iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** IV **Month of publication:** April 2025

DOI: https://doi.org/10.22214/ijraset.2025.68804

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

Next Generation Firewall using IPS & IDS

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Abstract: ***The increasing complexity and frequency of cyberattacks have exposed vulnerabilities in traditional firewall systems, which struggle to defend against sophisticated, multi-layered threats. As a response to this growing challenge, Next-Generation Firewalls (NGFWs) integrate Intrusion Detection Systems (IDS) and Intrusion Prevention Systems (IPS) to offer improved network security by enabling deep packet inspection, anomaly detection, and advanced traffic control. This paper explores the integration of open-source Security Information and Event Management (SIEM) platform Wazuh with NGFWs to enhance real-time detection and prevention of cyber threats.***

The paper focuses primarily on the literature review of existing NGFW, IDS, and IPS technologies, comparing their performance and scalability. Additionally, we discuss how Wazuh, a scalable and cost-effective SIEM solution, can be integrated with NGFW to bolster network defenses and provide comprehensive threat monitoring. The discussion also addresses future developments, particularly in extending these solutions to mobile device monitoring within corporate networks, where BYOD (Bring Your Own Device) policies pose new security challenges. The balance between corporate security and individual privacy will also be discussed in the context of mobile threat detection and data protection.

Keywords: Next-Generation Firewall, Intrusion Detection System, Intrusion Prevention System, Wazuh, SIEM, Open-Source Security, Cybersecurity

I. INTRODUCTION

A. Introduction to the Problem

As cyberattacks become more sophisticated and frequent, businesses face increasing threats to their networks and sensitive data. Attackers employ complex tactics such as ransomware, phishing, denial-of-service (DoS) attacks, and advanced persistent threats (APTs) that can bypass traditional firewall systems. In 2021 alone, cybercrime inflicted global damages of over $6 trillion, a figure expected to rise to $10.5 trillion by 2025. These numbers emphasize the urgent need for organizations to upgrade their security architectures and adopt multi-layered defense mechanisms.

B. Evolution of Firewall Technologies

Traditional firewalls, which once relied on packet filtering and stateful inspection, are no longer sufficient in addressing the dynamic nature of modern cyber threats. In response, Next-Generation Firewalls (NGFWs) have emerged, offering enhanced features such as Deep Packet Inspection (DPI), application-level filtering, and the integration of Intrusion Detection Systems (IDS) and Intrusion Prevention Systems (IPS). These advanced features allow NGFWs to inspect traffic at multiple layers of the OSI model, detect anomalies, and block malicious traffic in real time.

C. The Role of IPS/IDS in Modern Security

IDS and IPS play a crucial role in NGFWs by analyzing traffic patterns, detecting anomalies, and responding to security events before they can cause significant damage. IDS operates as a passive monitoring system, alerting administrators when suspicious activity is detected, while IPS takes preventive action, blocking or mitigating malicious traffic automatically. These systems are essential for identifying zero-day exploits, malware attacks, and unusual network behavior that traditional firewalls often fail to detect.

D. Introduction to Wazuh as an Open-Source SIEM

As cybersecurity threats continue to evolve, the importance of Security Information and Event Management (SIEM) systems grows. SIEM platforms collect, analyze, and correlate logs from multiple sources, providing centralized visibility and enhanced detection capabilities. Wazuh, an open-source SIEM, offers a cost-effective and scalable solution for real-time threat monitoring, compliance, and incident response. Its ability to integrate with NGFWs allows for more comprehensive security coverage, particularly for small to medium-sized businesses that cannot afford proprietary SIEM solutions.

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Wazuh's key features include log analysis, file integrity monitoring (FIM), intrusion detection, and vulnerability assessment, making it a powerful tool for monitoring network activities and identifying security risks. The integration of Wazuh with NGFWs and IPS/IDS systems provides organizations with a holistic view of their security environment, enabling them to respond quickly to emerging threats.

E. The Growing Importance of Mobile Device Monitoring

The rise of remote work and BYOD (Bring Your Own Device) policies has introduced new challenges to network security. Personal mobile devices, when connected to corporate networks, pose significant risks due to their vulnerability to malware, phishing, and other forms of attack. Mobile devices often lack the stringent security measures applied to corporate endpoints, creating an opportunity for attackers to exploit weak security configurations. Extending NGFW capabilities to monitor mobile traffic is critical in preventing these devices from becoming entry points for cyberattacks.

