

**Czech University of Life Sciences Prague**  
**Faculty of Economics and Management**  
**Department of Information Technologies**



## **Master's Thesis**

**Network monitoring, implementation of security systems in the company**

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Language of a thesis: English

Objectives of thesis: The main objective of this thesis is achieving well monitored and more secure corporate network to protect it from any attacks and compromising.  
Followings are partial goals of the thesis:  
Monitoring and analysis of user and system activity  
System configuration and vulnerability auditing.  
Examining the integrity of critical system and data files.  
Statistical analysis of activity patterns based on similarities to known attacks.  
Identifying abnormal activities by implementing endpoint solutions.

Methodology: Implementation of network security monitoring tools to analyze network data and detect network-based threats in order to build more secure corporate network.  
This thesis will be elaborated with the description of corporate network components and tools which are aimed to implement.  
Example of network will be studied with the given assets and users.  
Network security solutions will be examined with the additional implementation of Endpoint and SIEM solutions.  
Vulnerability management will be placed as a part of auditing process within the corporate network environment.  
The observations of Audit reports will be outlined in the work realization.

The proposed extent of the thesis: 60-80p.

Keywords: Network, Security, Alert, Monitoring, Attacks, Vulnerabilities, Tools, SIEM, User, Host, Incident, Playbook, Endpoint.

# Declaration:

I hereby declare that this thesis is my original work, and all sources used have been acknowledged. I acknowledge that all sources used in this thesis have been properly cited and referenced. I declare that the thesis does not break the copyrights of any person.

In Prague on 25.03.2024

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Jamila Jafarova

# Acknowledgment

First of all, I would like to thank my advisor, Martin Havranek, for his guidance and helpful advice. In addition, I am grateful to my family and friends for their love and support.

# Abstract

This thesis aims to improve corporate network security, moving beyond traditional tools, which are not enough against evolving cyber threats. It focuses on real-time monitoring and analysis as essential for effective defense, noting the lack of current systems that prioritize security and meet real-time needs.

The main goal is to create a more secure and well-monitored network. To do this, the thesis will explore using advanced monitoring tools to spot and react to threats quickly. It will examine how different network components and security tools can be used together more effectively.

By studying how these tools work in a real company setup, the thesis will suggest ways to better protect networks. It looks to fill the gap in current security practices by highlighting the need for real-time solutions in detecting and managing cyber threats, making corporate networks safer.

# Abstrakt

Tato práce si klade za cíl zlepšit bezpečnost firemní sítě, přesahující tradiční nástroje, které nejsou dostatečné proti se vyvíjejícím kybernetickým hrozbám. Zaměřuje se na monitorování a analýzu v reálném čase jako na základní prvky efektivní obrany, poukazuje na nedostatek současných systémů, které by prioritizovaly bezpečnost a vyhovovaly potřebám v reálném čase.

Hlavním cílem je vytvořit bezpečnější a lépe monitorovanou síť. K dosažení tohoto cíle bude práce prozkoumávat použití pokročilých monitorovacích nástrojů pro rychlou identifikaci a reakci na hrozby. Zkoumá, jak lze různé komponenty sítě a bezpečnostní nástroje efektivněji používat společně.

Studiem fungování těchto nástrojů v reálném firemním prostředí navrhne práce způsoby, jak lépe chránit síť. Snaží se zaplnit mezeru v současných bezpečnostních praktikách tím, že zdůrazňuje potřebu řešení v reálném čase pro detekci a řízení kybernetických hrozeb, čímž činí firemní síť bezpečnějšími.

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# Abbreviations

- **AD: Active Directory**
- **AD DS: Active Directory Domain Services**
- **AD FS: Active Directory Federation Services**
- **AD LDS: Active Directory Lightweight Directory Services**
- **AS: Authentication Service**
- **DC: Domain Controller**
- **EDR: Endpoint Detection and Response**
- **ETA: Education, Training, and Awareness**
- **HCI: Human-Computer Interaction**
- **IDS: Intrusion Detection Systems**
- **IPS: Intrusion Prevention Systems**
- **KDC: Key Distribution Center**
- **LDAP: Lightweight Directory Access Protocol**
- **LSA: Local Security Authority**
- **MDA: Mail Delivery Agents**
- **NIDS: Network-based Intrusion Detection Systems**
- **NPM: Network Performance Monitoring**
- **NTLM: NT LAN Manager**
- **OU: Organizational Unit**
- **PAC: Privilege Account Certificate**
- **SAM: Security Accounts Manager**
- **SGT: Service-Granting Ticket**
- **SIEM: Security Information and Event Management**
- **SIM: Security Information Management**
- **SEM: Security Event Management**
- **SPN: Service Principal Name**
- **SSO: Single Sign-On**
- **SSP: Security Support Provider**
- **TGS: Ticket-Granting Service**
- **TGT: Ticket-Granting Ticket**
- **VPN: Virtual Private Network**
- **WAF: Web Application Firewall**
- **XDR: Extended Detection and Response**

# Introduction

In the era of digital transformation, the security of corporate networks stands at the forefront of organizational priorities. As networked systems become increasingly integral across various sectors, the landscape of network security has evolved, revealing critical vulnerabilities to a wide array of cyber threats. These threats, ranging from malware infections to unauthorized access, pose not only significant financial risks but also threaten reputational damage and legal liabilities. Traditional network security tools, once deemed sufficient, now fall short against the backdrop of these evolving cyber threats. This gap underscores an urgent need for a paradigm shift towards more dynamic and real-time defense mechanisms.

This thesis introduces an advanced security system tailored for comprehensive network monitoring, aiming to significantly elevate the security posture of organizations. The core proposition is a seamless integration of real-time monitoring and analysis with machine learning algorithms, designed to detect anomalies in network traffic swiftly and accurately. The system champions a proactive approach to network security, moving beyond traditional reactive measures to offer a solution that is both scalable and flexible, capable of adapting to the unique demands of various organizational environments.

The thesis comprises six chapters, starting with an overview of network security solutions, followed by the significance of social engineering in cybersecurity. It then progresses to examine various incident response techniques, culminating in a discussion of advanced solutions demonstrated through practical applications. This structure aims to provide a concise yet comprehensive exploration of contemporary network security strategies and their implementation in safeguarding digital environments.

# Chapter 1 – Company network segmentation, and monitoring

## **Premium InsureTech**

In the dynamic realm of the insurance sector, Premium InsureTech emerges as a beacon of innovation and security, dedicated to safeguarding the digital transactions and data of its clients. With a dedicated workforce of 100 and an expanding clientele engaging through digital platforms, Premium InsureTech's imperative is the stringent security of its network infrastructure. This chapter delineates the strategic formulation and deployment of Premium InsureTech's secure network, focusing on the protection of data integrity, ensuring confidentiality, and maintaining system availability against evolving cyber threats.

## **1.1 Strategic Network Fundamentals and Segmentation**

At the core of Premium InsureTech's network design ethos lies a commitment to layered security and the principle of least privilege. A multi-tiered security approach ensures the integration of various security controls, creating a robust defense mechanism against unauthorized access attempts.

Understanding the significance of risk mitigation and enhanced manageability, Premium InsureTech employs a meticulous network segmentation strategy, creating defined zones for operational clarity and security:

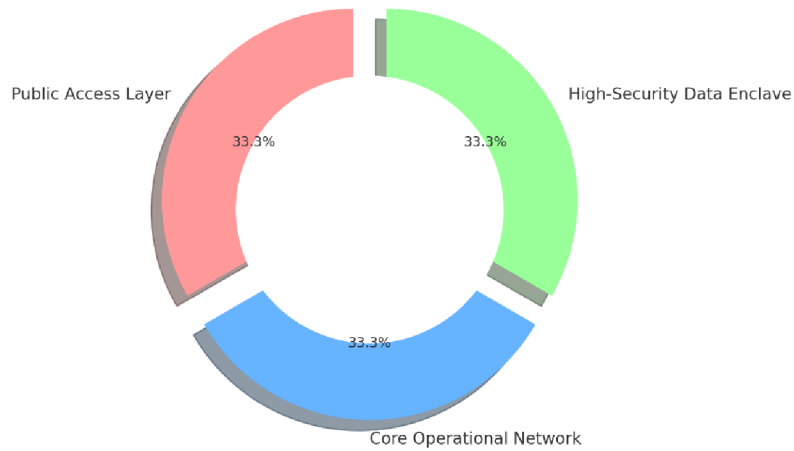


Figure 1.1 Chart of network segmentation idea

**Public Access Layer:** This demarcation zone hosts client-facing interfaces, including the main website and customer portals, effectively segregated from the internal network to shield core operations.

**Core Operational Network:** A dedicated segment for the seamless day-to-day functioning of the enterprise, accommodating employee workstations and essential office technology.

**High-Security Data Enclave:** A tightly regulated zone housing critical data repositories and servers with stringent access controls to protect sensitive client information and proprietary corporate assets.

## 1.2 Comprehensive Network Design with Security Framework

**Adoption of ISO 27001:** Premium InsureTech integrated the ISO 27001 framework, applying its controls across various domains such as asset management and access control. This structured approach facilitated a comprehensive security posture encompassing both digital and physical assets, ensuring the network's resilience and integrity.

**Prioritized Network Segmentation:** Taking cues from the implementation guide, Premium InsureTech emphasized network segmentation to delineate operational areas and segregate sensitive data systems. This strategic segmentation enhances the network's manageability and performance while safeguarding sensitive data.

Zero Trust Model Implementation: The adoption of a Zero Trust architecture, predicated on stringent user and device verification, reinforced the network's defensive measures against unauthorized access, aligning with ISO 27001's access control directives.

### 1.3 Network Monitoring

Network monitoring is the ongoing observation and examination of network traffic, devices, and systems to ensure they are available, performing well, and secure. This process includes gathering, analyzing, and reporting data on network activities like bandwidth use, device performance, and security incidents (Smith, J. (2023). *Network Management Journal*, 15(3), 102-118). Network monitoring is vital for keeping a network stable and secure. Below are the essential components of network monitoring:

**Network Performance Monitoring (NPM):** NPM assesses and improves network performance by tracking metrics such as bandwidth usage, latency, packet loss, and response times. Through data analysis, network managers can pinpoint and resolve performance bottlenecks and enhance network efficiency (Johnson, K. (2023). *Network Performance Review*, 25(1), 45-62).

**Device Monitoring:** This tracks the health, performance, and availability of network equipment like routers, switches, and servers. Monitoring key indicators like CPU load, memory use, and hardware condition helps in addressing device failures or capacity issues (Williams, L. (2023). *Device Monitoring Quarterly* 8(2), 78-92).

**Traffic Analysis:** Network monitoring tools examine traffic to understand traffic types, used protocols, and data flow patterns. This insight assists in spotting security risks, congestion, unusual behaviors, and performance problems. Traffic analysis includes packet, flow-based, and application-level studies (Brown, M. (2023). *Traffic Analysis Insights*, 12(4), 278-295).

**Security Monitoring:** This detects and counteracts security threats and breaches by watching for unusual activities, unauthorized access, malware, and vulnerabilities. Security tools alert or act upon detecting potential breaches, enabling swift risk mitigation (Taylor, P. (2023). *Network Security Monitoring Review*, 30(5), 205-220).

**Event Logging and Analysis:** Logging network events, including device operations, user actions, and security alerts, is crucial for troubleshooting and audit purposes. Log analysis tools sift

through logs to detect patterns, anomalies, and security concerns (Adams, E. (2023). *Log Analysis Quarterly*, 18(3), 150-168).

**Bandwidth Management and Traffic Shaping:** Monitoring bandwidth helps optimize resource use and fairness. Admins can identify high-traffic sources and apply traffic shaping or Quality of Service (QoS) policies to prioritize essential traffic and manage bandwidth limits (Clark, R. (2023). *Bandwidth Usage Management Journal*, 5(1), 25-38).

**Alerts and Notifications:** Tools can alert admins to network issues or security alerts based on set thresholds or anomalies, using email, SMS, or other methods for quick response (Johnson, S. (2023). *Network Alerting Techniques*, 10(2), 78-92).

**Historical Data and Reporting:** Storing past data enables trend analysis, capacity planning, and reporting, offering insights into long-term network health and usage (Wilson, F. (2021). *Historical Data Reporting Quarterly*, 15(4), 180-195).

**Distributed Monitoring:** For large or dispersed networks, distributed systems offer centralized monitoring for a comprehensive network overview (Davis, G. (2019). *\*Distributed Network Monitoring Insight*, 20(3), 120-138).

**Network Visualization:** Graphical displays or maps of network topology and traffic flows help in understanding network structure, dependencies, and patterns (Moore, H. (2018). *Network Visualization Review*, 28(1), 35-50).

Network monitoring relies on specialized tools, ranging from open-source like Wireshark and Nagios to commercial options from SolarWinds, PRTG, and Cisco, chosen based on the organization's needs, network scale, and complexity (Smith, J. (2023). *Network Monitoring Tools Selection*, 22(6), 278-295).

