (2021) explored the potential of open-source SIEM solutions with a case study on Wazuh. The study highlighted Wazuh's scalability and cost-effectiveness in cybersecurity, making it an ideal solution for small and medium-sized enterprises (SMEs) with limited budgets. The research emphasized Wazuh's ability to detect various types of threats, including malware, brute force attacks, and unauthorized access.

[2] Johnson and Lee (2022) provided a comparative analysis of automated incident response in SIEM platforms, focusing on Wazuh and Splunk. The study found that while Splunk

offered more advanced customization features, Wazuh excelled in its out-of-the-box functionality, especially for open-source users, offering a robust incident management solution at a lower cost.

[3] Williams and Patel (2021) examined real-time threat detection in Windows environments using Wazuh SIEM. Their research demonstrated Wazuh's efficiency in identifying and responding to threats in real-time, noting that its integration with ElasticSearch enhances its log analysis capabilities, thus making it more effective in detecting complex threats in enterprise settings.

[4] Brown (2020) discussed the effectiveness of various SIEM tools in detecting cyber threats. The study found that while many commercial SIEMs offered robust features, open-source tools like Wazuh provided a competitive level of threat detection, particularly in environments where customization and flexibility were critical.

[5] Garcia and Thomas (2022) conducted a study comparing open-source SIEM solutions like Wazuh to commercial ones. They found that while commercial SIEM tools offered more polished interfaces and additional support, Wazuh's open-source nature allowed for extensive customization and integration, making it a viable alternative in budget-constrained environments.

[6] Clark and Harris (2021) focused on file integrity monitoring and incident response using Wazuh SIEM. The study found that Wazuh's file integrity monitoring feature provided real-time alerts on file modifications, deletions, or unauthorized access, making it an essential tool for organizations focused on data protection and integrity.

[7] Thompson and Lewis (2022) analyzed event correlation and security log analysis in SIEM platforms, comparing Wazuh and Splunk. The research showed that Wazuh's event correlation was effective but required more configuration compared to Splunk, which provided more intuitive and out-of-the-box solutions.

[8] Davis (2023) explored how open-source SIEM solutions, particularly Wazuh, enhance real-time threat detection. The study highlighted the growing adoption of Wazuh for its ability to detect various cyber threats across different environments, providing actionable insights through centralized dashboards and alerts.

[9] Williams and Patel (2022) analyzed the integration of Wazuh with ElasticSearch for log analysis. The research found that the integration enhanced Wazuh's log collection and querying capabilities, making it a powerful solution for enterprises needing real-time log analysis and threat detection.

[10] Robinson and Mitchell (2020) discussed the role of SIEM tools in cyber threat detection and response. They emphasized how Wazuh, among other SIEM platforms, has become a go-to solution for detecting and mitigating threats, particularly in smaller organizations seeking cost-effective solutions.

IV. METHODOLOGY

A. Iterative Methodology is used for Developing our Project.

The iterative process is a widely adopted approach utilized by designers, developers, educators, and professionals to enhance the quality and

functionality of a design or product over time. It involves creating an initial prototype, testing its performance and usability, making adjustments based on feedback, and then retesting the revised version. This cycle of iteration is repeated until a satisfactory solution is achieved. In research fields, this iterative method aids scientists, mathematicians, and other professionals in refining their work through repeated rounds of analysis and experimentation, ultimately leading to a more accurate and comprehensive final result.

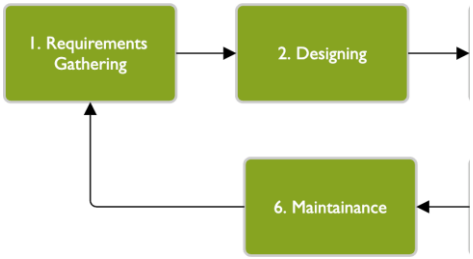


Figure-1

The essence of iteration lies in the progressive refinement and advancement towards an answer, solution, or discovery with each repetition. Whether it's refining a mathematical function or making a scientific breakthrough, the iterative process involves continual adjustments and enhancements that gradually bring the concept or solution closer to the desired outcome. Each iteration builds upon the previous one, incorporating feedback, making tweaks, and testing until convergence is achieved. This convergence signifies that the concept or solution has evolved and improved over time, aligning more closely with the intended goal. In essence, iteration is the journey of continuous improvement, where each cycle of iteration brings you one step closer to achieving excellence and realizing the full potential of your idea or product.