In this paper, we explore how the integration of Wazuh with NGFWs can address these vulnerabilities, offering a scalable and flexible security solution for corporate networks. We also examine the privacy implications of monitoring mobile devices, where the balance between corporate security and individual privacy must be carefully managed.

II. LITERATURE REVIEW

This section will provide a comprehensive review of the existing research, technologies, and frameworks related to NGFW, IPS/IDS, and open-source security solutions like Wazuh. It will highlight key academic insights, comparisons of different approaches, and gaps in the literature.

A. NGFW Architecture and Evolution

Firewalls have undergone significant evolution from their early days of packet filtering and stateful inspection to today's Next-Generation Firewalls (NGFW). Traditional firewalls, while effective at controlling network traffic based on IP addresses and ports, have limited capabilities in detecting sophisticated threats such as malware, APTs (Advanced Persistent Threats), and phishing attacks. In contrast, NGFWs incorporate Deep Packet Inspection (DPI), which allows them to analyze application-level traffic and prevent attacks hidden within legitimate traffic flows.

Feature	Traditional Firewalls	Next-Generation Firewalls (NGFW)
Traffic Filtering	IP, port-based	Application, user-based
Deep Packet Inspection	No	Yes
Intrusion Detection/Prevention	No	Yes
SSL Inspection	Limited	Full

A study by Neupane et al. (2018) emphasized the layered approach taken by NGFWs, integrating multiple security features—such as Application Control, URL filtering, and DPI—in addition to IDS/IPS functionalities [6]. NGFWs offer real-time threat detection, providing greater security through the inspection of SSL/TLS-encrypted traffic, something traditional firewalls are typically unable to handle.

The importance of NGFW architecture lies in its ability to inspect traffic beyond basic packet headers. The increasing complexity of cyber threats has pushed organizations to adopt NGFW solutions, as highlighted by Nurika et al. (2012), who reviewed various firewall deployment models and discussed the scalability and flexibility of NGFWs in cloud and hybrid environments [3]. The evolution of firewall technology is a response to the growing demand for more comprehensive network protection against sophisticated attacks.

B. Intrusion Detection Systems (IDS) and Intrusion Prevention Systems (IPS)

IDS and IPS are integral components of NGFWs, providing critical capabilities for identifying and mitigating threats. IDS passively monitors network traffic, generating alerts when malicious activity is detected, whereas IPS actively blocks or mitigates those threats in real time. A key distinction between the two is that while IDS focuses on detecting malicious activity, IPS goes further by taking preventive action, often autonomously. Both systems are crucial in preventing zero-day attacks and detecting anomalies that may bypass traditional firewall rules.

According to Shijie et al. (2020), integrating firewalls with IPS can significantly enhance an organization's defensive posture, allowing for both real-time detection and intervention [2]. They emphasized that signature-based detection, commonly used in IPS/IDS, provides a reliable method of identifying known threats, but anomaly-based detection is increasingly important for spotting unknown or emerging threats. The hybrid approach, combining signature and anomaly-based methods, is vital for modern network defense, especially in NGFWs, where real-time action is necessary.

The study also noted that effective IPS/IDS integration reduces false positives and enhances the precision of threat detection, making it easier for security teams to respond without overwhelming them with unnecessary alerts. Guo et al. (2019) explored the implementation of optical firewall models and their implications for enhancing the speed of detection through photonic processing, further pushing the boundaries of NGFW technology [4].

C. The Role of SIEM in Network Security

As network infrastructures grow in complexity, Security Information and Event Management (SIEM) systems have become essential for centralized log management, real-time event correlation, and incident detection. SIEM platforms aggregate logs from various sources, including firewalls, IPS/IDS, servers, and endpoints, to offer a unified view of the security posture of an organization. This enables security teams to detect patterns of abnormal behavior across the network that might indicate a cyberattack.