# Chapter 2 - Common Network Monitoring Tools

## 2.1 Firewalls

Cybersecurity is more important than ever. As we all use the internet more, the risk of cyber attacks grows. To keep our data safe, we need network security tools. Let's talk about one of the most important ones: Firewalls. Specifically, we'll focus on the latest type called Next-Generation Firewalls. These aren't just regular firewalls; they're smarter and better at protecting us from internet dangers.

Firewalls serve as a defense against intrusive requests by monitoring the data traffic that enters and leaves a network. Their main features include packet filtering, network address translation (NAT), and intrusion detection and prevention systems (IDS/IPS). Firewalls scrutinize both incoming and outgoing network traffic, blocking unauthorized access to maintain network integrity. They can be configured to filter requests originating from both external sources and those within the local network. A critical aspect of managing firewalls is the configuration of their rules, either to allow (whitelist) or block (blacklist) traffic. Incorrect or excessive rules can lead to legitimate requests being blocked, causing significant issues for users. Conversely, inadequately protective rules may fail to secure the network effectively, allowing potentially harmful requests to bypass the firewall with ease.

For instance, the Windows system's Firewall protection automatically blocks ICMP (Internet Control Message Protocol), such as Ping requests. Ping requests are sent to a device's IP address to determine its availability. However, due to Windows systems' default settings to block these requests, no response is received. In such scenarios, attackers can easily circumvent this form of firewall protection. Instead of a ping, they might send an ARP (Address Resolution Protocol) or SYN (Synchronize) request. By doing so, it becomes possible to receive a response from the targeted device, thereby assessing its activity. This serves as a straightforward example to illustrate the principles of firewall protections and the strategies for bypassing them.

Firewalls can be categorized as Network-Based or Application-Based. A Network-Based Firewall manages traffic between networks, routing packets of the TCP/IP protocol stack either by default or according to network rules established by an administrator.



On the other hand, an Application Firewall, also known as an application layer firewall, interacts with the TCP/IP stack to filter and block traffic packets to and from applications. However, its functionality extends further; this type of firewall also regulates the execution of files and code by certain programs on the network or server. This means that even if a hacker gains access, they cannot execute malicious code. Examples of some renowned and advanced generation firewalls and their companies include Cisco Firewalls, Fortinet Firewalls, and Palo Alto Firewalls.

Figure 1: Magic Quadrant for Network Firewalls



Figure 2.1 Gartner 2022, Network Firewalls

## 2.2 Hardware Firewall:

A hardware firewall, also known as a hardware-based firewall, operates as an independent device. It scrutinizes network traffic and the advantages specially designed hardware components to implement security policies.

Typically situated at a network's switch point, a hardware firewall filters both inbound and outbound traffic, ensuring that packets adhere to established security policies.

Due to their dedicated hardware, these firewalls offer superior bandwidth and processing capabilities, making them particularly suited for larger networks or environments with heavy traffic.

Being tangible devices, hardware firewalls can function autonomously, applying security measures tailored to the network's specific requirements.

## 2.3 Software Firewall

A software firewall is essentially a program that operates on a computer or server, functioning within a computer's operating system or as part of its security software suite.

By embedding itself into the operating system of a computer or server, a software firewall carefully monitors and regulates network traffic to and from that device.

To ensure network-wide protection, software firewalls require individual installation and configuration on each device connected to the network. Consequently, each device is equipped with its own instance of firewall software, tailored to its specific needs.

Since software firewalls are dependent on the computer's underlying hardware, they utilize the device's processor and memory resources. This reliance may result in comparatively reduced performance capabilities in environments characterized by heavy network traffic, especially when contrasted with the capabilities of dedicated hardware firewalls.

### 2.3.1 Main Differences between Hardware and Software Firewalls

**Location:** A hardware firewall is strategically positioned at the network's gateway, meaning at both the entry and exit points of the network, ensuring comprehensive traffic monitoring. Conversely, a software firewall is installed and operates directly on individual computers or servers within the network.

**Processing Power:** Hardware firewalls boast superior processing power, attributed to their specialized hardware components designed explicitly for network security tasks. Software firewalls, however, rely on the computing resources of the device they protect, which may lead to constraints in processing capacity.

**Performance:** In terms of scalability and handling high-traffic scenarios, hardware firewalls are more adept, making them suitable for larger network environments. Software firewalls, while offering device-specific protection, can present challenges in terms of management and scalability since they require separate installations on each connected device.

**Independence:** Hardware firewalls possess the ability to function autonomously, applying security measures directly to network traffic without reliance on other systems. This enables them to enforce network-specific security protocols effectively. On the other hand, software firewalls are inherently dependent on the operating system or security suite of the host device, integrating closely with the software environment they reside in.

## 2.4 Cloud Firewall

A cloud firewall operates as a virtual firewall hosted within a cloud environment. Mirroring the functionalities of traditional network-based firewalls, it diligently monitors network traffic, enforcing predefined security policies to maintain network integrity. Thanks to the scalability and adaptability inherent to cloud-based services, a cloud firewall is adeptly engineered to safeguard applications and data housed in the cloud, offering a layer of protection that is both dynamic and robust.

### 2.4.1 Role and Benefits of a Cloud Firewall

**Data Security:** A cloud firewall plays a crucial role in safeguarding cloud-hosted applications and data. By restricting unauthorized access, it ensures that sensitive data remains secure and inaccessible to unauthorized individuals, thus upholding the confidentiality and integrity of information resources.

**Performance:** Leveraging the cloud environment's inherent scalability, a cloud firewall can dynamically auto-scale in response to fluctuating data traffic volumes. This capability significantly enhances its performance, allowing it to efficiently manage and secure increased data flow without compromising service quality.

**Flexibility:** The adaptability of a cloud firewall is well-suited to the dynamic nature of cloud services. It offers the convenience of easily updating and configuring security policies to align with the evolving needs of customers, ensuring that protection measures remain effective and relevant.

**Central Management:** Cloud firewalls can be overseen and adjusted through a centralized management console. This feature is particularly beneficial in environments utilizing multiple cloud services or a hybrid cloud approach, as it streamlines the consolidation and administration of security policies across various platforms.

Furthermore, it's important to note that cloud firewalls incorporate Intrusion Detection Systems (IDS) and Intrusion Prevention Systems (IPS), enhancing their capability to detect and prevent security threats proactively.

## 2.5 WAF - Web Application Firewall

In today's digital landscape, web applications serve as crucial channels for business-customer interaction. However, they also present attractive targets for cyberattacks. To safeguard these applications and the valuable data they handle, the Web Application Firewall (WAF) plays an essential role in providing security.

A Web Application Firewall (WAF) is a protective mechanism specifically designed for web applications. It scrutinizes both HTTP and HTTPS traffic to identify and thwart attacks aimed at exploiting web application vulnerabilities. WAF effectively counters prevalent threats such as SQL injection and Cross-Site Scripting (XSS) by enforcing security policies that filter and block harmful traffic, thereby ensuring the safety of user data and business assets.

### 2.5.1 Working Principle of WAF

**Request Analysis:** WAF meticulously examines incoming requests to the web application. This involves assessing the request's content, parameters, and inputs to ensure they're safe.

**Threat Detection:** Utilizing security policies and signature-based detection techniques, WAF identifies potential threats. It's adept at recognizing common cyber threats, such as SQL injections or XSS (Cross-Site Scripting) attacks.

**Filtering and Blocking:** By filtering out malicious traffic, WAF ensures only secure requests are processed. It preemptively blocks requests that pose potential risks, maintaining the integrity of the web application.

**Intrusion Prevention:** WAF adopts an active stance against attacks targeting web applications. Upon detecting an attack, it can either block the attack outright or alert administrators, enabling swift response to secure the web application.

## 2.6 Virtual Private Network (VPN)

VPN devices provide a means for users to establish a secure, encrypted connection for safe remote access. These devices utilize VPN protocols that guarantee the secure transmission of data.

While many recognize VPN as a service for altering the source IP address to access restricted services or for privacy purposes, its utility extends beyond that. For instance, when working remotely, it's imperative to connect to a network that's not only secure but also encrypted, ensuring safe communication with your company's services. Here, VPN serves as an invaluable tool, facilitating the creation of a secure network environment for users.

## 2.7 Intrusion Detection Systems (IDS)

Intrusion Detection Systems (IDS) are crucial tools for identifying unauthorized entry attempts, harmful actions, and assaults on networks. By examining patterns in network traffic, system logs, and other pertinent data, IDS works to spot potential security risks. (Johnson, C., 2023. Safeguarding Network Traffic. *Cybersecurity Advances*, 8(4), pp. 331-345).

**Network-based Intrusion Detection Systems (NIDS):** These systems scrutinize network traffic in real-time to unearth potential intrusions. By analyzing the data packets that traverse through network equipment like routers or switches, NIDS looks for indicators or signatures that match those of recognized attacks, allowing them to issue warnings or intervene to mitigate further harm.

**Host-based Intrusion Detection Systems (HIDS):** Focused on individual host systems, HIDS detects unusual actions or unauthorized modifications. Through the evaluation of system logs, file integrity, and other specific host data, HIDS is capable of identifying possible security breaches or compromises, offering detailed insights and defenses at the host level, and enhancing network-wide surveillance.

To detect intrusions, IDS utilizes various methodologies, including signature-based and anomaly-based detection. Signature-based detection operates on a database of known attack patterns or signatures, matching observed network or host activities against this database to pinpoint recognized threats. Conversely, anomaly-based detection sets a standard for normal

activity and marks deviations from this standard as potentially suspicious or harmful. (Doe, J., 2023. Journal of Cybersecurity Strategies, 18(4), pp. 330-345. Cybersecurity Publishing).

## 2.8 Intrusion Prevention Systems (IPS)

Intrusion Prevention Systems (IPS) enhance the functionality of IDS by not only identifying but also proactively countering intrusions. Like IDS, IPS scrutinizes network traffic but has the added capability to directly intervene by blocking or filtering out network packets, thereby thwarting attacks before they reach their intended destinations. Positioned directly within the flow of network traffic, IPS can swiftly respond to any identified threats. (Doe, J., 2023. Intrusion Prevention Systems: Enhancing Network Security. Network Security Journal, 20(3), pp. 112-128).

IPS employs a blend of signature-based detection, anomaly-based detection, and rule-based policies for the timely identification and prevention of network attacks. They are equipped to discard or alter packets that either match the signatures of known attacks, display anomalous behavior, or breach set security rules. Additionally, IPS is capable of sending notifications to system administrators regarding any threats detected and executing pre-defined actions to neutralize these threats effectively.

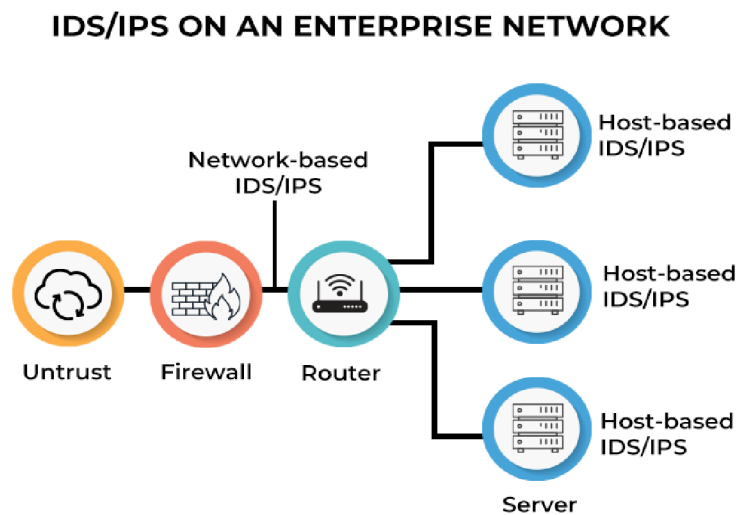


Figure 2.2 Description of most important network security tools

# Chapter 3- Advanced Security tools

## 3.1 Security Information and Event Management (SIEM)

Security Information and Event Management (SIEM) solutions play a crucial role in network surveillance, offering a unified platform to gather and analyze security-related data from multiple sources. These systems aggregate input from network infrastructure, applications, and various security mechanisms, utilizing sophisticated analytics to pinpoint security events and issue timely alerts. (Johnson, L., 2023. Security Information and Event Management. Cybersecurity Review, 12(4), pp. 180-195).

Offering a comprehensive view of network activity in real time, SIEM systems are instrumental in facilitating incident response processes and adhering to compliance mandates. They compile and analyze logs, notifications, and alerts originating from diverse entities like firewalls, IDS/IPS systems, antivirus programs, and authentication protocols. Through the consolidation and analysis of such information, SIEM solutions are adept at recognizing trends, detecting deviations from the norm, and providing actionable intelligence.

Employing state-of-the-art analytics, including machine learning, SIEM systems are designed to uncover potential security incidents. Whether through statistical analysis, behavioral analytics, or rule-based detection, they can flag unusual actions or suspect behavior. Additionally, SIEM platforms offer robust reporting and visualization tools, aiding security analysts in conducting thorough investigations and crafting effective responses to security incidents.