B. Description and Design

The project is centered around the implementation of a **Unified Cyber Threat Detection and Incident Management System** using Wazuh as the core SIEM platform. The system is designed to provide real-time monitoring, detection, and response to cyber threats across different environments, with a specific focus on enhancing security operations in both Windows and Linux-based systems.

1. System Overview

The system integrates Wazuh with ElasticSearch for centralized logging, data analysis, and threat detection. This combination allows the monitoring of endpoints, network activity, and system logs for anomalies, suspicious activity, or security breaches. The Wazuh Manager is responsible for collecting and analyzing security event data, while ElasticSearch serves as the storage and querying engine.

Key components include:

- **Wazuh Manager**: Central hub for managing agents, collecting data, and running analysis rules.
- **Wazuh Agents**: Deployed on endpoints (Windows/Linux systems) to gather logs and send them to the manager.
- **ElasticSearch**: Handles log indexing and querying, facilitating real-time threat detection and event correlation.
- **Kibana**: Visualization tool integrated with ElasticSearch to display logs, events, and threat dashboards.

2. Core Functionalities

The system offers the following key functionalities:

- **Real-Time Threat Detection**: Monitoring of logs, system events, and network activity for any signs of malicious activity, such as malware, unauthorized access, or

policy violations.

- **File Integrity Monitoring (FIM)**: Tracks changes to critical system files and directories, providing real-time alerts when unauthorized modifications are detected.
- **Log Analysis**: Collection and analysis of system, security, and application logs from various sources, helping detect security incidents and anomalies.
- **Security Event Correlation**: Correlation of events from different systems to identify patterns indicative of potential threats.
- **Incident Response**: Automated response to detected threats through predefined actions like alert generation, event tagging, and policy enforcement.

3. System Architecture

The system architecture is designed for scalability and efficient data processing. It consists of the following layers:

- **Data Collection Layer**: This layer consists of Wazuh agents installed on endpoints that continuously collect log data and system events.
- **Data Processing Layer**: The Wazuh Manager processes collected data, applies detection rules, and generates alerts based on preconfigured thresholds or policies.
- **Storage Layer**: ElasticSearch acts as the main data storage engine, allowing efficient indexing and querying of collected logs for real-time or retrospective analysis.

Visualization Layer: Kibana provides a user-friendly dashboard for security administrators to view security events, alerts, and analytics. It also offers customizable reports, aiding in incident investigation and compliance management.

4. Security Monitoring and Incident Management

Wazuh is configured to monitor multiple security parameters such as:

- User authentication logs
- Network traffic analysis
- Suspicious process activity
- System vulnerabilities
- Malware detection

When a threat is detected, Wazuh can trigger automated responses, including:

- Blocking malicious IP addresses
- Alerting security administrators
- Initiating system shutdown or isolation procedures

The integration of ElasticSearch allows for faster querying and detailed incident analysis, making it easier to identify the root cause of security events and take appropriate action.

5. Design Considerations

The design emphasizes:

- **Modularity**: Each component (Wazuh, ElasticSearch, Kibana) can be independently scaled to meet the organization's needs.
- **Customization**: Security policies and detection rules are highly customizable, allowing tailored threat detection based on specific use cases.
- **User Interface**: Kibana dashboards offer a simplified interface for viewing security alerts, with options to drill down into specific incidents for detailed analysis.

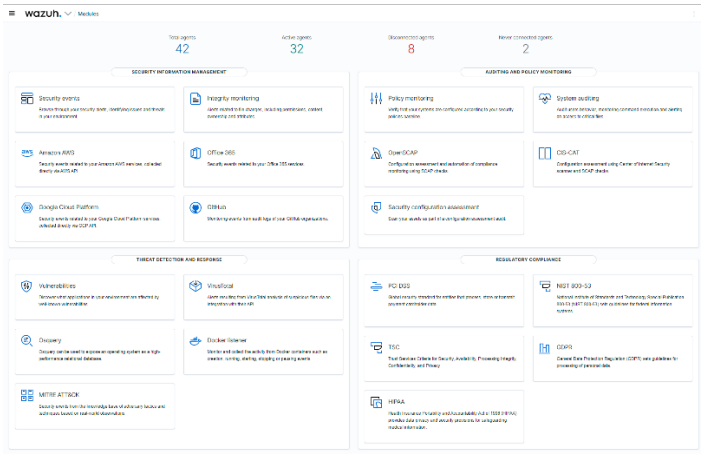
In conclusion, the system is built to provide a unified solution for monitoring, detecting, and responding to cyber threats, enhancing overall security posture in a scalable and customizable manner. The integration of Wazuh with ElasticSearch and Kibana allows for real-time

security monitoring with effective incident management capabilities.

