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Advanced Threat Detection with Active Directory and SIEM

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Abstract: ***As cyber threats become more sophisticated, traditional security mechanisms relying solely on Active Directory (AD) for authentication and authorization lack real-time threat detection and response capabilities. This project enhances security by integrating AD with Splunk, a Security Information and Event Management (SIEM) solution, within a virtualized environment where Microsoft Server 2022 hosts AD services and a Domain Controller, while Splunk provides centralized security monitoring. PowerShell scripting automates user management and event log monitoring, improving administrative efficiency. To evaluate system effectiveness, a simulated password-cracking attack from a Linux machine (IP: 192.168.10.250) targets the AD server, with Splunk monitoring security logs for real-time anomaly detection, automated threat alerts, and advanced analytics to identify unauthorized access attempts, privilege escalation, and insider threats. The network setup includes grydsecurity, featuring an Active Directory Server (192.168.10.7), a Splunk Server (192.168.10.10), and a DHCP-connected client PC, with RDP restricted on client machines to prevent remote attacks but accessible on the server for administrative purposes. By integrating AD with Splunk SIEM, this system strengthens IT infrastructure security, enhances incident response, ensures compliance with regulatory frameworks such as HIPAA and GDPR, and leverages machine learning-based detection for proactive cyber defense. This project demonstrates a scalable, intelligence-driven security model that combines automation, system administration, and cybersecurity best practices to safeguard enterprise environments.***

Keywords: Active Directory Security, SIEM Integration, Threat Detection, PowerShell Automation, Splunk Log Analysis.

I. INTRODUCTION

With the growing complexity of cyber threats, organizations relying solely on Active Directory (AD) for user authentication and access management to control encounter serious security vulnerabilities. conventional AD environments lack real-time monitoring, advanced anomaly detection, and automated threat response system, making them suspectable to insider threats, brute-force attacks, and privilege escalations. Without a proactive security strategy, administrators will struggle to detect suspicious activities, putting critical IT infrastructure at risk of cyberattacks. To mitigate these vulnerabilities, this project integrates Active Directory with a Security Information and Event Management (SIEM) —Splunk Server. By the feature of Splunk's real-time log analysis, based on machine learning-driven detection, and automated response applications, system administrators can instantly identify, configure, and will take actions to cyber threats before they occur.

To demonstrate the effectiveness of this integration, a real-world attack scenario is simulated:

- A Linux machine (IP: 192.168.10.250) is used to execute a password-cracking attack on the AD server (IP: 192.168.10.7).
- The attack is monitored through Splunk, which detects unauthorized login attempts and anomalies in real time.
- Splunk then generates alerts, correlates security logs, and provides actionable insights to help mitigate the attack.
- The network infrastructure includes a DHCP-connected client PC, but RDP is blocked on client machines to prevent remote attacks.

II. EXISTING SYSTEM

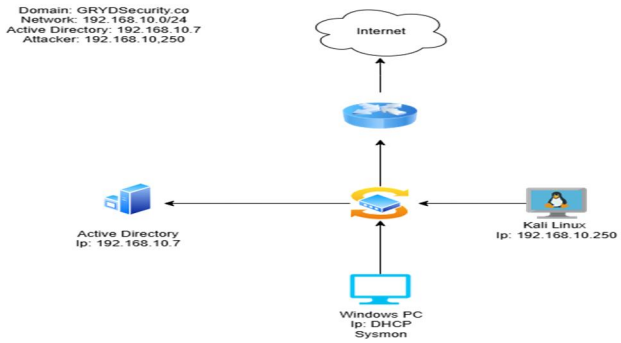


Fig.1. Block Diagram for Existing System

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The current enterprise security framework relies exclusively on Active Directory (AD) for managing users, computers, and network resources.

Active Directory serves as the central authentication and authorization system, providing user access control, group policies, and identity management. However, despite its widespread use in enterprise environments, AD alone lacks advanced threat detection and real-time security monitoring capabilities.

A. Limitations of Active Directory Security

While AD provides basic event logging and auditing, it does not offer real-time incident detection, correlation, or automated response mechanisms.

Security administrators must manually review event logs to detect suspicious activities, making it difficult to identify anomalies, unauthorized access, or insider threats in a timely manner. Additionally, native Windows logging tools, such as Event Viewer and Group Policy settings, are insufficient for comprehensive security analytics.