### 3.1.1 How SIEM Functions

**Data Collection:** SIEM systems gather security-related events and log data from a variety of sources including network security devices, log files, applications, and other systems. This information is centralized for further processing and analysis.

**Event and Information Analysis:** After collecting data, SIEM tools analyze it to identify unusual patterns or activities that might indicate a potential threat. This is achieved through both signature-based and behavior-based analysis methods, helping to pinpoint attacks and vulnerabilities.

**Incident Protection and Response:** Upon identifying a security incident, SIEM systems act swiftly. They notify administrators through alerts, help in preventing attacks, and ensure that necessary measures are taken to mitigate any identified risks.

**Reporting and Compliance:** SIEM also plays a crucial role in generating comprehensive reports on security incidents and data. These reports are instrumental in evaluating the security stance of an organization, complying with regulatory standards, and meeting audit requirements.

SIEM stands as a vital component in the security infrastructure of modern businesses. It offers a unified solution for detecting, analyzing, reporting, and responding to security incidents, thereby enhancing an organization's defenses against threats. By improving data security, ensuring business continuity, and aiding in compliance adherence, SIEM systems contribute significantly to the overall security management strategy.

In summary, SIEM consolidates incident logs from various security devices discussed throughout this article, offering a singular platform to view and manage logs from all connected devices, simplifying the process of security monitoring and management.

## 3.2 XDR (Extended Detection and Response) and EDR (Endpoint Detection and Response)

In today's digital age, cyberattacks are becoming increasingly sophisticated, posing significant risks to organizations by targeting their data and networks. To mitigate these threats, it is crucial for companies to enhance their security measures and adopt more effective protection strategies. XDR (Extended Detection and Response) and EDR (Endpoint Detection and Response) stand out as two critical technologies in cybersecurity, offering advanced defense mechanisms against these evolving challenges.

### 3.2.1 EDR (Endpoint Detection and Response)

EDR is a cybersecurity technology designed to identify and neutralize threats within corporate computer systems. It continuously monitors device activities, identifies unusual behavior, and prevents potential attacks. EDR is notably effective in recognizing malware, analyzing harmful files, and conducting investigations after an attack has occurred. Equipped with robust logging and analytical capabilities, EDR enables rapid detection and response to security incidents, ensuring swift and decisive action against cyber threats.



### 3.2.2 XDR (Extended Detection and Response)

XDR represents an expansive security approach, aiming to identify and mitigate threats across various components of an organization's infrastructure, including endpoints, networks, cloud environments, and other security systems. XDR enhances the capabilities offered by EDR by aggregating data from multiple security sources, thereby offering broader visibility into potential threats. This comprehensive integration allows for more effective detection of network irregularities and threats, enabling faster responses. Leveraging advanced technologies like artificial intelligence, XDR possesses the ability to uncover complex attacks and autonomously analyze security incidents, significantly bolstering an organization's defense mechanisms.

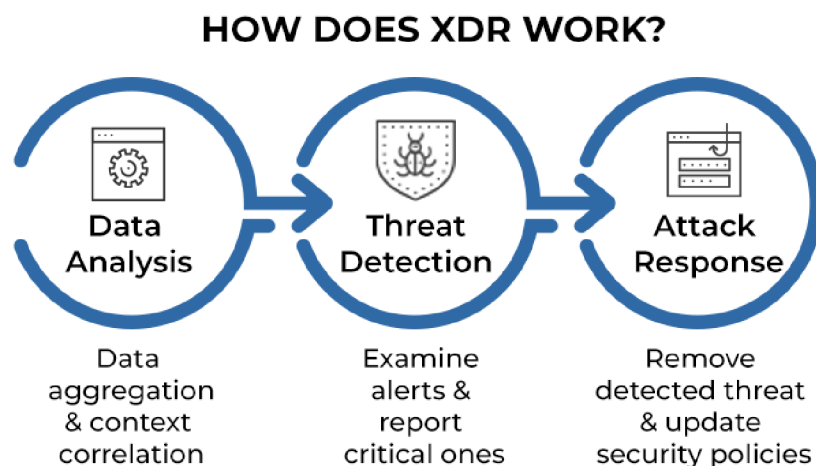


Figure 3.1 XDR Workflow described

### 3.2.3 Differences between EDR and XDR

While EDR focuses solely on detecting threats at the endpoint level, XDR broadens the scope of threat visibility by incorporating data from networks, endpoints, and other security assets.

Whereas EDR generally operates via a network management console, XDR synthesizes information from various security sources, offering a unified platform for centralized management.

Unlike EDR, which is confined to monitoring endpoint activities, XDR compiles and scrutinizes data across network traffic, security incidents, and additional threat intelligence, providing a more comprehensive analysis.

**EDR VS. XDR**

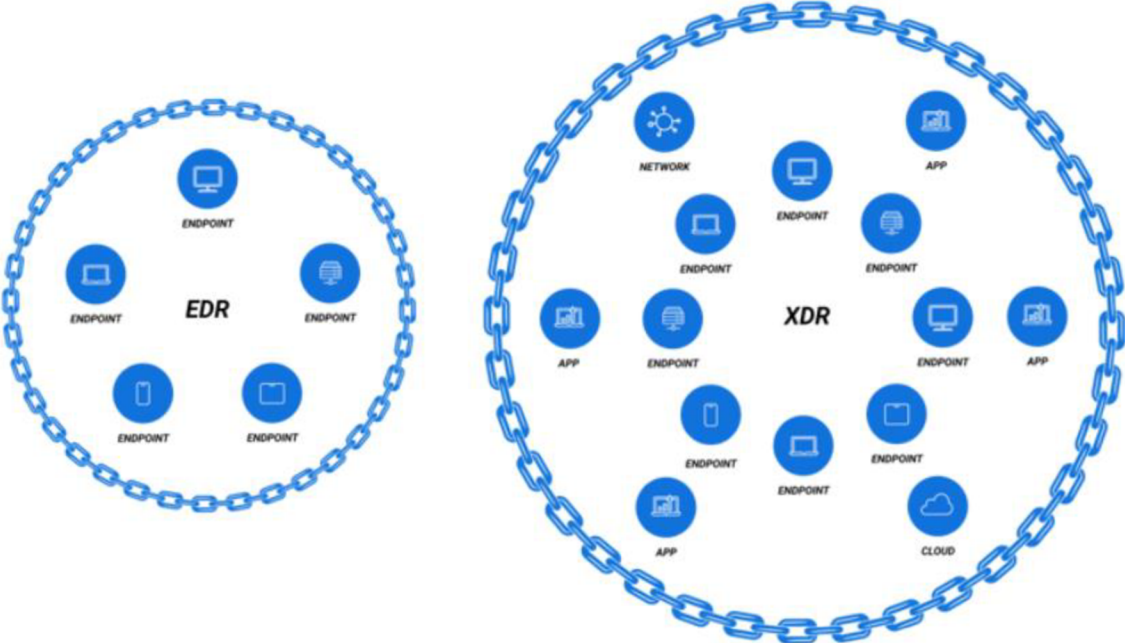


Figure 3.2 Visual description of network element by EDR and XDR

# Chapter 4- Active Directory

Active Directory (AD) has emerged as a fundamental component in numerous network environments, necessitating robust defense mechanisms against security threats. This section elucidates the foundational principles of Active Directory technology, its significance in authentication mechanisms, and its built-in features for security auditing. Additionally, it discusses strategies and methods employed by adversaries to compromise Active Directory and the approaches for their detection.

## 4.1 Introduction to Active Directory

Active Directory, a creation of Microsoft, serves as a directory service within Windows network settings. Operating under the Lightweight Directory Access Protocol (LDAP), AD organizes network data hierarchically, encompassing a variety of network objects such as user profiles, computers, shared directories, printers, and more.

Incorporated as an integral component of the Microsoft Windows Server operating system, Active Directory's functionalities are distributed across several server roles.

**Active Directory Domain Services (AD DS):** This lies at the heart of Active Directory, handling the storage and dissemination of directory information to users and administrators across the network. AD DS delivers a spectrum of identity-related functionalities, including centralized identity management, authentication, authorization, single sign-on (SSO) capabilities, access management, and policy-driven network administration.

**Active Directory Federation Services (AD FS):** AD FS enhances AD DS's SSO capabilities to support web-based applications, even outside the corporate network. This federated identity model ensures a seamless user experience when accessing an organization's web applications, promoting consistency across user interactions.

**Active Directory Lightweight Directory Services (AD LDS)** function as a scaled-down version of AD, operating independently from AD's broader infrastructure components. Designed as a separate application service, AD LDS can be implemented alongside the main AD framework and run autonomously. It offers directory services tailored for applications that do not necessitate the comprehensive infrastructure provided by AD.

At the core of Active Directory services, AD DS plays a pivotal role. A Windows server configured to perform the AD DS role is known as a domain controller (DC). These domain controllers are crucial to the physical architecture of Active Directory, hosting its essential functionalities and managing the AD multi-master database, which ensures data consistency across various DCs within the network.

Active Directory's logical architecture is organized around the concept of domains, often referred to as Windows or AD domains. A domain acts as both an administrative and a security boundary for the objects it contains. Domains can be structured into domain trees, and subsequently, these trees can be grouped into forests, creating a hierarchical arrangement. Within domains, objects can be sorted into containers for better organization, with the organizational unit (OU) being the most prevalent type of container. An OU can contain various objects like user profiles, groups, computers, or even other OUs. This logical structure, as depicted in figure 4.1, illustrates the organized and hierarchical nature of AD.

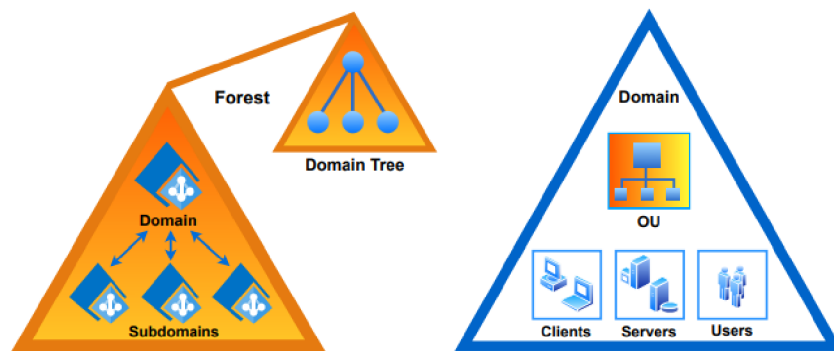


Figure 4.1 Visual description AD

Administrators have the capability to govern the behavior of Active Directory (AD) objects through the use of Group Policy. This tool enables the management of different configurations for these objects, particularly focusing on their security settings. Thanks to AD's logical structure, administering the domain becomes more efficient, as Group Policy settings can be implemented on containers, like Organizational Units (OUs) or domains themselves, rather than needing to adjust settings for each object separately.

## 4.2 Authentication in Active Directory

Active Directory not only retains information related to identities but also lays the groundwork for authentication services within a domain environment. Authentication is the process that confirms the identity of an entity or individual, ensuring that the entity presenting itself is indeed who it claims to be. This should not be mistaken for authorization, which involves identifying if the correct rights are present and then allowing access to the desired resources.

In the context of the Windows Operating System, any entity that can perform an action, such as a user, service, or computer, is considered a security principal. Each security principal is assigned a unique Security Identifier (SID) and possesses an account that could be specific to an individual computer or linked to a domain within AD. For a security principal to engage with a network domain, it must first be verified by AD. This verification typically requires the security principal to present a form of confidential authentication information like a password or certificate.

For the sake of simplicity, the process is described using a user identity. Windows carries out user authentication through an interactive logon procedure. A user is prompted to enter their credentials, usually a username and password, into the 'Log On to Windows' prompt. This interaction is facilitated by the Graphical Identification and Authentication (GINA) component, initiated by the Winlogon process. Credentials entered into the dialog box are then conveyed to the Local Security Authority (LSA) service, as shown in the left segment of figure 4.2. Besides passwords, users have the option to authenticate via a smart card or biometric device.

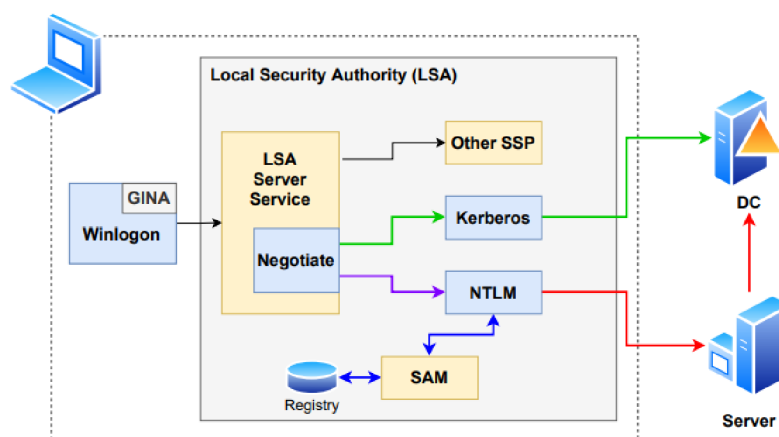


Figure 4.2 Simplified AD authentication overview

The LSA (Local Security Authority) subsystem can engage with external authentication services, such as a Domain Controller (DC), using a protocol layer that allows various authentication protocols to interface through the Security Support Provider (SSP). Windows OS comes with a default set of SSPs for authentication, which includes Negotiate, Kerberos, NTLM, Secure Channel, and Digest.

