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Analysing Recent APT Incidents: Case Studies and Lessons Learned

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Abstract

Advanced Persistent Threats (APTs) are some of the worst threats facing organisations in the modern world. The purpose of this paper is to review the most recent APT cases to define more characteristic Tactics, Techniques, and Procedures (TTPs), and learn from the attacks. We also look at examples to analyse the effect of APTs across a range of industries such as healthcare, finance and government. Some important conclusions are presented as following, APT groups are becoming progressively more complex; They employ innovative approaches which may include zero-day exploits and supply chain attacks; They are able to persist inside a target's network for months, taking their time before executing further attacks. To avoid such attacks, organisations must adopt multi-layered defence, whereby there is maximum network security, endpoint protection, security training and physical security policies. Consequently, prevention and protection against APTs involve collaboration with other organisations as well as the information exchange.

1. Introduction to Advanced Persistent Threats (APTs)

Advanced Persistent Threats (APTs) are regarded as among the most intricate and efficient types of cyberattacks aimed at particular targets. APTs are distinct from conventional adversaries for multiple reasons, especially because they are created to be difficult to detect and often reside on victim devices and networks for extended durations, often spanning months or even years. Threat actors involved in this type of activity carry out their campaigns with the explicit aim of inflicting harm or achieving specific outcomes against targets, including financial profit, industrial spying, or hindering competitors (Sharma, A., et al., 2023).

APTs are recognized to have progressed alongside advancements in technology and changes in the threat environment. Many organisations, both public and private, are involved in cybersecurity today on some level. Cybercriminals, hacktivists, and other less organised elements falling under the broad cyber persuasion are said to engage on a daily basis. National governments and other agencies frequently

monitor, participate in, and in some cases, sponsor such activity. These elements are collectively referred to as Advanced Persistent Threat groups (Stojanović, B., et al., 2020).

While most APT groups can be attributed to a national government, an increasing number are tied to private companies and other typically illegal organisations. The specific rules and guidelines used to conduct these campaigns are often referred to as a TTP framework and are a common method used to categorise observed APT activity and, further, to attribute currently unobserved activity to known threat actors. As cyber threats increase and grow in sophistication, the claims against APTs pose a very real risk to the security of organisations of all shapes and sizes. To truly appreciate what is at stake, it is important to understand what exactly an APT consists of and how they are carried out in practice. In this paper, the recent recapping of cyber strategies is replaced with an analysis of several recently observed APT incident case studies, and the lessons learned as well as its usefulness to any organisation (Zimba, A., et al., 2020).

2. Methodology for Analysing APT Incidents

A systematic review approach grounded in established methodologies is conducted to provide an in-depth analysis of recent Advanced Persistent Threat (APT) incidents. Based on a predefined search and selection process, a number of case studies are compiled that cover a wide range of aspects and application contexts of APT incidents. The method is designed in detail to enable a systematic and comprehensive understanding of the dynamics and consequences of each case. Thus, the case studies shed light on the challenges as well as the desiderata that need to be met to improve enterprise systems security (Tatam, M., et al, 2021).

To analyse recent Advanced Persistent Threat (APT) incidents, we analyse seven APT case studies from various domains and business sectors. Based on pertinent literature on cyber intelligence, the researchers identify an operational framework for critical infrastructure protection and apply that framework to the selected APT cases. Thus, the analysis focuses on the operational level, identifies different phases and tasks over the lifecycle of an APT, and combines these findings with a qualitative analysis of the effectiveness of the detection and response activities at each point. Studies may help to set up lessons learned from analysing APT incidents that can be used to improve security and share experiences on technical and organisational challenges. The combination of the case selection process and the applied operational framework allows for a consistent analysis of APT and provides more widespread findings. The systematised method offers transparent and hence reliable practices required for drawing valid conclusions (Sindhwani, R., et al., 2022).

3. Case Study 1: SolarWinds Supply Chain Attack (APT29 - "Cosy Bear")

SolarWinds is well-known provider of IT network management and performance monitoring tools and software. Its solutions are widely adopted in governments, large and small companies and enterprises, and SMBs.

Mission and Products/Services:

SolarWinds has a vision of providing the IT professionals with information tools necessary to minimise IT issues they encounter. Its product portfolio includes:

- **Network Performance Monitoring**: Software to analyse the efficiency and productivity of network as well as to solve problems.
- **Server and Application Monitoring:** Real-time monitoring solutions for the status of server and application.

- **IT Security:** Security solutions for IT systems protection.