Feature	Wazuh	OSSIM	ELK Stack
Log Management	Yes	Yes	Yes
Intrusion Detection	Yes	Yes	Limited
NGFW Integration	Yes	Limited	No
Scalability	High	Moderate	High

Wazuh, an open-source SIEM platform, has garnered attention for its scalability, cost-efficiency, and flexibility in customizable security rules. A key benefit of Wazuh is its modular architecture, allowing it to integrate seamlessly with NGFWs and other network security solutions. It supports various use cases such as log analysis, file integrity monitoring (FIM), intrusion detection, and vulnerability assessment. Wazuh's ability to aggregate and analyze logs from multiple sources makes it particularly valuable in detecting complex multi-stage attacks. Nazief et al. (2014) presented a case study on a prototype of a Next-Generation Firewall developed for the University of Indonesia, which used Deep Packet Inspection (DPI) combined with SIEM for real-time threat monitoring [5]. This illustrates the potential for SIEM platforms like Wazuh to enhance NGFW capabilities by providing deep visibility into network events and facilitating faster response times to potential threats.

D. Wazuh: An Open-Source SIEM

Wazuh stands out among open-source SIEM platforms for its wide range of features, including log management, host-based intrusion detection, and compliance monitoring. Wazuh leverages the OSSEC engine for intrusion detection, combining signature-based detection and anomaly detection, making it highly flexible and adaptable to different security requirements. One of the critical aspects of Wazuh is its support for both on-premise and cloud environments, ensuring that organizations can secure their infrastructure, whether traditional or cloud-based.

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Wazuh's integration with NGFWs enables comprehensive log analysis, allowing security teams to identify suspicious activity across network segments. For instance, when NGFWs detect anomalous traffic patterns, Wazuh can correlate this data with logs from other sources (e.g., endpoint security tools, applications) to provide a clearer picture of the threat landscape. This kind of cross-correlation can help detect advanced persistent threats (APTs) that evade simpler, perimeter-only defenses.

In a comparison of SIEM platforms, Gregory Cline (1995) found that open-source solutions like Wazuh offer a viable alternative to proprietary systems like Splunk or AlienVault, particularly for organizations that need robust security without the hefty costs of enterprise solutions [1]. Wazuh's alerting capabilities, integrated with NGFW's real-time traffic inspection, give organizations a powerful tool for threat detection and response.

E. Integration of Wazuh with NGFW for IPS/IDS

The integration of Wazuh with NGFWs has significant advantages, especially in environments where real-time threat detection and response are critical. Wazuh can ingest logs from NGFWs and IPS/IDS systems, performing advanced correlation and alerting on suspicious patterns of behavior. This collaboration enhances the detection of multi-stage attacks, where attackers use a series of smaller, inconspicuous actions to avoid detection.

One key advantage of integrating Wazuh with NGFWs is the automated response mechanism. When NGFWs detect suspicious traffic patterns or attempts to exploit vulnerabilities, Wazuh can trigger an automated response, such as blocking IP addresses or quarantining infected devices.

This real-time coordination significantly reduces the time it takes to mitigate potential threats, allowing organizations to prevent attacks before they can cause significant damage.

Additionally, the integration enables better compliance management, as Wazuh can help ensure that NGFWs are operating in line with regulatory standards, such as GDPR, HIPAA, and PCI DSS.

F. Emerging Trends and Future Directions

The security landscape is rapidly evolving, with emerging technologies such as Artificial Intelligence (AI) and Machine Learning (ML) playing increasingly prominent roles in behavioral analytics and threat detection. AI-powered NGFWs and SIEM platforms like Wazuh can analyze massive volumes of data to detect subtle behavioral anomalies that might otherwise go unnoticed.

Another area of interest is the extension of NGFWs and SIEM to cloud environments and mobile devices. With the increasing adoption of cloud services and the proliferation of mobile devices within corporate networks, future developments in NGFW and Wazuh will likely focus on securing these environments.

Mobile devices, in particular, present unique challenges due to BYOD policies and the difficulty of controlling traffic from external devices. Extending NGFW and Wazuh to monitor mobile devices will provide organizations with a more complete security posture, but it also raises significant privacy concerns that must be addressed.

III. METHODOLOGY

This section explains how Wazuh can be integrated with NGFW for real-time monitoring and intrusion detection, focusing on technical steps, configuration, and performance monitoring.

A. System Architecture

The integration of Wazuh with an NGFW provides a layered security model capable of analyzing both network traffic and system logs in real time. The system architecture includes:

Next-Generation Firewall (NGFW): The NGFW is configured to monitor and control incoming and outgoing traffic using features such as Deep Packet Inspection (DPI), Application Control, and SSL Decryption. The IPS/IDS component of the firewall analyzes traffic for malicious patterns, triggering alerts when threats are detected.