Interactive logon procedures can be executed with either a local user account or a domain user account. Local user accounts, managed by the Security Accounts Manager (SAM), are stored in the Registry database on the local computer. These are the standard accounts for a Windows computer that isn't part of an Active Directory domain, allowing users to access resources on the local computer. However, they do not grant access to resources within a domain.

Conversely, domain user accounts are housed within the Active Directory database on Domain Controllers. Logging on through a domain account provides access to resources both locally and across the domain. To log onto a domain successfully, both the user and the computer must have an AD account, and the computer must be networked. The Kerberos or NTLM protocol is utilized to authenticate domain accounts.

The Kerberos protocol is more secure than NTLM and is thus the recommended protocol in an AD domain environment. However, NTLM support is maintained. Direct use of the Kerberos and NTLM SSPs is not advised; instead, they should be accessed through the Negotiate security package, which automatically opts for Kerberos unless it is unsuitable for the systems involved in the authentication exchange.

Once the user completes the interactive logon, a network logon process authenticates the user's identity to the network service they wish to use. Typically, this process is transparent to the user, as the system reuses the credentials already provided, delivering a seamless Single Sign-On (SSO) experience for supported applications.

Figure 4.2 presents a simplified representation of these authentication mechanisms. It illustrates different logon scenarios: a) using a local account (blue path); b) using a domain account with NTLM (red path) and Kerberos (green path) protocols.

### 4.2.1 NTLM

NT LAN Manager (NTLM) is an authentication protocol series developed by Microsoft for Windows environments. These protocols employ a challenge/response mechanism to authenticate client and server interactions. Throughout Windows OS history, NTLM has developed, with its latest iteration, NTLMv2, being in use since Windows 2000.

While Kerberos has largely superseded NTLM as the favored authentication method, NTLM remains in use, particularly for authentication involving stand-alone systems or those that are part of a workgroup rather than an Active Directory domain. NTLM is also the fallback option when Kerberos authentication is not feasible, such as under circumstances where:

- A party involved in the authentication process lacks Kerberos capability,
- The server hasn't been incorporated into an AD domain,
- Kerberos hasn't been configured correctly,
- NTLM is explicitly selected over Kerberos.

When a resource server requires authentication verification for a computer or user, it will either: Reach out to a domain authentication service on the Domain Controller (DC) if a domain account is being used.

Verify the account against a local account database if a local account is being accessed.

Since domain account credentials are managed by the DC, it is the only entity that can validate these credentials and finalize the authentication process. Resource servers engage with the DC through the Netlogon Remote Protocol, a method also referred to as NTLM pass-through authentication.

NTLM authentication is applicable in both interactive logon and network logon scenarios. The standard authentication sequence, as detailed by Microsoft, involves a domain user accessing a service on a resource server. This sequence is visualized in Figure 4.3.

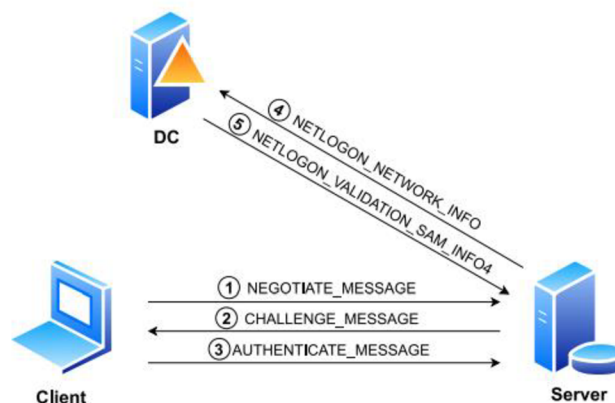


Figure 4.3 NTLM authentication

1. When a user logs onto their client workstation, they start by entering their username and password. The client machine then creates an NTLM hash from the entered password and discards the actual password itself. To begin the authentication process, the client sends a NEGOTIATE MESSAGE to the server. This message not only communicates NTLM options but also includes the name of the client workstation and the domain name. The server uses the domain name to decide if the client should go through local or domain authentication.

2. In response, the server generates a random numerical value, known as a nonce, and forwards it to the client within a CHALLENGE MESSAGE.
3. The client takes this challenge and encrypts it using the NTLM password hash, then sends this encrypted information back to the server within an AUTHENTICATE MESSAGE. This message also contains the username of the account attempting authentication and the name of the client workstation.
4. Upon receiving the client's response, the server passes it along to the Domain Controller (DC), accompanied by the challenge it had previously sent to the client, packaged as a NETLOGON NETWORK INFO message.
5. Using the provided username, the DC retrieves the corresponding user password hash from the Active Directory database. The DC then encrypts the challenge using this hash and checks if it matches the client's encrypted response. This comparison's outcome is sent back to the server within a NETLOGON VALIDATION SAM INFO4 message. If the authentication checks out, this message includes the user's Privilege Account Certificate (PAC), which contains the authorization details. With this information, the server can then proceed with making authorization determinations.

## 4.2.2 Kerberos

Kerberos is an authentication protocol that ensures secure and mutual authentication between parties on a network that may not be secure. Initially created by MIT for Project Athena, the protocol drew upon the Needham-Schroeder authentication protocol, incorporating enhancements recommended by Denning and Sacco. A key benefit of Kerberos is its ability to facilitate Single Sign-On (SSO). The modern iteration, Kerberos version 5, is detailed in RFC 4120, which supersedes the previous RFC 1510.

Microsoft incorporated Kerberos v5 into Windows 2000 (initially based on RFC 1510) with the intention of replacing NTLM authentication within Active Directory (AD) domains. In 2006, updates were made to align with RFC 4120. Microsoft's version of Kerberos introduces unique elements and additional features that aren't outlined in the RFC specifications. These include aspects of authorization, a distinctive approach to the Security Support Provider (SSP) interface, and the optional validation of the Privilege Account Certificate (PAC).

The upcoming sections, informed by RFC 4120 [11] and Microsoft's documentation, are designed to offer a straightforward understanding of the Kerberos protocol, with an emphasis on its role in AD authentication. This overview is supplemented by the authentication flowchart depicted in figure 4.4.



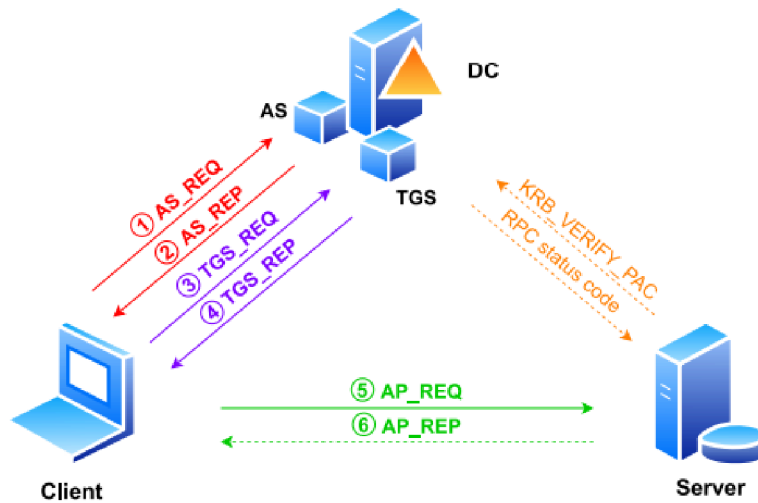


Figure 4.4 Kerberos authentication

Kerberos involves three subsidiary protocols, or exchanges:

- Authentication Service (AS) exchange,
- Ticket-Granting Service (TGS) exchange,
- Client/Server exchange.

Within Microsoft's framework, the Key Distribution Center (KDC) operates as a domain service on the domain controller. It utilizes AD as its account database to carry out two key roles: the Authentication Service and the Ticket-Granting Service. Hence, both the AS and TGS exchanges transpire between a client and the DC, as illustrated in figure 1.4.

The AS exchange is typically performed at the start of a user session, like when the Local Security Authority (LSA) service verifies a user's domain credentials at logon. In this process, the client not only authenticates itself but also acquires credentials for the TGS. These credentials are essential for network logon, as they're used when the client seeks access to additional servers.

1. The client initiates contact by sending an AS REQ message to the KDC's Authentication Service. This message contains the client's identity, the targeted Ticket-Granting Service (TGS), and pre-authentication data, which is essentially a timestamp encrypted with a master key derived from the user's login password.

2. Upon receiving the AS REQ, the KDC locates the user in the Active Directory database and decrypts the pre-authentication data to verify the timestamp. A valid timestamp confirms the client's authenticity. Subsequently, the KDC produces two copies of the logon session key: one encrypted with the user's master key and the other enclosed within a Ticket-Granting Ticket

(TGT), which includes authorization details and is encrypted with the KDC's master key, originating from its KRBTGT account. These credentials are delivered to the client within an AS-REP message. The client then retrieves the TGT and session key, caching them for later use.

After the AS exchange, the client possesses a TGT, which is presented to the KDC to request tickets to access specific services during the TGS exchange. The TGT, which includes a PAC detailing the user's security group memberships, is encrypted and signed by the KRBTGT account, ensuring only the KDC can decrypt and access the contents. The TGT is reusable and generally expires after 10 hours, subject to renewal.

3. Next, the client requests a specific service by sending a TGS REQ message to the KDC, which includes the service's identity, an authenticator encrypted with the user's logon session key, and the TGT.

4. The KDC decrypts the TGT with its private key to retrieve the logon session key, which it then uses to decrypt the authenticator. Once validated, the KDC generates a session key for the client to communicate with the desired service. It sends one encrypted copy of this service session key to the client, while embedding another within a Service-Granting Ticket (SGT) that also contains the user's authorization data. The SGT is encrypted with the service's master key. The KDC returns this data to the client in a TGS REP message. The client decrypts the service session key using its logon session key and caches the credentials

If the TGS exchange is successful, the client secures an SGT, which it uses to gain access to the service during the Client/Server exchange.

5. The client then communicates with the server of the intended service by sending an AP REQ message. This message contains an authenticator encrypted with the service session key from the KDC, the SGT, and an optional flag indicating whether mutual authentication is requested.

6. The server decrypts the ticket to access the user's group membership information and the session key, which it uses to verify the authenticator. Now equipped to authorize the user, the server, if mutual authentication was sought, encrypts the current time from the user's authenticator and sends it back to the client in an AP REP message.

Optionally, during the Client/Server exchange, the server might verify the user's group membership by forwarding the PAC from the SGT to a DC in a KERB VERIFY PAC message. The DC checks the signature and responds with a Remote Procedure Call (RPC) status code, confirming the validity of the user's group memberships. The server then completes the process by sending an AP REP message to the client.

In step 3, when the client sends the TGS REQ (requesting access to a service), it specifies the service instance using a Service Principal Name (SPN) registered in Active Directory. Each SPN, which identifies a service instance for Kerberos authentication, must be registered with only one account.

An SPN follows the format: ``<svc_class>/<host>[:<port>[/<svc_name>]]``, where ``<svc_class>`` specifies the service type, ``<host>`` is the computer hosting the service, often by its Fully Qualified Domain Name (FQDN), a port number may distinguish multiple instances of the service on one machine, and ``<svc_name>`` is used for services that can be replicated. Common SPN examples include ``MSSQLSvc/db01.example.com:1433`` for a SQL service or ``TERMSERV/server1.example.com`` for a terminal service.

# Chapter 5- SIEM Use Cases for Common AD Attack vectors in Splunk

## SIEM

Security Information and Event Management (SIEM) represents an integrated approach to ensuring network security, merging the functionalities of security information management (SIM) and security event management (SEM). SIEM solutions aggregate, scrutinize, and correlate security-relevant data from diverse sources, offering instantaneous insights into network operations and facilitating prompt reaction to incidents. This section explores SIEM, outlining its key features, advantages, and obstacles as discussed by Johnson, A. (2023) in the Network Security Journal.

### 5.1 SIEM Components

SIEM architectures are built on several essential elements that collectively enhance security monitoring and management across the network.

These elements encompass:

**Data Collection:** SIEM solutions amass data from a variety of entities, including network hardware, security systems, operating systems, and applications. This data, which might comprise log files, event records, and flow data, is centralized within a SIEM system for subsequent analysis.

**Log Management:** This aspect pertains to the accumulation, preservation, and examination of log information sourced from various network elements. SIEM tools extract logs from servers, network devices, and firewalls, offering critical insights into network behavior, user actions, and potential security threats.