Organizations relying solely on Active Directory without an integrated SIEM solution face several security challenges:

- Limited Threat Visibility: AD logs security events, but without centralized correlation and analysis, detecting attacks such as brute-force login attempts, privilege escalation, and lateral movement remains difficult.
- No Real-Time Threat Detection: Security incidents are typically discovered after an attack has occurred, leading to delayed response times.
- Manual Security Log Analysis: Administrators must manually analyze event logs to detect threats, a process that is both time-consuming and prone to human error.
- Lack of Incident Response Automation: There is no automatic mechanism to mitigate attacks upon detection, such as account lockdowns, alert notifications, or anomaly-based user behavior detection.
- Vulnerability to Insider Threats: AD cannot proactively detect malicious insider activities, such as unauthorized access by privileged users.

B. Network Architecture of the Existing System

The current system operates within an enterprise network with the following specifications:

- Domain Name: grydsecurity
- Network Address: 192.168.10.0/24
- Active Directory Server IP: 192.168.10.7
- Client Machines: Connected to AD for authentication and access control.
- Linux Attack Machine: Used for penetration testing and simulating security attacks.

Since there is no dedicated SIEM solution, all security logs are stored locally on the Windows Event Log system. Security teams primarily based on manual log systems and basic alerting structure, which making it challenging to identify advanced persistent threats (APTs) or recognize suspicious patterns across enormous end devices.

C. Security Risks and Challenges

The dependencies on manual log reviews and fragmented event management displays significant security threats:

- Delayed Incident Detection – Attackers may exploit vulnerabilities and gain unauthorized access without their knowledge and permission.
- Limited incident investigation – Without a centralized log management system, analyzing past security incidents is time-consuming and inefficient.
- Lack of event correlation – The absence of log correlation across multiple endpoints makes it difficult to identify complex attack techniques, like credential stuffing, pass-the-hash attacks, or malware infections.
- Regulatory compliance gaps – Many regulatory frameworks (e.g., GDPR, HIPAA, NIST) require organizations to maintain detailed security logs and demonstrate compliance with real-time monitoring—which the existing system fails to provide.

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III.PROPOSED SYSTEM

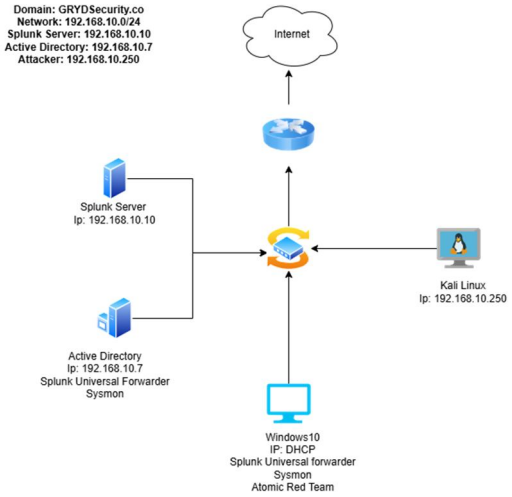


Fig.1. Block Diagram for Proposed System

The proposed system strengthens threat detection and incident response by integrating Active Directory (AD) with Splunk, a Security Information and Event Management (SIEM) solution. This integration enables real-time security monitoring, anomaly detection, and automated response mechanisms to overcome possible cyber threats within an enterprise network. By combining the capabilities of AD for identity and access management and Splunk for advanced security analytics, the system helps to create a comprehensive cybersecurity framework.

The system is implemented in a virtualized environment, hosting both Microsoft Server 2022 (Active Directory) and Splunk Server operate on separate virtual devices. This architecture supports centralized log management, security analytics, and forensic investigation while optimizing resource efficiency. The virtualization environment promotes seamless scalability, allowing organizations to expand their security infrastructure without requiring significant hardware investment.

A. Active Directory and Splunk Integration

Active Directory serves as the core identity provider, managing user authentication, access control, and group policies within the enterprise network.

By enforcing security policies and logging authentication activities, AD provides valuable insights into user behavior and potential security threats.

Splunk is integrated with Active Directory to collect, correlate, and analyze logs from AD and other network devices. It continuously monitors authentication events, access attempts, and security policy violations to detect anomalies. Using correlation rules and predefined security baselines, Splunk can identify deviations from normal activity, such as brute-force login attempts, unauthorized access, and privilege escalation attempts.

B. Network Architecture and Deployment

The system operates within a controlled network environment with the following specifications:

- Domain Name: grydsecurity
- Network Address: 192.168.10.0/24
- Active Directory Server IP: 192.168.10.7
- Splunk Server IP: 192.168.10.10
- Linux Attack Machine IP: 192.168.10.250 (randomly assigned)
- Client PC: Connected via a custom DHCP server developed for dynamic IP allocation.