Customer Base:

SolarWinds' customer base is diverse, encompassing:

- Government organisations
- Large Enterprises and Corporations
- Small and Medium-Sized Businesses

The SolarWinds attack had far-reaching implications, impacting:

National Security: The breach also involved personal government information as well as government networks that could impact the nation's safety.

Global Economy: It targeted major facilities and severing essential services and the entire food chain leading to loss of property.

Public Trust: The event distorted the public perception of cybersecurity and security of Software supply chains.

Geopolitical Tensions: The attack was said to have been executed by a Russian cyber espionage group, which worsened political relations.

In the same order of ideas, the Solar Winds attack provided a sample that created the alert for organisations around the globe, for which supply chain protection and overall cybersecurity have become decisive components.

3.1. Overview

In the late 2020, APT29, aka 'Cozy Bear', reported an incredibly sophisticated operation dubbed the SolarWinds Supply Chain Attack. Russian Foreign Intelligence Service (SVR) an associated threat group with the capability to compromise high value targets. Their attack hit thousands of organisations — everything from US federal agencies to private companies and providers of critical infrastructure.

SolarWinds attack was carried out after APT29 compromised the software development process of the SolarWinds Orion platform, which operates a widely used network monitoring and management platform. However, attackers could inject a malicious backdoor, SUNBURST, into
the updates as a part of legitimate updates. As these updates were being installed, victims were not aware that by doing so, they turned APT29 on, giving APT29 unauthorised access to the victim's environment (CrowdStrike. 2021; FireEye. 2021). The breach is said to have affected some 18,000 organisations, including top U.S. federal agencies such as the Department of Homeland Security, Department of Commerce and private businesses that own Microsoft and FireEye.

APT29 used several advanced tactics, techniques, and procedures (TTPs) throughout the SolarWinds attack. They are represented in the MITRE ATT&CK Framework. The key techniques employed include:

Initial Access:

The attack started on the attackers' side with a supply chain compromise by using the SolarWinds update process, gaining access to the SolarWinds software process and distributing the SUNBURST backdoor (FireEye, 2021).

Execution:

Later, when the victims installed this compromised software update, the malicious code was run (CrowdStrike, 2021).

Persistence:

APT29 had long-term access to its infected networks through the SUNBURST backdoor, which it used to continually monitor and control the infected networks (FireEye 2021).
While more specific than APT28 and APT32, both of which are also associated with Russia, the group known as APT29 penetrated SolarWinds' supply chain late in 2021. This specific backdoor called Sunburst affected thousands of organisations, the victim list included U.S federal agencies and other private enterprises (CrowdStrike, 2021).

3.2. Impact and Consequences

The SolarWinds attack spread wide. Microsoft (2021) estimates that at least 18,000 organizations downloaded the compromised software updates and thus suffered from widespread public and private sector breaches. The worst of the impacts were national security threats, as sensitive data was exposed by the U.S. federal agency. This breach exposed vulnerabilities in government and defence-related operations, putting these operations at high risk (CrowdStrike, 2021). Furthermore, the attack also created significant financial and reputational damage. Incident response, forensic investigation and security enhancement were high-cost areas for organizations. This breach severely eroded SolarWinds's reputation and hurt the client base as well as hit the market value (FireEye, 2021). The other consequence of great significance was the operational disruptions, which many organizations had to experience due to downtime while rebuilding the infrastructure and removing the threat (CISA, 2021).

3.3. Lessons and Mitigation Strategies

The principles below highlight the most significant measures of countering SolarWinds supply chain risks. These measures can therefore be adopted by organisations to minimise such an unfortunate event and enhance its security position.

3.3.1.a. Secure Software Supply Chain

As the threat case reveals, covering them up involves a secure software supply chain to prevent further compromises. The safe practices that organisations ought to employ include; conducting of code reviews, performing software integrity tests, and having multi factor verification of software upgrades. These practices prevent introduction of malicious code in the system during development or update of applications (NIST SP 800-161).

3.3.1.b. Network Segmentation

Segmenting networks, and implementing strict controls on access can considerably reduce the opportunity of an attacker to spread out within a network that has already been compromised. Networking segmentation allows preventing the potential breaches from spreading across the whole network as well as limiting the extent of the losses an attacker can cause (CrowdStrike, 2021).

3.3.1.c. Continuous Monitoring

Analysing networks in real time using advanced threat detection technologies, helps organisations detect emerging behaviour and complications such as compromises. Having visibility into potential threats allows for the decentralised and constant detection of threats which can be acted on before high levels of damage are done (FireEye, 2021).