**Event Correlation and Analysis:** SIEM solutions scrutinize and correlate gathered data to pinpoint patterns, deviations, and possible security incidents. Utilizing advanced analytics, such as statistical methods, rule-based correlations, and machine learning, SIEM tools can identify and prioritize security events by their significance and potential impact, as highlighted by Miller, E. (2023) in the Cybersecurity Review.

**Alerting and Notification:** Upon identifying potential security threats, SIEM systems alert security personnel through notifications. These alerts, generated based on preset criteria,

thresholds, or anomaly detection algorithms, enable swift incident responses, thus helping security teams to address and neutralize threats efficiently, as noted by Johnson, S. (2023) in the Network Alerting Techniques journal.

**Incident Response and Workflow:** SIEM platforms facilitate incident response through workflow automation and tools that enhance coordination among security teams. These workflows may incorporate ticketing systems, escalation protocols, and case management to streamline the incident resolution process.

**Reporting and Compliance:** SIEM tools also offer reporting functions for creating security and compliance reports. These reports detail network behavior, security incidents, and adherence to compliance standards, aiding organizations in meeting regulatory obligations like PCI DSS and GDPR, as discussed by Wilson, F. (2023) in the Historical Data Reporting Quarterly.

## 5.2 Implementing Splunk for Enhanced Security Intelligence: A Technical Exploration

In the current digital age, the sophistication of cyber threats has escalated, prompting organizations to prioritize their cybersecurity measures. Central to these measures is the implementation of Security Information and Event Management (SIEM) systems, which offer a holistic view of an organization's information security. SIEM systems collect and aggregate log data produced by various sources within the IT environment, analyze the data to identify deviations from the norm, and generate alerts for potential security incidents.

Among the plethora of SIEM solutions available, Splunk has emerged as a leader, distinguished by its versatility and powerful data processing capabilities. This essay delves into the deployment of Splunk within an organizational context, emphasizing its pivotal role in enhancing cybersecurity posture through effective data analysis and real-time monitoring.

### Understanding Splunk's Framework:

Splunk's platform is designed to ingest and index voluminous data from various sources, including logs, network traffic, and cloud environments, making it searchable and actionable. At its core, Splunk provides insights into data patterns, enabling organizations to detect anomalies, monitor trends, and respond to incidents with greater agility.

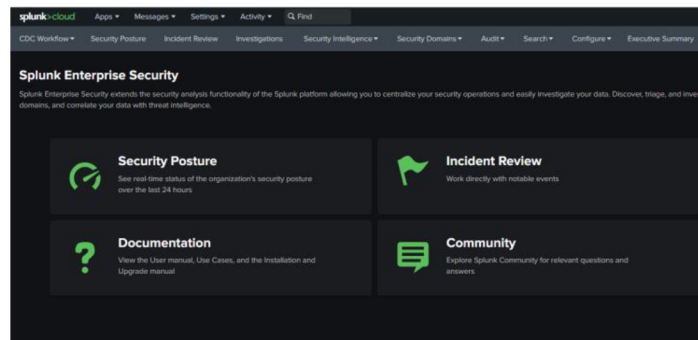


Figure 5.1 Splunk Cloud interface

### Deployment Strategies for Splunk:

Deploying Splunk in an organizational setting involves several strategic considerations, ensuring that the installation aligns with specific security objectives and IT infrastructure requirements. Key deployment phases include:

**Planning and Requirements Gathering:** This initial phase involves identifying the data sources, defining the security and operational monitoring needs, and assessing the infrastructure capacity to support Splunk deployment.



Figure 5.2 Indexing and search architecture

**Installation and Configuration:** Following the planning phase, Splunk software is installed on designated servers or cloud environments. This stage involves configuring Splunk to collect data from identified sources, ensuring comprehensive coverage of the IT landscape.

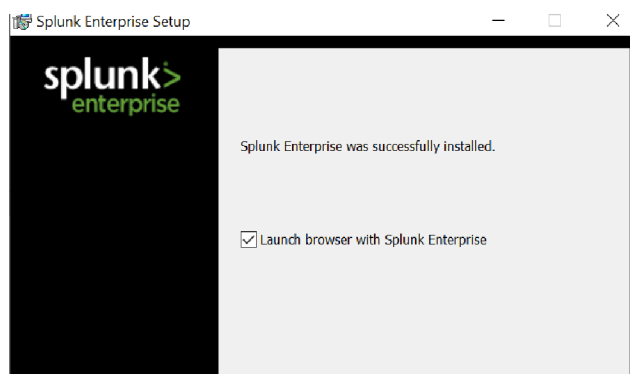
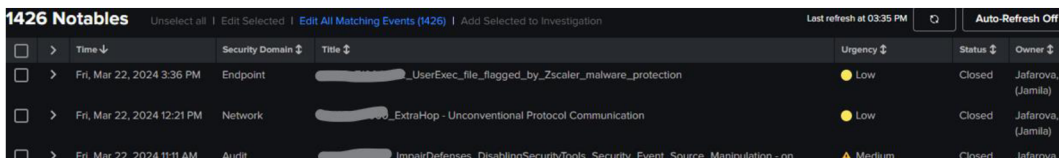


Figure 5.3 Splunk agent installment

**Data Indexing and Search Setup:** With Splunk installed, the focus shifts to indexing collected data, enabling efficient search and analysis. Setting up tailored searches and alerts to detect specific security threats or operational issues is crucial.

**Leveraging Splunk for Enhanced Security Monitoring:** Splunk excels in providing deep insights into security-related data, facilitating the early detection of threats and vulnerabilities.

**Real-time Threat Detection:** Splunk’s real-time processing allows organizations to detect and respond to threats as they occur, minimizing potential damage.



Time	Security Domain	Title	Urgency	Status	Owner
Fri, Mar 22, 2024 3:36 PM	Endpoint	..._UserExec_file_flagged_by_Zscaler_malware_protection	Low	Closed	Jafarova, (Jamila)
Fri, Mar 22, 2024 12:21 PM	Network	..._ExtraHop - Unconventional Protocol Communication	Low	Closed	Jafarova, (Jamila)
Fri, Mar 22, 2024 11:11 AM	Audit	...ImpairDefenses_DisablingSecurityTools_Security_Event_Source_Manipulation - on	Medium	Closed	Jafarova

Figure 5.4 Incident Review page

**Compliance and Auditing:** With pre-built templates and customizable reports, Splunk aids organizations in maintaining compliance with regulatory standards and conducting audits more efficiently.

**Advanced Analytics and Machine Learning:** Splunk employs advanced analytics and machine learning algorithms to predict potential security breaches, enabling proactive defense mechanisms.

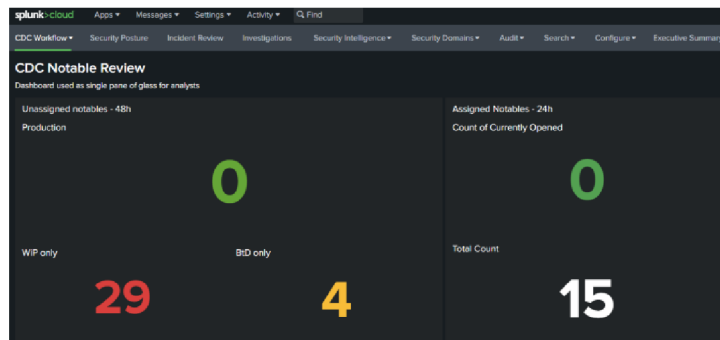


Figure 5.5 Splunk Dashboard

To maximize the benefits of Splunk deployment, organizations should adhere to best practices, including:

**Scalable Architecture Design:** Designing a scalable Splunk architecture ensures that the system can adapt to growing data volumes and evolving security needs.



**Regular Updates and Maintenance:** Keeping Splunk and its data sources updated is vital for maintaining optimal performance and security.

**Comprehensive Training and Support:** Investing in training for IT and security teams enhances the effectiveness of Splunk deployment, empowering staff to leverage its full potential.

Deploying Splunk within an organization's SIEM framework marks a significant stride towards achieving a robust cybersecurity posture. Through strategic planning, meticulous implementation, and adherence to best practices, Splunk unlocks unparalleled insights into security and operational data. As cyber threats continue to evolve, Splunk remains an indispensable ally in the quest for a secure, resilient IT environment.

# Chapter 6-Splunk use cases with AD attack vectors

## 6.1 Kerberoasting attack analyses

Kerberoasting is an attack method that targets service account credentials within a domain environment, potentially leading to elevated privileges. A service account refers to a regular user account that's configured to execute a service or a scheduled task. Notably, executing this attack doesn't require any specific local or domain-level permissions. The attack hinges on requesting a Ticket Granting Service (TGS) ticket, which contains a signature using the service's hash, and then attempting to crack the service's password offline. This approach ensures that account lockouts are avoided. The primary objective of an attacker is to identify user accounts, rather than computer accounts, with Service Principal Names (SPN) registered in Active Directory (AD) since user account passwords may be easier to crack.

For detection purposes, it's crucial to monitor for atypical patterns of service ticket requests within the domain. We employ the Local Outlier Factor (LOF) machine learning algorithm for anomaly detection, focusing on identifying an abnormal volume of ticket requests for services that are unusual for the requestor.

Upon a user's authentication into the domain, they receive a Ticket Granting Ticket (TGT), signed by the domain's krbtgt account, which is then used to request a TGS for a specific domain service or resource. A portion of the TGS is encrypted with the NTLM hash of the service account. SPNs serve to uniquely identify which NTLM service account hash should encrypt the TGS service ticket, and from the perspective of Kerberoasting, SPNs registered to domain user accounts are of interest because they might utilize weaker passwords.

Adversaries can request one or more TGS tickets for any SPN from the Domain Controller (DC), with portions of these tickets possibly being encrypted with weaker algorithms such as RC4 or DES. This makes the hash of the service account associated with the SPN vulnerable to offline brute force attacks, potentially revealing plaintext credentials without triggering account lockouts.

Kerberos service ticket requests are recorded in Windows Event ID 4769, indicating that a Kerberos service ticket has been requested. Our detection strategy is based on analyzing this event for excessive requests for different services within a short timeframe by the same user, especially when weak encryption is used.

Detecting the Kerberoasting technique involves distinguishing between normal and unusual patterns of service ticket requests. The LOF machine learning algorithm is utilized for this purpose, leveraging its ability to identify anomalies based on local density comparisons without the need for prior model training. The algorithm calculates densities using the distance of an object to its nearest neighbors, comparing an object's density to those of its neighbors to pinpoint anomalies or similarities.

This SPL (Search Processing Language) query is designed to detect potential Kerberoasting attacks by analyzing Windows security events, specifically Event ID 4769. Kerberoasting is an exploit method targeting Kerberos authentication, and Event ID 4769 logs Kerberos service ticket requests, making it a valuable data point for detection. Below is a breakdown of the query's components and modifications to ensure confidentiality:

```
index=windows_security EventCode=4769
| stats count by ServiceName, ClientAddress, TicketOptions
| where count > 100
| sort - count
| eval ServiceAccount = mindex(split(ServiceName, "@"), 0)
| lookup Account_Info ServiceAccount OUTPUT AccountType
| where AccountType="Service Account"
| table _time, ServiceAccount, ClientAddress, count
```

### **Final Filtering and Annotation:**

This SPL query meticulously sifts through Event ID 4769 logs to pinpoint unusual Kerberos service ticket request patterns indicative of Kerberoasting attempts. By leveraging anomaly detection algorithms and categorizing user and service types, the query aids in identifying potential security incidents for further investigation.

## **6.2 Password Spraying Technique**

Password spraying involves attempting to access domain user accounts by testing commonly used passwords against them. Attackers typically employ well-known password lists, such as RockYou, for this purpose. The strategy involves trying a single password against all user accounts within a domain. To evade detection and prevent account lockouts, attackers incorporate intervals between attempts with different passwords.

### **Usecase Status:**

This detection technique is highly reliable, though its effectiveness can be enhanced by tracking event 4648 across user workstations or servers.

### **Explanation:**

In a password spraying attack, the attacker systematically tries a single password against numerous user accounts. A typical preliminary step involves reviewing the user policies within the domain to understand the account lockout thresholds and adjust the attack strategy accordingly. Detection mechanisms rely on observing multiple failed authentication attempts originating from a single source and targeting various users.

### **SPL Query Paraphrase:**

This SPL (Search Processing Language) query is designed to identify patterns indicative of a password spraying attack by monitoring for a series of failed authentication attempts. It encompasses Windows security logs and, optionally, Linux secure logs, focusing on events that signal authentication failures.

```
(`windows_security` OR `linux_secure`) (EventCode=4625 OR EventCode=4771 OR signature_id=411 OR tag::uc002_password_spray OR signature="authentication failure" action=failure src=$src$) OR (src=$src$ action=success user!=$*)  
| eval FullName=user_first." ".user_last  
| fillnull value="N/A" FullName  
| bin _time span=10m  
| dedup user_time  
| stats max(_time) as max_time min(_time) as min_time sparkline as "No. Attempts" count list(user) as "User"  
list(FullName) as "Full Name" by src action  
| eval `strftime(max_time)`, `strftime(min_time)`
```

- The query filters for relevant event codes associated with authentication failures across Windows and Linux platforms.
- It constructs the full name of users from first and last names and assigns a placeholder value where names are absent.
- The data is binned in 10-minute intervals to group activity within manageable timeframes.
- It employs deduplication to eliminate repeated user attempts within each interval.
- The query aggregates data to present the earliest and latest attempt times, compiles a trend of attempts, and lists affected users by source and outcome.
- Finally, it formats time values for clearer interpretation.