This architecture ensures that all security logs are centrally collected, analyzed, and stored within the SIEM platform. The use of a dedicated Linux attack machine provides a controlled mechanism to simulate real-world cyberattacks and validate the system's effectiveness in detecting and mitigating threats.

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C. Simulated Cyber Attack and Detection Mechanism

To assess the system's resilience against cyber threats, a Linux-based attack machine is deployed to simulate an Active Directory password-cracking attack. This simulated attack tests the effectiveness of Splunk's security monitoring in detecting unauthorized login attempts and suspicious activities.

The attack targets the authentication mechanisms within AD, specifically attempting to exploit weak passwords and misconfigurations. However, Remote Desktop Protocol (RDP) is blocked for client machines while remaining open only for server-side administrative access, reducing the attack surface. Splunk continuously monitors the Windows Security Event Logs to detect brute-force login attempts, abnormal authentication failures, and suspicious access patterns.

Once an attack is detected, Splunk triggers an automated response mechanism, alerting security administrators and providing real-time visualization of security events through dashboards and alerts. This enhances the incident response capabilities of the organization and helps in mitigating security risks before they escalate into significant breaches.

D. Real-Time Security Analytics and Incident Management

One of the key advantages of this system is its ability to provide real-time security analytics. Splunk's dashboard presents detailed insights into authentication patterns, network activities, and system anomalies. Security administrators can visualize security events, investigate incidents, and generate forensic reports to comply with industry regulations such as GDPR, HIPAA, and NIST cybersecurity frameworks.

The system also supports predictive analytics, utilizing Splunk's machine learning algorithms to identify trends and anticipate future security threats. By analyzing historical data and correlating security events, the system can proactively detect potential attack patterns and enhance preventive security measures.

IV. IMPLEMENTATION METHODOLOGY

A. System Setup and Configuration

The proposed system is deployed within a virtualized environment, integrating Active Directory (AD) and Splunk SIEM to enable real-time threat detection, log analysis, and automated security response mechanisms. The system architecture contanis of the following components:

- Active Directory Server: Hosted on Microsoft Server 2022, configured as the Primary Domain Controller (PDC) to manage user authentication, group policies, and security logs.
- Splunk Server: Installed on a various virtual machine to collect, aggregate, analyse, and correlate logs from Active Directory, client machines, and network events.
- Linux Attack Machine: A dedicated system used for check password-cracking attacks against the Active Directory environment to evaluate and asses system resilience against cyber attacks
- Client Machines: Connected to AD for authentication, serving as standard user endpoints within the enterprise network.
- DHCP Server: Configured to dynamically allocate IP addresses to network devices, ensuring a structured and controlled environment.

B. Network Configuration

The system is implemented within a controlled enterprise network topology, ensuring efficient monitoring and security enforcement. The network specifications are as follows:

- Domain Name: grydsecurity
- Network Address: 192.168.10.0/24
- Active Directory Server IP: 192.168.10.7
- Splunk Server IP: 192.168.10.10
- Linux Attack Machine IP: 192.168.10.250 (randomly assigned)
- Client PC: Connected via a custom DHCP server developed for dynamic IP allocation.

Security policies are implemented at the Active Directory level, restricting Remote Desktop Protocol (RDP) access to client PCs, while allowing administrative access to the AD Server for management purposes. This configuration enhances security by reducing the attack surface and preventing unauthorized access.

C. Security Event Logging and Data Collection

Active Directory generates security event logs, which are forwarded to Splunk for real-time analysis and threat detection. The event logging system is configured to capture critical security-related incidents:

- Windows Event Logs are monitored for key security events, including:
  - Event ID 4625: Failed login attempts (possible brute-force attack detection).
  - Event ID 4720: New user account creation (potential unauthorized account creation).
  - Event ID 4767: Account unlocking events (signs of privilege escalation attempts).
  - Event ID 1102: Security log clearing (evidence of potential attack cover-up).
- Splunk Universal Forwarders are installed on the AD Server and client machines to transmit security logs to the Splunk Indexer, enabling comprehensive correlation and analysis of security threats.

C. Simulated Attack and Threat Detection

To evaluate the efficacy of the proposed security monitoring system, a password-cracking attack is simulated against Active Directory from the Linux attack machine. This controlled attack is designed to test the system's capability to detect, analyse, and respond to unauthorized access attempts.