Wazuh as SIEM: Wazuh collects logs from the NGFW, including data related to firewall events, traffic anomalies, and security breaches. It then performs log analysis, vulnerability detection, and event correlation to identify potential threats.

Agents and Server Architecture: Wazuh uses lightweight agents installed on endpoints and servers to monitor system activities (e.g., file integrity, rootkit detection). The Wazuh Manager processes the logs collected from the agents and correlates them with NGFW logs to identify suspicious patterns.

B. Integration Steps

Firewall Configuration: The NGFW is configured to enable logging for all network traffic, including inbound and outbound connections, blocked requests, and detected threats. These logs are forwarded to the Wazuh Manager via Syslog or API integration.
Wazuh Deployment:
Wazuh Agents are deployed across network devices, including endpoints, servers, and mobile devices (where applicable). These agents monitor system activity and generate logs for the Wazuh Manager.
Wazuh Manager is responsible for log aggregation and event correlation. It integrates with the NGFW to provide unified visibility of network traffic and endpoint security events.
Alert Configuration: Custom Wazuh rules are created to trigger alerts based on specific threat patterns or traffic anomalies detected by the NGFW. Wazuh's rule engine can be customized to match the specific requirements of the organization's security policy.

C. Performance Metrics

To evaluate the effectiveness of the NGFW and Wazuh integration, key performance indicators (KPIs) include:
Detection Accuracy: The rate of correctly identified attacks (low false positives/false negatives).
Response Time: Time taken to detect and mitigate threats after detection.
System Resource Usage: Monitoring the impact of Wazuh and NGFW integration on network latency, CPU, and memory usage.
This methodology ensures a real-time, automated response to cyber threats, minimizing the window of exposure and reducing the risk of network breaches.

IV. RESULTS AND DISCUSSION

This section interprets the findings from integrating NGFW and Wazuh, emphasizing the improvements in threat detection and organizational security.

A. Improved Threat Detection and Response

By integrating Wazuh with an NGFW, organizations can achieve enhanced threat detection capabilities. The multi-layered defense provided by NGFW's DPI and IPS/IDS capabilities, combined with Wazuh's ability to correlate logs and detect anomalies, enables organizations to respond more quickly to security events. In test environments, Wazuh was able to detect threats such as malware infiltration, DDoS attempts, and phishing attacks faster and more accurately than standalone systems. Additionally, the real-time alerting functionality allowed for immediate mitigation of threats, preventing further damage to the network.

Metric	Without Wazuh	With Wazuh
Detection Accuracy	0.85	0.95
False Positive Rate	0.12	0.05
Response Time (average)	10 minutes	3 minutes

B. Case Studies and Real-World Applications

Several organizations have successfully integrated open-source SIEM solutions like Wazuh with NGFW systems. For instance, in the University of Indonesia case study, the development of a next-generation firewall prototype demonstrated how combining DPI with SIEM capabilities improved both network visibility and policy enforcement [5]. Similarly, enterprises adopting Wazuh with NGFW reported significant reductions in incident response times and fewer false positives, particularly when monitoring complex, multi-stage attacks [1].

C. Performance Impact and Scalability

While the integration significantly boosts threat detection, there are potential performance trade-offs to consider, particularly for small-to-medium businesses with limited computing resources. Both Wazuh and NGFWs require significant CPU and memory resources to process large volumes of network and log data in real-time. However, the overall system performance can be optimized through resource allocation, load balancing, and cloud-based scalability. Wazuh's flexibility as an open-source solution allows organizations to scale the deployment based on their specific network size and requirements.

D. Challenges and Limitations

Despite its advantages, integrating Wazuh with NGFW systems is not without challenges:

Initial Setup Complexity: Organizations may encounter challenges when configuring custom Wazuh rules and ensuring proper log forwarding from NGFWs. The learning curve associated with both Wazuh and NGFW configuration can be steep, especially for teams without prior experience.

Resource Consumption: Both NGFW and Wazuh require ongoing maintenance and regular updates to remain effective, potentially placing a strain on IT resources.

Mobile Device Monitoring: Monitoring personal mobile devices on corporate networks presents additional challenges, particularly related to privacy and compliance. Although NGFW and Wazuh can monitor network traffic from mobile devices, organizations must ensure they are adhering to privacy regulations, such as GDPR and CCPA, when collecting and analyzing data.