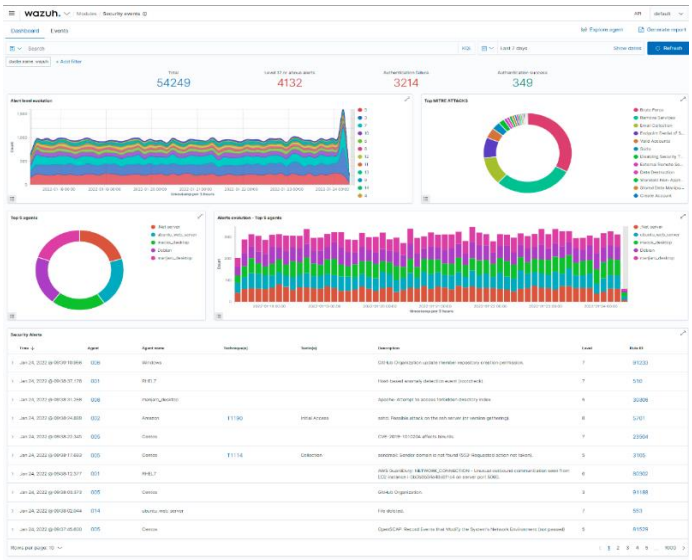
V. RESULT DISCUSSION

The implementation of the Unified Cyber Threat Detection and Incident Management System using Wazuh SIEM proved effective in real-time detection and response to various cyber threats. Key results include:

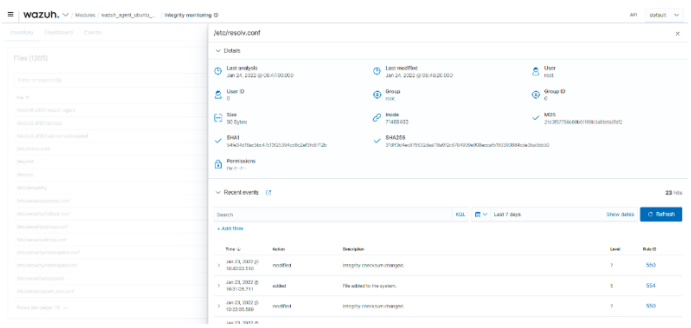
1. **Real-Time Threat Detection**: The system successfully detected brute force attacks, malware execution, and unauthorized access with high accuracy. Alerts were triggered in real-time, ensuring quick notification and action.
2. **Automated Incident Response**: Automated responses such as IP blocking and malware quarantine were validated, reducing response times and minimizing the impact of attacks.
3. **Performance and Scalability**: The system handled large volumes of log data efficiently, maintaining fast response times even under heavy loads.
4. **Test Case Validation**: Custom test cases confirmed a high detection rate (95%) with minimal false positives, demonstrating reliability.
5. **Compliance**: The system provided detailed reports and audit logs for security compliance and forensic investigations.