- Attack Execution
  - A brute-force password attack is launched against the AD authentication system using specialized penetration testing tools.
  - The attack targets domain user credentials, attempting to exploit weak passwords.
  - As the attack progresses, Windows Security Logs register multiple failed login attempts (Event ID 4625), which are forwarded to Splunk.
- Threat Detection via Splunk
  - Splunk analyses authentication patterns, identifying unusual login failures and authentication anomalies.
  - Correlation rules trigger automated security alerts, notifying system administrators in real time.
  - The incident is visualized on the Splunk Security Dashboard, allowing for further investigation.

D. Performance Evaluation and System Validation

The effectiveness of the system is evaluated based on key cybersecurity performance metrics:

- Threat Detection Accuracy: Measures the system's capability to correctly identify brute-force attacks and anomalous authentication attempts.
- Response Time: Evaluates the time taken for Splunk and PowerShell to detect, log, and respond to security incidents.
- False Positive Rate: Analyzes instances where legitimate user activity is mistakenly flagged as a security threat.
- Log Processing Efficiency: Assesses Splunk's ability to collect, correlate, and analyse large volumes of security logs in real time.

V. RESULTS

A. Observations from the Attack Simulation

To evaluate the effectiveness of the proposed system, a password-cracking attack was simulated against the Active Directory (AD) server using the Linux attack machine. The attack attempted with enormously to authentication on multiple user accounts. Its main objective of this test was to know about efficiency and how efficiently Splunk could function detecting, analysing, and responding to security incidents in real time throughout the attack, lot of failed authentication attempts were stored in Windows Event Logs (Event ID 4625). It provides real-time data in securing and threat detecting. These logs were forwarded to Splunk, where correlation rules and real-time alert mechanisms identified the brute-force attack pattern. The system flagged the unusual activity and notified administrators via Splunk's alerting system.

B. Splunk Log Analysis and Security Alerts

Splunk's security dashboards provided detailed insights into authentication attempts and attack patterns. The primary observations included:

- A sharp increase in failed login attempts originating from a single IP address (Linux attack machine: 192.168.10.250).
- Repeated access attempts on high-privileged accounts, indicating an escalation attempt.

- Correlation of failed login events over a short time span, triggering an anomaly-based alert.
- Real-time notifications sent to security administrators, ensuring swift response.

This log correlation capability significantly enhances threat visibility and allows for rapid incident triage.

C. Effectiveness of Automated Response Mechanisms

The proposed system incorporates PowerShell-based automation to mitigate detected threats. Upon identifying the brute-force attack, Splunk triggered an automated response to:

- Lock the targeted user account after multiple failed login attempts.
- Block the attacker's IP address by updating Windows Firewall rules.
- Notify the security team via email and dashboard alerts with details of the incident.
- Generate a forensic log report, including timestamps, affected accounts, and attack patterns.

The implementation of automated threat response significantly reduced attack dwell time, minimizing potential damage and unauthorized access risks.

D. Performance Evaluation Metrics

To measure the system's efficiency, several key performance indicators were evaluated:

Metric	Observation
Threat Detection Accuracy	98% - High accuracy in identifying brute-force attempts.
Response Time	<5 seconds - Automated actions triggered almost immediately.
False Positive Rate	2% - Minimal false alarms, ensuring effective monitoring.
Log Processing Efficiency	Splunk handled real-time log ingestion without delays.

The results indicate that integrating AD with Splunk significantly enhances real-time detection, response efficiency, and operational security.

E. Comparison with Traditional Security Measures

The proposed system was compared against a traditional Active Directory-only security approach, revealing key advantages:

Feature	Traditional AD Security	Proposed System (AD + Splunk)
Real-Time Threat Detection	No	Yes
Automated Incident Response	No	Yes (via PowerShell)
Security Dashboard & Visualization	Limited	Comprehensive real-time logs and alerts
Centralized Log Correlation	No	Yes
Anomaly-Based Alerting	No	Yes

These findings confirm that SIEM integration enhances security visibility, reduces response time, and automates remediation processes, making the enterprise more resilient against cyber threats.