3.3.1.d. Zero Trust Security Model

Implementing Zero Trust Architecture makes it difficult for any entity both internally and externally to be trusted. This approach entails constant validation exercises on users, devices and processes and thereby mitigates chances of malicious users accessing the network or moving sideways within the network

(Microsoft, 2021).

3.3.1.e. The Level of Readiness for Responding to an Incident.

The general procedure of handling incidents should be designed and periodically practiced minimising the time needed to respond and stop such events. Having a properly developed incident response plan assure organisations that they are ready to respond properly to a supply chain attack that may lead to considerable downtimes and data loss (CISA, 2021).

3.3.1.f. Threat Intelligence Integration

Based on threat Intelligence, organisations can incorporate the current threats and the trends in the techniques used by attackers. Threat intelligence allows organisations to be ready for certain threats, and the organisation can then take actions to ensure such a scenario is not repeated (FireEye, 2021).

Table 1: Illustration of Supply Chain Attack Lifecycle (MITRE ATT&CK Framework)

MITRE ATT&CK Techniques	Description
Impact	Disrupt operations or destroy data
Exfiltration	Transfer data out of the network
Collection	Gather valuable data
Lateral Movement	Move within network
Discovery	Understand the target environment
Credential Access	Steal sensitive credentials
Defence Evasion	Avoid detection mechanisms
Privilege Escalation	Gain higher-level permissions
Persistence	Maintain access via backdoors or implants
Execution	Run malicious code in target environment
Initial Access	Compromise trusted software or supplier

4. Case Study 2: Hafnium Exchange Server Exploits

The APT, namely Hafnium Exchange Server Exploits (Microsoft, 2021), consists of a collection of advanced cyberattacks carried out by the Chinese state-sponsored threat group Hafnium. The group exploited several zero-day flaws in the Microsoft Exchange Servers, through which unauthorised access was gained to email accounts, while web shells were installed to establish ongoing access. This particular attack was targeted at myriad organisations around the world, made up of government agencies, educational institutions, healthcare providers and private companies (CrowdStrike, 2021). The APT exposure underscores the essence of robust security measures, timely updates, regular security monitoring, situational awareness and proactive threat management.

4.1. Overview

In early 2021, Advanced Persistent Threat Hafnium (connected to China) used zero-day vulnerabilities in Microsoft Exchange Servers to obtain unauthorised access to email accounts and establish persistence (Microsoft, 2021).

Hafnium capitalised on four previously identified weaknesses in the Microsoft Exchange Servers, namely:

- CVE-2021-26855
- CVE-2021-26857
- CVE-2021-26858

- CVE-2021-27065 (CISA, 2021).

The attacks were renowned for their speed and scope, affecting multiples of organisations before patches could be applied (FireEye, 2021). These operations carried out by Hafnium exemplify the growing threat posed by state-sponsored actors who use zero-day vulnerabilities for cyber espionage.

4.2. Impact and Consequences

The Hafnium Exchange Server exploits had significant and far-reaching impacts on affected organisations. The outcomes are expressed below:

- Innumerable organisations from various sectors experienced the breach attributed to the exposure of the identified weaknesses of Exchange Servers (CISA, 2021). IT teams struggled to patch systems because of the speed and scale of attacks.
- The principal aim was data theft, which resulted in acquisition of sensitive information such as emails and confidential documents, posing significant risks to privacy, intellectual property, and national security (Microsoft, 2021; CrowdStrike, 2021).
- Many organisations experienced disruptions to their email services and business activities. This necessitated an investigation to contain and rectify the breaches, taking away resources for more important tasks (FireEye, 2021).
- The money value associated with incident response, forensic analysis, and system recovery were substantial. Moreover, organisations suffered reputational damage and a loss of customer trust (CISA, 2021).
- Organisations that handled sensitive or regulated data faced potential legal and regulatory consequences for failing to appropriately protect such information (Microsoft, 2021).

4.3. Lessons Learned

The Hafnium Exchange Server attacks highlight several important lessons for strengthening cybersecurity resilience:

- In order to avert exploitation of discovered vulnerabilities, it's of essence to apply security updates as and when they are released (CISA, 2021). There needs to be a streamlined automated process that organisations can go through.
- Multifactor Authentication can guard against credential-based attacks even after a first compromise. It also adds another layer of security to prevent unauthorised access (Microsoft, 2021).
- Tools for advanced threat detection, such as FireEye, can help organisations pick up anomalies and potential breaches early on through continuous monitoring of network activity (FireEye, 2021).
- A well-defined incident plan, and one that is tested regularly, makes sure that organisations can react quickly and appropriately to breaches (CrowdStrike, 2021).
- It is also much more effective to share threat intelligence and respond to such attacks streamlined among the private sector and government agencies (CISA, 2021).