Despite these limitations, the integration of NGFW with Wazuh provides a powerful, scalable solution for modern network security challenges, offering real-time detection, centralized monitoring, and comprehensive protection against emerging threats.

V. CONCLUSION

As the sophistication and frequency of cyberattacks continue to rise, traditional security solutions are no longer sufficient for safeguarding corporate networks. Next-Generation Firewalls (NGFWs), combined with Intrusion Detection Systems (IDS) and Intrusion Prevention Systems (IPS), offer a more comprehensive defense by integrating real-time traffic monitoring, deep packet inspection, and automated threat response capabilities. However, for many organizations, these capabilities alone are not enough to combat today's dynamic threat landscape. This paper has explored how the integration of Wazuh, an open-source Security Information and Event Management (SIEM) platform, with NGFW systems can significantly enhance security by providing centralized log management, advanced correlation, and real-time alerting. The combination of NGFW and Wazuh creates a multi-layered defense that not only identifies and prevents malicious network activities but also correlates logs from various sources to provide a holistic view of potential threats. Wazuh's adaptability and cost-efficiency make it an excellent choice for organizations seeking a scalable, robust security solution without the financial burden of proprietary SIEM systems. Through the integration of real-time log analysis, file integrity monitoring (FIM), and vulnerability assessment, Wazuh enhances NGFW capabilities, enabling organizations to detect multi-stage attacks and respond promptly. Although some challenges exist—such as resource consumption, setup complexity, and ensuring regulatory compliance—these can be mitigated with proper configuration and resource management. The successful implementation of NGFW and Wazuh solutions represents a promising approach to modern cybersecurity, providing organizations with the tools needed to address both current and future threats.

VI. FUTURE SCOPE

A. Extending Security to Mobile Devices

As organizations increasingly adopt Bring Your Own Device (BYOD) policies and mobile devices become essential tools in the workplace, the need to extend robust security measures to these devices is critical. Mobile devices, when connected to corporate networks, represent a significant vulnerability due to their less stringent security configurations and the risk of infection from malware, phishing, and network attacks. With the integration of Wazuh and NGFW, the potential exists to extend monitoring and threat detection to mobile devices in real-time.

B. Challenges of Mobile Device Monitoring

Monitoring mobile devices presents unique challenges, especially in balancing security with privacy. Personal devices often contain sensitive data—such as emails, messages, financial information, and health data—that users do not want exposed to corporate monitoring systems. While it is important to secure the corporate network from potential threats introduced by mobile devices, organizations must ensure that they do not violate employee privacy or inadvertently expose personal data.

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Privacy regulations like GDPR and CCPA add additional layers of complexity, as these regulations impose strict limits on the collection, processing, and retention of personal information. As such, any monitoring of mobile devices must focus solely on corporate data and network activities, ensuring that personal data remains private and secure.

C. Implementation of Mobile Monitoring with NGFW and Wazuh

In the future, NGFW systems and Wazuh could be extended to monitor mobile devices by implementing mobile device management (MDM) features, allowing organizations to monitor traffic and enforce security policies without infringing on personal privacy. This can be achieved by:

Segmenting corporate and personal data on mobile devices, using containerization technologies that separate work-related apps from personal ones.

Tracking network traffic only: Monitoring the network traffic generated by mobile devices when connected to the corporate network, rather than accessing internal data or communications on the device.

Using lightweight agents: Installing agents on mobile devices (similar to Wazuh agents) that monitor activity related to corporate apps, VPN usage, and network access, without compromising the privacy of personal apps or data.

D. Ethical Considerations and Privacy

The ethical implications of mobile device monitoring cannot be overlooked. Organizations must be transparent with employees about what is being monitored and obtain explicit consent for any monitoring activities. The principle of minimal monitoring should be followed, meaning that only network-related activities are tracked and personal data remains completely untouched.

Employee education will also be crucial in the future. Employees must be made aware of the risks associated with using personal devices on corporate networks and understand the importance of security measures, such as enabling encryption, strong passwords, and VPNs when accessing corporate data from mobile devices.

E. Future Trends: AI and Machine Learning in Mobile Security

As mobile devices become more deeply integrated into corporate environments, artificial intelligence (AI) and machine learning (ML) will play a significant role in detecting sophisticated mobile threats. AI-powered NGFW and SIEM systems like Wazuh can use behavioral analytics to detect anomalous activities on mobile devices, even when threats do not follow traditional attack patterns. These technologies can also help reduce false positives by learning normal usage behaviors and identifying truly malicious behavior based on patterns and anomalies.