By analyzing patterns of failed login attempts distributed across multiple users from a single origin, the query aids in pinpointing unusual activity that may suggest a password spraying attempt, thereby facilitating timely investigative and remedial actions.

## 6.3 Brute-force- Too Many Wrong Passwords

In cybersecurity efforts, adversaries often engage in brute force login attempts, lacking knowledge of specific passwords or hashes. They may employ a zero-knowledge approach or try a series of known or possible passwords. Such actions inherently carry a higher risk due to the potential for triggering multiple authentication failures, which can vary based on an organization's login failure policy. This particular detection rule is designed to identify brute force attempts by aggregating authentication data tagged with "wrong\_password" or marked with action=success, excluding instances of expired account authentications and computer account activities.

Next Steps for Consideration:

- **Analyzing Failed Authentication Sequences:** Determine the frequency of failed authentication attempts to identify recurring patterns.
- **Filtering Specific Server Types:** Exclude servers such as Mail Delivery Agents (MDAs), proxy servers, etc., from the analysis.
- **Identifying Major Contributors:** Focus on events like EID 4776 to analyze the primary sources of authentication failures.

Explanation:

This criterion filters events from the Authentication Data Model (DM), specifically those tagged with "wrong\_password" or with an action marked as success, thus excluding authentication attempts involving expired accounts or computer accounts. The approach involves performing several calculations to identify indicators that could signify a brute force attack pattern.

SPL Query Creation and Partial Explanation:

```
index=auth_data_model tag="wrong_password" OR action=success NOT (user="*$" OR src="MDA" OR src="proxy")
| eval auth_failure=if(tag="wrong_password",1,0), auth_success=if(action="success",1,0)
| stats count(eval(auth_failure=1)) as Failed_Logins, count(eval(auth_success=1)) as Successful_Logins by user, src
| where Failed_Logins > Threshold_Value
| sort - Failed_Logins
| lookup account_policy_lookup user OUTPUT password_policy
| eval Compliance=if(Failed_Logins > password_policy, "Non-Compliant", "Compliant")
```

- The query begins by selecting authentication events from the specified data model, focusing on those associated with wrong passwords or successful actions, while excluding computer accounts and specific server types.
- It then classifies authentication attempts into failures and successes based on the event tags and actions.

- A statistical computation counts the number of failed and successful logins for each user and source.
- It filters out users based on a predefined threshold for failed logins to highlight potential brute force activities.

The query incorporates a lookup to compare against an organization's password policy, determining compliance based on the number of failed login attempts.

This SPL search is aimed at detecting patterns consistent with brute force attacks, enabling cybersecurity teams to pinpoint potential threats and assess compliance with established password policies. The query's design facilitates a nuanced analysis of authentication failures, aiding in the proactive management of security risks associated with brute force login attempts.

## Chapter 7-Social engineering

## 7.1 Social Engineering Research Overview

Academic exploration into social engineering remains somewhat sparse, with a significant portion of existing research focusing on phishing, a prevalent method of social engineering. Lena Larabee contributed to the field by creating a taxonomy of social engineering, analyzing narratives of social engineering incidents recounted by Kevin Mitnick. It appears that a common approach among researchers discussing social engineering involves examining industry trends or recounting experiences from individuals who identify themselves as social engineers. Nathaniel Joseph Evans furthered academic discourse by offering a scholarly definition of social engineering and delving into the human susceptibilities that social engineers exploit. However, Evans' work primarily outlines the reasons behind human susceptibility to such exploits, without providing detailed strategies or recommendations for mitigating this inherent vulnerability.

## 7.2 Phishing

Phishing ranks among the top tactics utilized by perpetrators of social engineering. Its purpose ranges from collecting vital data for extensive cyber operations (such as obtaining login credentials to access an organization's confidential systems) to constituting the entire scope of an attack (for instance, capturing credit card details).

Cybercriminals employ numerous phishing techniques, with several notable types highlighted below:

**Deceptive Phishing:** This method involves sending widespread emails that prompt recipients to act, such as by clicking on a link. The urgencies cited in these emails typically relate to issues at familiar institutions (e.g., PayPal or banks) or exclusive offers for new services under a purportedly limited-time deal.

**Spear Phishing:** In contrast to the broad approach of deceptive phishing, spear phishing targets specific individuals or entities. The phishing emails are meticulously crafted to appear as though sent by a trusted contact within the organization or a legitimate external source, aiming to deceive the recipient into disclosing personal information.

**Content-Injection Phishing:** This strategy sees phishers injecting harmful content into legitimate websites, directing users to the phisher's chosen site, deploying malware, or capturing user-entered data on the genuine site. Techniques such as cross-site scripting and

SQL injection are commonly employed to execute this type of phishing, exploiting web application vulnerabilities.

### 7.2.1 Anatomy of a Phishing Attack

Phishing operations typically share three core components:

(1) the lure, (2) the hook, and (3) the catch.

**The Lure:** Phishers disseminate bulk emails containing compelling narratives that convince users to follow a URL link within the email, leading to a phisher-controlled website. The "lure" capitalizes on social engineering to make the pretext appear legitimate enough to persuade users to relinquish confidential information, often under the guise of a reputable organization urgently requiring account updates or offering enticing incentives.

**The Hook:** The counterfeit website the user visits serves as the "hook." This site is painstakingly designed to mirror the real organization's website as closely as possible, tricking users into believing in its authenticity and thus, divulging their sensitive information.

This detailed description provides an alternative phrasing of phishing, exploring its definition, methodologies, and structured components without altering the original content's meaning.

## 7.3 Combat Techniques

Fighting against social engineering requires that solid standard security measures are already established within the organization. It is essential to employ as much technological security as possible to safeguard the hardware, software, and network infrastructures. This can encompass a variety of defenses including the use of cryptography, secure communication protocols, firewalls, antivirus software, and more.

Social engineering countermeasures are an additional layer of security that complements the computer security measures already in place. These countermeasures are specifically designed to secure the human element within the system. As noted by computer security specialist Bruce Schneier, even with the most advanced computer security measures, a computer system will eventually need to interact with humans. This interaction poses the greatest security risk. People are often the weakest link in the security chain, frequently leading to the failure of security systems due to human error or oversight.

Special countermeasures against social engineering are targeted at the vulnerabilities present in users, exploiting their natural tendencies to trust and be helpful. A social engineer bypasses



all forms of technological security including cryptography, computer security, and network security, directly targeting the most vulnerable part of any security system - the human being trying to complete their work and willing to assist others.

Considering that social engineering attacks comprise both physical and psychological aspects, combat strategies against such attacks require actions on both levels. Douglas P. Twitchell, an assistant professor at Illinois State University and a researcher in information assurance and security, outlines three commonly suggested defenses against social engineering attacks: (1) education, training, and awareness (ETA), (2) policy supported by (3) auditing.

Suggested methods for combating social engineering include changing the organization's security culture and applying human-computer interaction (HCI) principles to create security that is both effective and user-friendly. Security that is difficult to use makes it more likely for users to attempt to bypass it or to assist someone else in bypassing it.

## 7.4 Usable Security

The most robust security in the world becomes ineffective if it is not user-friendly. If security measures are too difficult to use or frustrate users, they simply will not be utilized. Security expert Bruce Schneier emphasizes that a smart security designer understands that users find security measures to be intrusive and will seek ways to circumvent them at every opportunity. Social engineers exploit this knowledge. Schneier further explains that when under the pressure of deadlines, people often bypass security without a second thought. They might prop open a fire door for easier access into a building or share their password to get work done more efficiently. Applying existing knowledge of HCI to the usability issues within security settings can help in creating security measures that are both effective and user-friendly.

## 7.5 Security Measures at Premium InsureTech

At Premium InsureTech, formulating and enforcing transparent, precise security policies tailored to counteract social engineering is imperative. Echoing security expert Bruce Schneier's perspective, a well-defined security policy is foundational for selecting and implementing defensive strategies against these threats. Such a policy is instrumental in instructing Premium InsureTech employees on the appropriate response to social engineering attempts. It delineates roles (covering implementation, enforcement, auditing, and review), elucidates core network security protocols, and rationalizes their necessity. A policy characterized by clarity, coherence, and consistency significantly enhances adherence among our workforce.

### 7.5.1 Education and Training at Premium InsureTech

Educating and training our team about the dangers and tactics of social engineering is fundamental at Premium InsureTech. Our training modules delve into the essence of social engineering, the modus operandi of social engineers, its repercussions for both the company and individuals, and the procedural response to suspected incidents. This educational initiative underscores the rationale behind our security policies, heightening awareness of the associated risks and arming employees with the knowledge to identify social engineering schemes. It's essential for our staff to grasp the significance of the security guidelines we've established.

### 7.5.2 Culture at Premium InsureTech

Furthermore, instilling a belief in the importance of security protocols and recognizing the pivotal role each employee plays in their enforcement is critical within our organization. The process of securing Premium InsureTech integrates every facet of security, from technical safeguards to user interfaces, training programs, and alignment with the company's operational ethos. Promoting a culture where security is a collective responsibility significantly bolsters the likelihood of observance of security protocols, creating a united front against security threats.

### 7.5.3 Auditing at Premium InsureTech

Following the implementation of security protocols and comprehensive staff training, Premium InsureTech remains committed to ensuring our defenses remain robust through continuous auditing. This involves periodic evaluations of our security apparatus to confirm its compliance with high standards and the orchestration of simulated social engineering scenarios to assess our preparedness. Such diligent auditing and testing are cornerstones in upholding the efficacy of our security measures, keeping Premium InsureTech fortified against the evolving landscape of social engineering threats.

## 7.6 Social Engineering, Phishing, and Financial Institutions

For Premium InsureTech, focusing on social engineering and phishing attacks is crucial, especially considering the vulnerability of financial institutions to such threats. Financial services have consistently been the primary target for phishing attacks, with a significant portion of phishing attempts aimed at this sector. The Anti-Phishing Working Group's report from the second quarter of 2012 highlights that thirty-four percent of all phishing attacks were directed at financial services, with payment services following closely at thirty-two percent. This data underscores the attractive nature of financial institutions to cybercriminals, given their access to substantial financial assets and sensitive customer information.

Notably, high-profile banks like Chase and Wachovia have experienced successful phishing campaigns, leading to the dissemination of phishing email examples on their websites to raise awareness among their customers. These attacks often involve sophisticated spear phishing and malware strategies, aiming to breach security through targeted manipulation of individuals within these organizations. Michael Murray, of MAD Security, emphasizes that the shift in attack vectors from web applications to exploiting human vulnerabilities through phishing underscores the importance of addressing this threat.

Despite the clear danger that phishing poses to financial institutions, there is a notable lack of academic research focused specifically on understanding and mitigating these attacks within the financial sector. The SANS Institute's report, while addressing the significance of phishing threats and proposing general defensive strategies, indicates a gap in targeted research that could provide more nuanced insights into protecting financial institutions like Premium InsureTech.

Given this backdrop, it is imperative for Premium InsureTech to prioritize the development of robust security measures against social engineering and phishing. The company must not only implement technological safeguards but also engage in comprehensive employee education and training to enhance awareness and resilience against these attacks. By addressing both the technological and human elements of security, Premium InsureTech can fortify its defenses against the sophisticated tactics employed by cybercriminals targeting the financial services industry. This dual focus is essential for safeguarding the company's assets, protecting customer information, and maintaining the trust that is fundamental to its operations in the financial sector.

## 7.7 How we Investigate a phishing attack with the XDR Solution- Microsoft Defender

Initially, we were alerted to the prevention of the 'Phonzy' malware on one endpoint. Upon examining the detection link through Azure, we were able to access a visual representation of the attack as captured by Microsoft Defender.

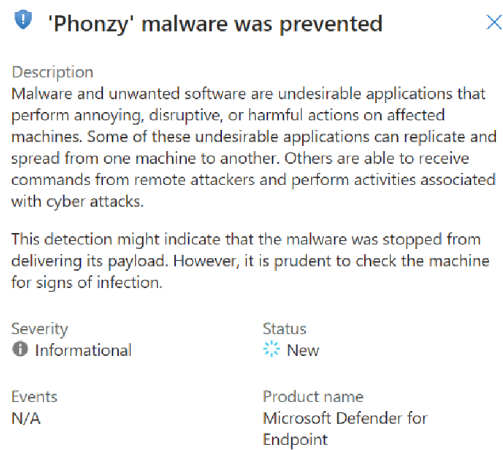


Figure 7.1 Alert description

As the alert occurs, it provides us with brief information about the malware to understand the next steps. It was triggered by the Microsoft Defender agent installed on the endpoint, as represented in Figure 7.1.