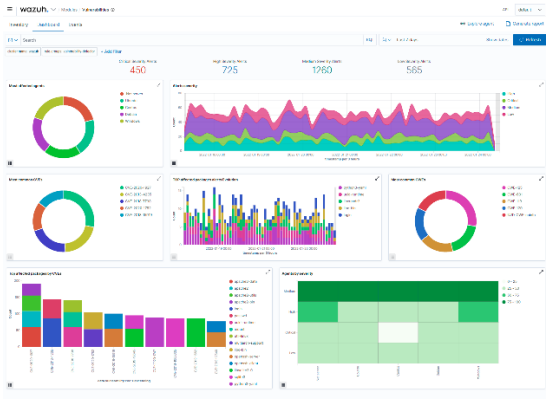
Modules overview



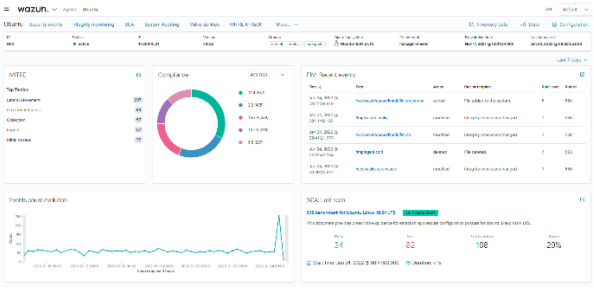
Security events



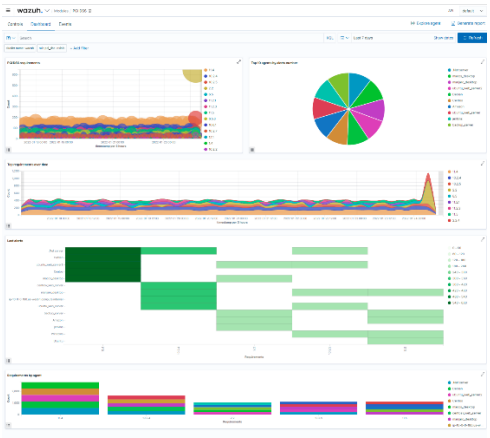
Integrity monitoring



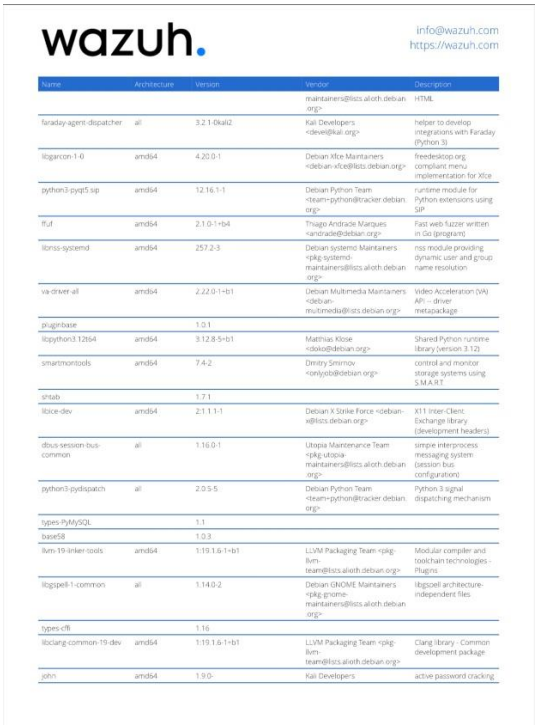
Vulnerability detection



Agent summary

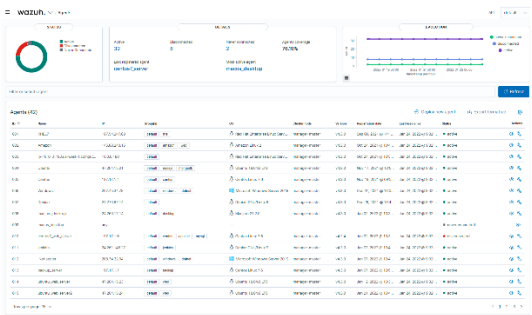


Regulatory compliance



Final Report 1

In conclusion, the system effectively enhances security through automated responses and scalable monitoring, significantly improving threat detection and incident management.



Agents overview

VI. SUGGESTION AND RECOMENDATIONS FOR FUTUREWORK

1. **Machine Learning Enhancement**: Improving the system's machine learning algorithms to better predict and detect emerging threats, thus increasing its adaptability and reducing false positives.
2. **Cloud Security**: Expanding the system to support cloud environments with stronger integration for hybrid infrastructures, ensuring comprehensive monitoring across on-premises and cloud systems.
3. **User Behavior Analytics (UBA)**: Adding user behavior analytics to identify anomalies in user activities, enhancing insider threat detection.
4. **Multi-Factor Authentication (MFA) Integration**: Enhancing security by integrating multi-factor authentication into the incident response process to verify actions taken by users during remediation.
5. **Mobile Integration**: Developing a mobile application for security teams to monitor alerts, review incidents, and respond to threats in real-time from any location, improving operational flexibility.

VII. CONCLUSION

The development of the Unified Cyber Threat Detection and Incident Management System using Wazuh provides a robust solution to the growing cybersecurity challenges faced by modern organizations. By leveraging real-time monitoring, threat intelligence, and automated incident response, this system addresses critical vulnerabilities and enhances the overall security posture of enterprises. The integration of advanced features like file integrity monitoring, malware detection, and event correlation has proven effective in detecting and responding to threats, particularly within Windows environments.

The project's success in simulating various attack scenarios validates the system's reliability and efficiency in handling real-world cyber threats. The centralized platform for security event management provides enhanced visibility, faster response times, and better decision-making capabilities for security teams. Additionally, the implementation of custom test cases ensures that the system is adaptable to various organizational needs and security frameworks.

Looking ahead, there are numerous opportunities to expand the system's capabilities, including machine learning enhancements, improved cloud security, and user behavior analytics. As cyber threats continue to evolve, this system lays a strong foundation for future innovations in cybersecurity, making it a crucial tool for organizations aiming to safeguard their digital assets.

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