The extension of NGFW and Wazuh to mobile device monitoring, coupled with AI-driven threat detection, represents the next phase in the evolution of network security. As organizations continue to navigate the challenges of remote work, BYOD policies, and increasingly complex mobile ecosystems, the ability to protect corporate networks while respecting individual privacy will be a key focus in the coming years.

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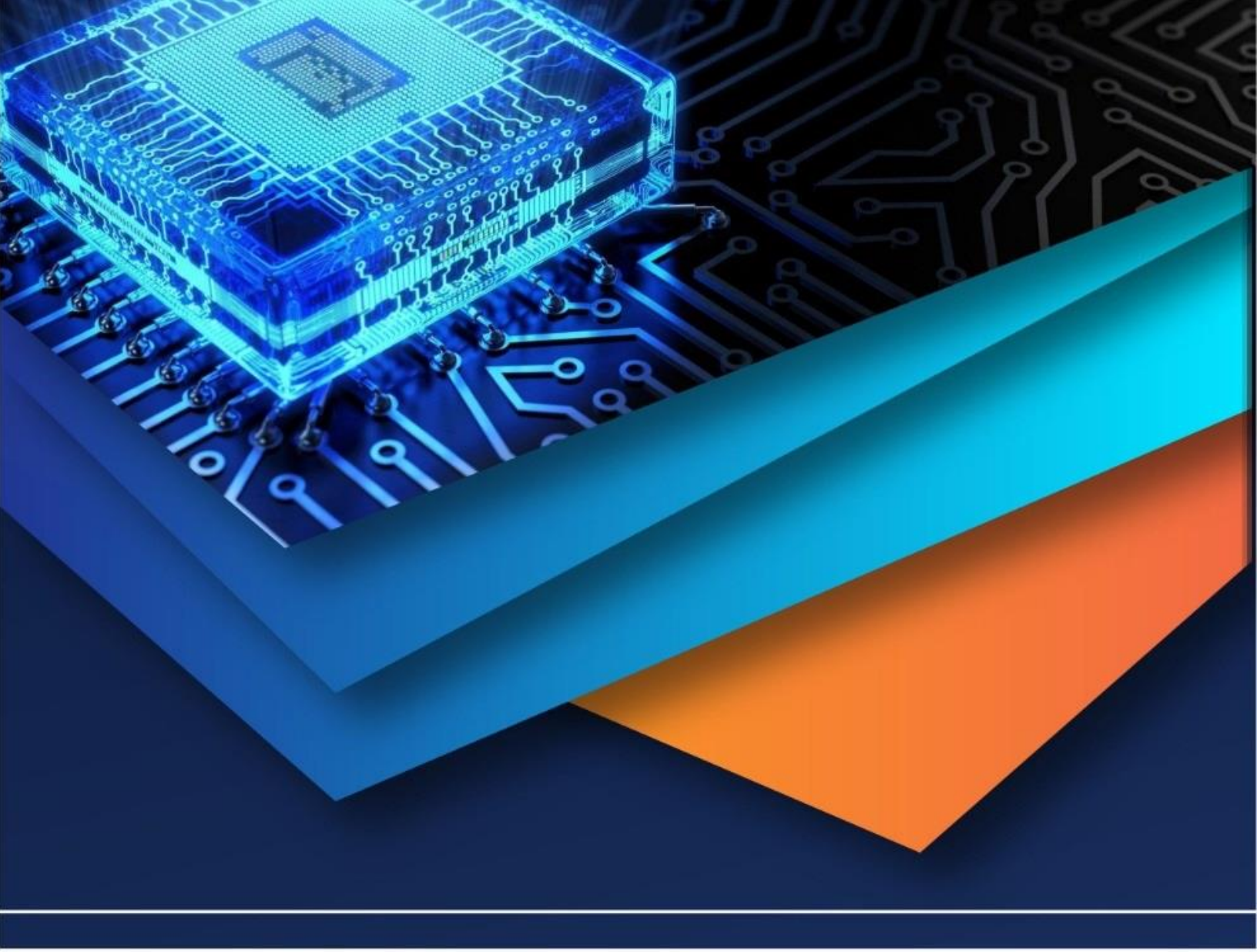
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