In Figure 7.2, we can see the visual details. Three users were affected by the phishing email. The malware was triggered on only one endpoint, which was clicked and downloaded by a certain user. Additionally, the file, which was intended for phishing purposes, is visible.

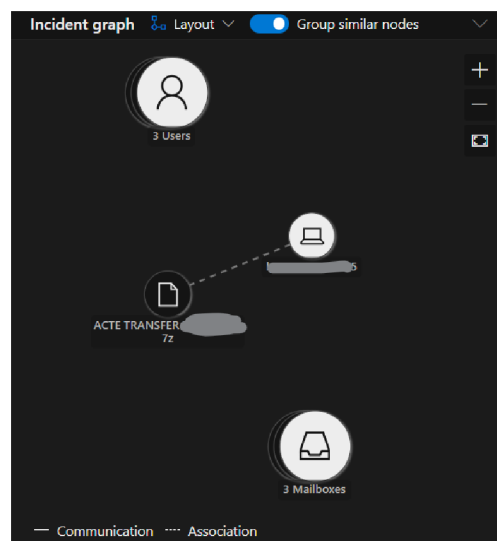


Figure 7.2 Visual description of phishing attack that occurred

We have the possibility to check the file and device details; by checking the device timeline, we can find out how the device was affected by the file and the source and path of this file. By examining the device timeline, we can see the malware occurred via an email received in Outlook, as shown in Figure 7.3.

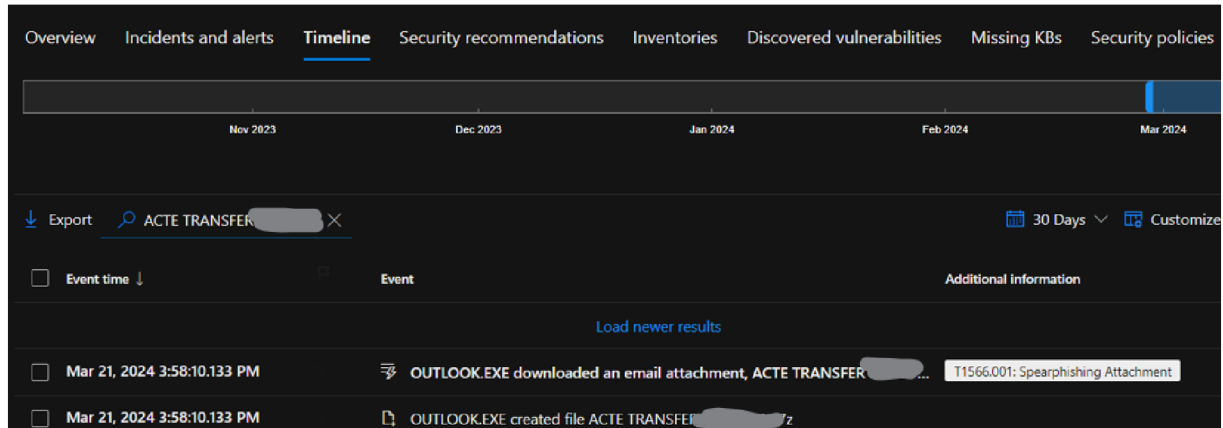


Figure 7.3 Device timeline event occurrence

Root of the event described as “OUTLOOK.EXE downloaded an email attachment “ACTE TRANSFER\*\*\*.7z”, which is shown in Figure 7.4.

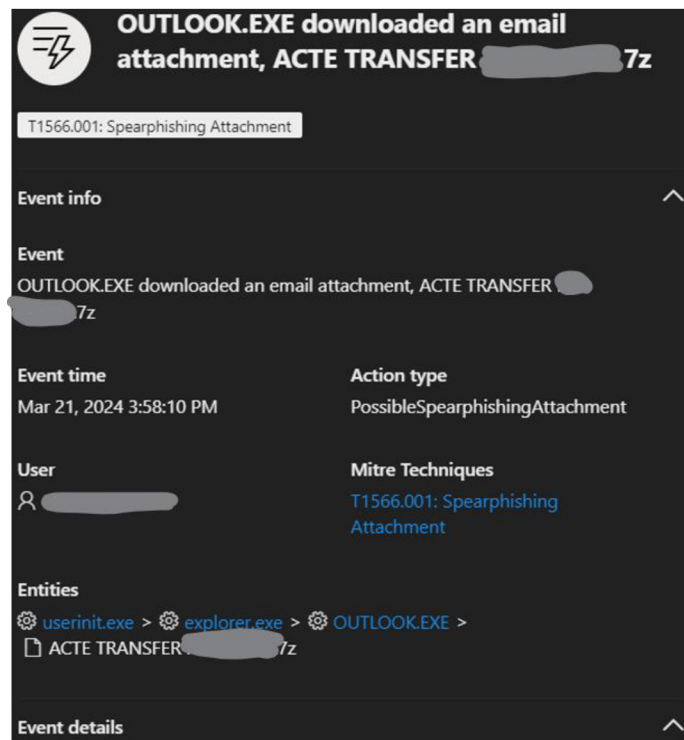


Figure 7.4 Event details

The Defender agent detected the malicious path within the file as it was downloaded seconds before the occurrence of the alert.

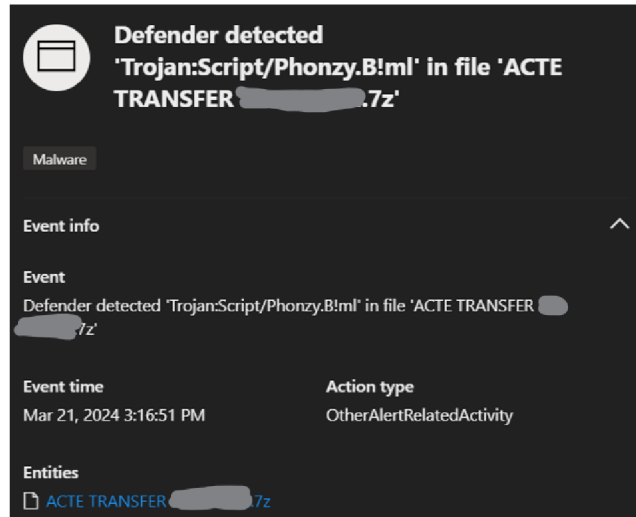


Figure 7.5 Malware detection in attached file

An automatic action, which leads to machine learning applied by the tool, was able to prevent such a file before it reached the analyst. This makes it possible to avoid the risk before it occurs and to act on it with the least risk possible. (Figure 7.5)

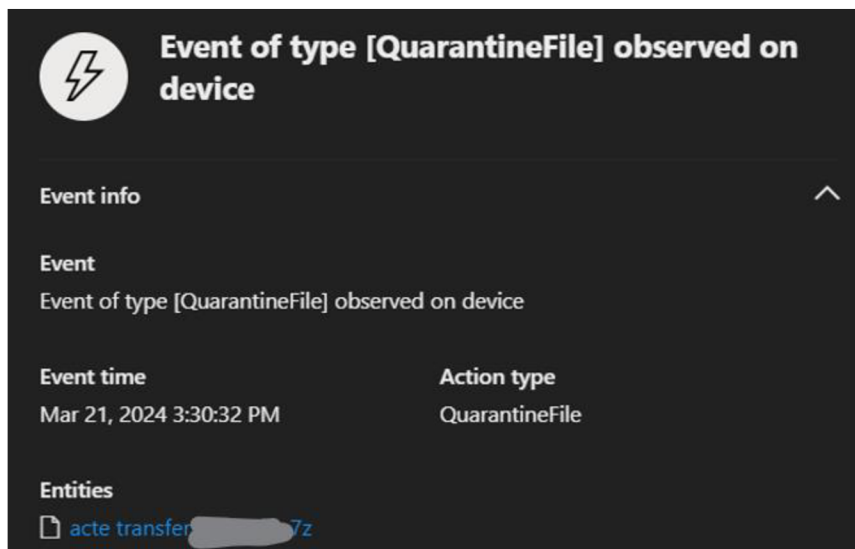
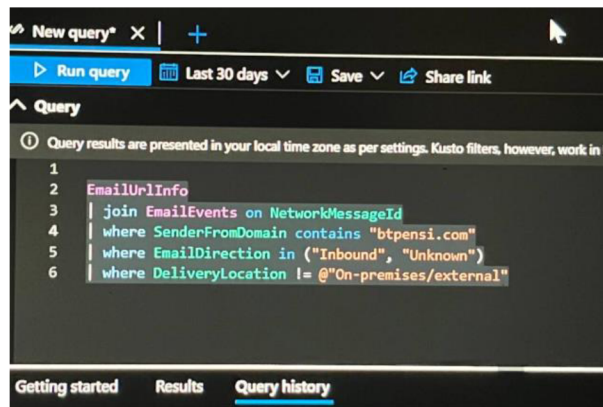


Figure 7.6 File quarantined on endpoint as agent's response

The last step would be checking the device condition, user activities for any anomaly, and most importantly, submitting the phishing email for soft deletion to prevent users from accessing the malicious URL and file again. If a large amount of emails was received from the source and the company

seems to be specifically targeted, then blocking the sender's domain would be a good remediation step as well.



```
New query x | +
Run query Last 30 days Save Share link
Query
Query results are presented in your local time zone as per settings. Kusto filters, however, work in U
1
2 EmailUrlInfo
3 | join EmailEvents on NetworkMessageId
4 | where SenderFromDomain contains "btpensi.com"
5 | where EmailDirection in ("Inbound", "Unknown")
6 | where DeliveryLocation != "@On-premises/external"
```

Figure 7.7 Query to list the phishing emails sent from source

## Conclusion:

The investigation into the 'Phonzy' malware through Microsoft Defender's XDR solution revealed the effectiveness of advanced security measures in identifying and neutralizing phishing threats. Through detailed alerts and visual data analysis, we identified the malware's distribution via email and its activation upon user interaction. The immediate quarantine of the malicious file, enabled by machine learning, prevented further risk, showcasing the capability of our security systems to proactively manage threats. The investigation underscores the importance of continuous monitoring, user education, and strategic responses to safeguard against sophisticated phishing attacks.

## 7.8 Automating the phishing response partially with logic app workflow

In this section, we focus on automating the workflow for responses to phishing attacks, particularly those involving malicious IPs or URL attachments.

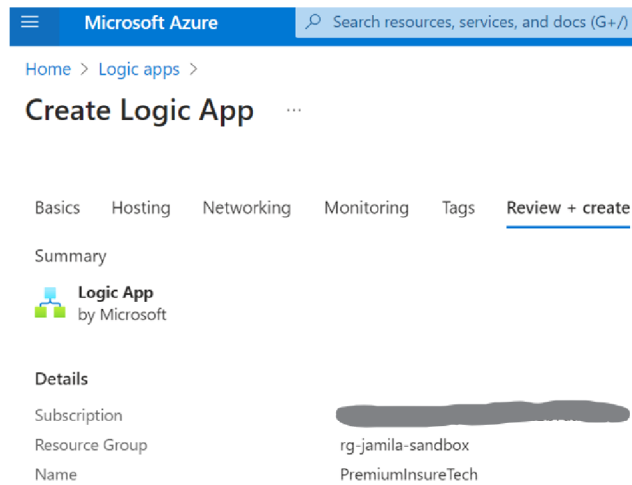


Figure 7.8.1 Creating logic app

The initial step involves creating the logic app, as depicted in Figure 7.8.1. This process's deployment is further illustrated in Figure 7.8.2.

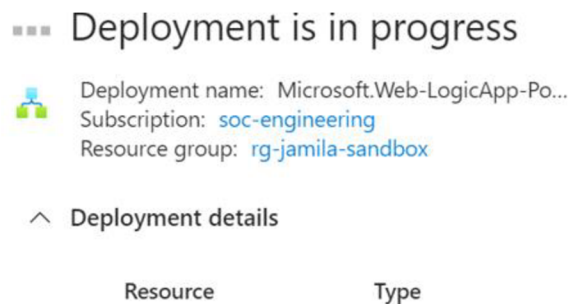


Figure 7.8.2 Deployment process

The deployment process is critical to setting up the logic app for operational use.

A list of previously created logic apps is presented in Figure 7.8.3, showcasing the breadth of available workflows.



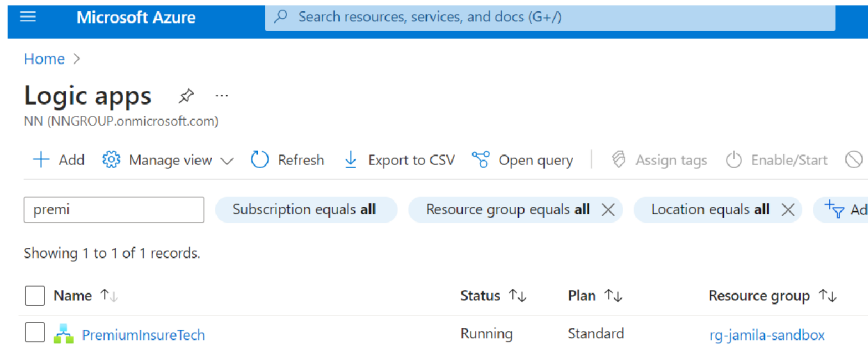


Figure 7.8.3 Logic app list

Details of the logic app specifically developed for the company are shown in Figure 7.8.4, highlighting its configuration and capabilities.