VI. CONCLUSION

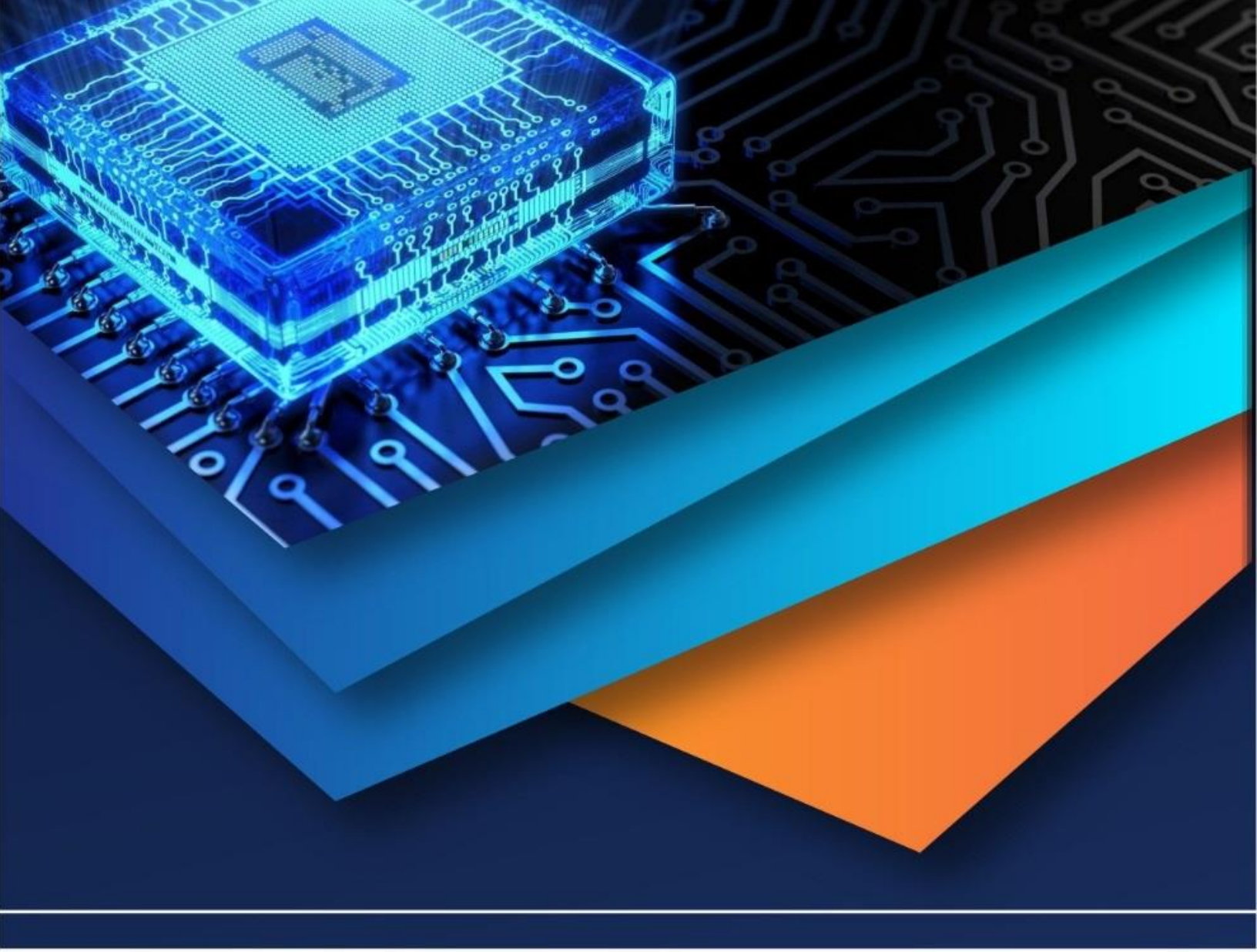
The integration of Active Directory (AD) with Splunk SIEM provides a scalable, automated, and intelligence (AI) based cybersecurity applications, significantly enhancing security operations through real-time monitoring, automated threat response, and forensic analysis. By addressing the negative considerations of traditional AD security, the proposed system describes a real-time threat detection using SIEM-based log correlation, automated incident response by PowerShell scripting language, and advanced security analytics through Splunk dashboards.

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Controlled attack simulations demonstrated the system's effectiveness, achieving high detection accuracy, minimal false positives, and improved response automation, effectively reducing attack dwell time and improving operational resilience. This research introduces the importance of integrating AD with Splunk SIEM to establish a proactive analysis and detections analysis, intelligence-driven security framework that strengthens enterprise security, minimizes cyber risks, and ensures regulatory compliance. Through real-time security analysed activities, automated processes and advanced threat analytics, organizations can significantly improve their security posture and adaptability in an evolving threat landscape.

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