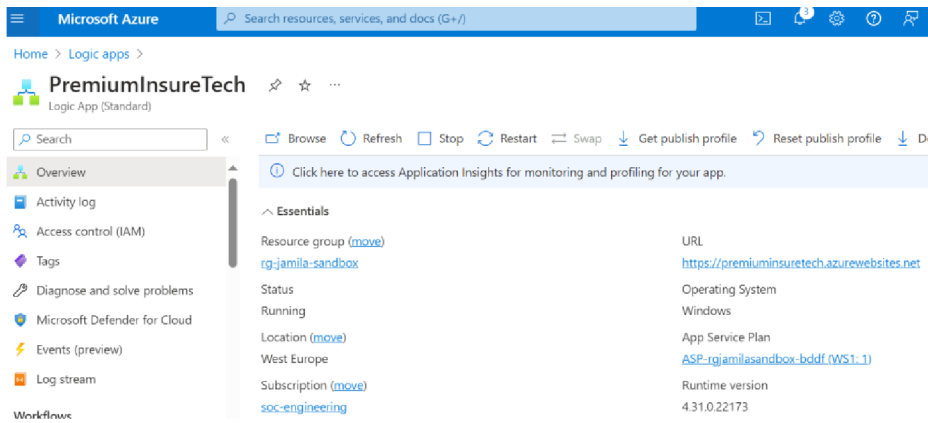


Figure 7.8.4 Logic app details

The development of the workflow, specifically aimed at phishing attack investigations, is the focal point of this section.

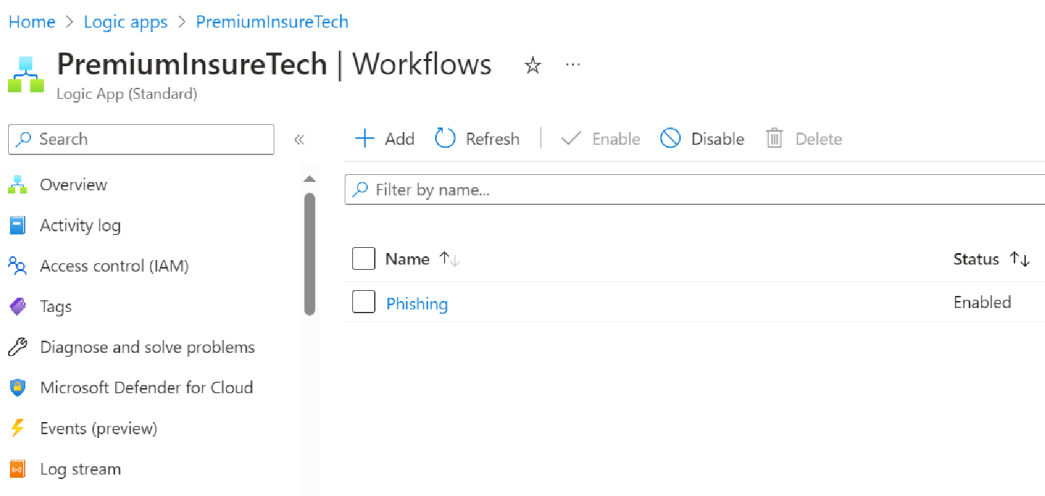


Figure 7.8.5 Creating the workflow for phishing investigation

The workflow begins by incorporating specific inputs into the playbook, as illustrated in Figure 7.8.5. It progresses by analyzing incoming emails, utilizing the "VirusTotal GET URL Report" to determine if an attached URL has a poor reputation.

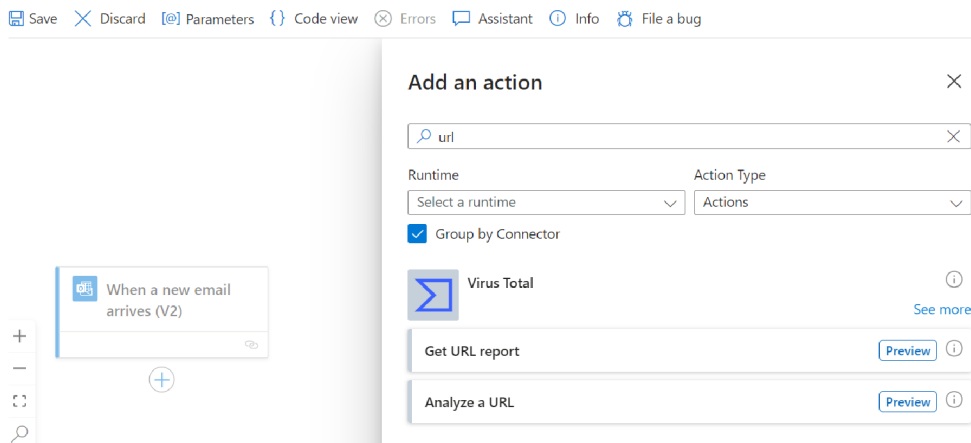


Figure 7.8.6 Workflow initially

The initial setup of the workflow is shown in Figure 7.8.6, starting with the analysis phase and progress. The completed workflow is depicted in Figure 7.8.7. It outlines a process where, in the event a user clicks on a malicious URL from an external email, a user password reset is triggered automatically as a preventive measure through the sequence of actions designed to respond to threats.

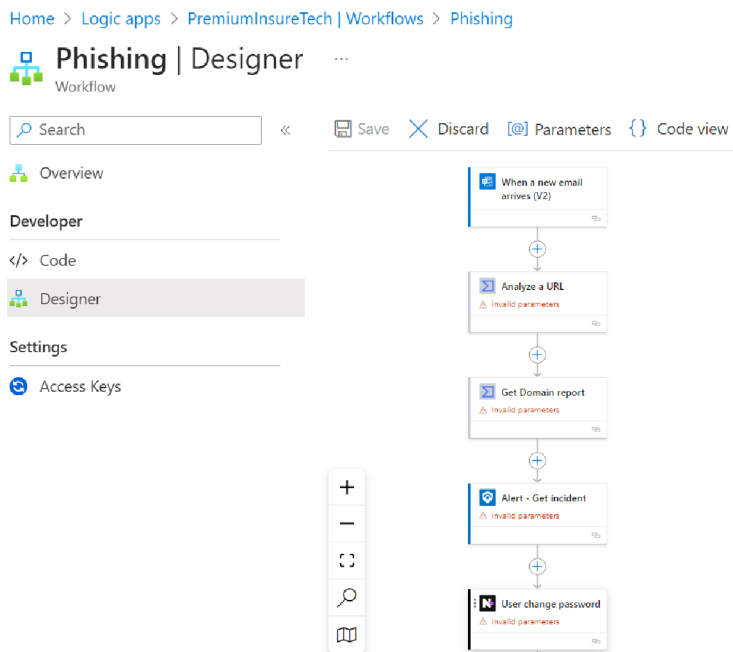


Figure 7.8.7 Playbook workflow details

The automation of the phishing attack response workflow through the creation and implementation of a logic app streamlines the process of identifying and mitigating threats from malicious URLs and IPs. By leveraging tools like VirusTotal for URL reputation checks and incorporating automatic user password resets, the system provides a robust defense mechanism against phishing attacks. This proactive approach enhances the security posture, ensuring rapid response to potential security breaches and maintaining the integrity of the company's digital environment.

# Chapter 9- Strengthening Cybersecurity

## 9.1 The Synergy of Vulnerability Management and SOC Audits

In the contemporary digital era, organizations are increasingly reliant on sophisticated IT infrastructures and cloud services to conduct their operations, making cybersecurity a paramount concern. The amalgamation of Vulnerability Management and System and Organization Controls (SOC) Audits forms a dual framework essential for enhancing an organization's cybersecurity measures. This comprehensive approach not only mitigates the risk of cyber threats but also establishes a robust compliance posture, thereby safeguarding sensitive data and maintaining trust with clients and stakeholders.

### **Deep Dive into Vulnerability Management:**

Vulnerability Management is an indispensable cybersecurity practice focused on the continuous cycle of identifying, assessing, treating, and reporting vulnerabilities within an organization's technology ecosystem. Its primary goal is to fortify the IT infrastructure by preemptively identifying weaknesses that could potentially be exploited by cyber adversaries.

The process involves several critical stages:

**Asset Identification:** Creating a detailed inventory of all IT assets, including hardware, software, and network elements, to ensure complete visibility.

**Vulnerability Assessment:** Utilizing automated tools and technologies to scan for known vulnerabilities within these assets, generating data on potential security gaps.

**Risk Analysis:** Evaluating the identified vulnerabilities to determine their potential impact on the organization, considering factors such as exploitability and the criticality of the affected system.

**Remediation and Mitigation:** Addressing identified vulnerabilities by applying patches, configuring changes, or implementing compensatory controls to reduce risk.

**Documentation and Reporting:** Maintaining records of vulnerabilities, remediation actions, and ongoing risk status to inform stakeholders and guide future cybersecurity strategies.

This proactive and iterative process is not only about fixing vulnerabilities but also about understanding and managing risk. By continuously monitoring and updating the security posture, organizations can adapt to new threats and technological changes, ensuring resilience against cyber attacks.

## 9.2 The Strategic Importance of SOC Audits

SOC Audits are specialized assessments that evaluate the effectiveness of an organization's controls related to the security, availability, processing integrity, confidentiality, and privacy of a system. Conducted by independent auditors, these audits provide a formal validation of the organization's commitment to maintaining a secure and reliable operational environment. The two primary types of SOC reports are:

**SOC 1:** Focused on controls relevant to financial reporting, providing assurance on the financial transactions processed by the service organization.

**SOC 2:** Tailored towards the management of data, assessing the organization's controls around security, availability, processing integrity, confidentiality, and privacy.

A SOC report serves as a credible and neutral evaluation of an organization's control environment, offering assurance to clients, regulators, and other stakeholders about the organization's capability to manage and protect data. The insights garnered from SOC Audits can highlight areas for improvement, driving enhancements in the organization's cybersecurity and operational practices.

## 9.3 Integrating Vulnerability Management with SOC Audits

The integration of Vulnerability Management and SOC Audits offers a holistic approach to cybersecurity, leveraging the strengths of both practices to build a more secure and compliant operational framework. Vulnerability Management's ongoing risk identification and mitigation efforts provide a dynamic foundation for the control environment assessed during SOC Audits. In turn, the findings and recommendations from SOC Audits can inform and refine the Vulnerability Management process, identifying gaps in the organization's cybersecurity practices and guiding targeted improvements.

This synergy ensures that organizations are not only protected against current threats but are also prepared to adapt to future challenges. It fosters a culture of continuous improvement, where security measures are regularly reviewed, updated, and enhanced in response to evolving threats and regulatory requirements. Moreover, this integrated approach demonstrates to clients, regulators, and other stakeholders the organization's dedication to maintaining the highest standards of cybersecurity and compliance.

As a result, the combined implementation of Vulnerability Management and SOC Audits represents a comprehensive and effective strategy for enhancing an organization's cybersecurity posture and compliance capabilities. This integrated framework not only mitigates the risk of cyber threats but also establishes a strong foundation for trust and reliability with clients and stakeholders. By adopting this dual approach, organizations can navigate the complexities of the digital landscape with confidence, ensuring their operations are secure, compliant, and resilient against the myriad of cyber threats they face today and in the future.

## Conclusion

The essence of this research underscores the paramount importance of implementing advanced network security monitoring tools. These tools are not merely technological safeguards but serve as the linchpins for securing corporate networks against the multifaceted threats that lurk within the digital domain. Through meticulous examination and practical application, the thesis presents a cogent argument for the necessity of real-time monitoring and analysis as indispensable elements of an effective cybersecurity defense strategy.

Moreover, the thesis adeptly navigates through the complexities of system configuration, vulnerability auditing, and the critical examination of system and data integrity. By employing statistical analyses and identifying aberrant activities through endpoint solutions, the research not only addresses the technical facets of network security but also elevates the discourse to encompass strategic considerations for achieving a secure corporate network environment.

This scholarly work, rendered in English and situated within the Department of Information Technologies at the Faculty of Economics and Management, not only contributes to the academic corpus on network security but also serves as a valuable resource for practitioners in the field. Through its detailed exploration of security information and event management (SIEM), extended detection and response (XDR), and the pivotal role of active directory in authentication processes, the thesis bridges the gap between theoretical knowledge and practical application.

In conclusion, this Master's Thesis embodies a profound inquiry into the critical aspects of network security within the corporate sphere. It underscores the dynamic interplay between technological advancements and strategic imperatives in the quest to fortify networks against the ever-evolving

landscape of cyber threats. As such, this work stands as a testament to the critical importance of vigilant monitoring, sophisticated security implementations, and the perpetual pursuit of innovation in cybersecurity practices.

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