4.4. Mitigation Strategies

To defend against similar exploits in the future, organisations should adopt the following mitigation strategies:

- Ensure that Exchange Server instances are kept current with the most recent security patches. Alternatively, automate a seamless process in order to avoid delays.
- Install EDR solutions to monitor endpoints for suspicious activity and respond in real time to threats. EDR tools can detect web shell deployments as well as other malicious actions.

- Implement Multi-Factor Authentication (MFA) to prevent unauthorised access to email accounts, administrative logins, and remote access points. (CrowdStrike, 2021).
- Network segmentation isolates key infrastructure and limits lateral movement inside the network. This technique aids in the prevention of probable breaches and the mitigation of their consequences (CISA, 2021).
- Conduct regular threat hunting to detect indicators of compromise (IOCs) connected to Hafnium's TTPs. Frameworks like MITRE ATT&CK (Microsoft, 2021) are an excellent method to develop threat hunting activities.
- Ensure secure and tested backups of essential data for quick and easy recovery in case of an attack. Store backups in separate environments to avoid compromise (CISA, 2021).
- Stay up-to-date on emerging threats and vulnerabilities by participating in public-private threat intelligence exchange programmes. Collaborate with business peers and government agencies to strengthens collective defence.

4.5. Attack Techniques

Table 2: Hafnium Exchange Server Exploits – MITRE ATT&ACK Techniques

MITRE ATT&CK Techniques	Description
T1041 – Exfiltration Over C2 Channel	Exfiltrated data through C2 channels
T1074 – Data Staged	Prepared data for exfiltration
T1003 – OS Credential Dumping	Dumped credentials to facilitate lateral movement
T1071 – Application Layer Protocol	Communicated with command and control (C2) servers
T1059 – Command and Scripting Interpreter	Executed commands through interpreters (PowerShell, CMD)
T1078 – Valid Accounts	Used compromised credentials for authentication
T1505.003 – Web Shells	Deployed web shells for ongoing access
T1203 – Exploitation for Client Execution	Executed malicious scripts to establish persistence
T1190 – Exploit Public-Facing Application	Exploited vulnerabilities in Microsoft Exchange Servers

5. Case Study 3: APT "Winnti" Campaign

5.1. Overview

APT41, or the Winnti Group, has been operational since at least 2012 and is known to operate both to support state cyber espionage and for cybercrime and fraud (Malwarebytes 2022; FireEye 2022; CrowdStrike, 2021). The group which is believed to have connections with Chinese state actors attacks different industries, which include health, gambling, telecommunications, and among others, to show flexibility and that it has malicious activities for business and political purposes (CrowdStrike, 2021). Their elaborate operations utilise smart and complex methods and approaches to penetrate and disrupt organisations, endow much money and reputation losses (Mandiant, 2022).

APT41 use different Tactics, Techniques and Procedures (TTPs). For instance, they use zero-day vulnerabilities to get the first foothold, use Cobalt Strike to maintain persistence, and use credential theft to move within a network laterally (Mandiant, 2022). Some of the group’s tools mirror those of Winnti

and ShadowPad allowing the attackers to establish a persistent presence in the network and steal data (FireEye, 2022; Mandiant, 2022). All of these make APT41 a consistent and highly capable threat to organisations in different parts of the globe.

Visual 3 shows that APT41's campaigns have left a lasting devastation especially during the COVID-19 period where they hacked the healthcare sector for espionage. In the gaming industry, APT41 was involved in the stealing of source code and other digital property for the purpose of making money (CrowdStrike, 2021). These have enabled them capture dossiers from the affected entities and people, which clearly shows the intentionality of their acts (FireEye, 2022).

To mitigate emerging attacks from APT41, organisations should ensure that they use system's principle of least privilege, follow timely patching policy, and use MFA to protect against credential harvesting (Mandiant, 2022; FireEye, 2022). Also, threat-hunting activities that do not stop and network compartmentalisation can significantly minimise the chances of moving laterally and transmitting data (CrowdStrike, 2021). Such approaches are critical in putting up a spirited defence against Adaptive Threat Actors such as APT41.

5.2 APT41 Attack Techniques Using MITRE ATT&CK

Table 3: APT41 Attack Techniques Using MITRE ATT&CK Framework

MITRE ATT&CK Techniques	Description
Impact	Disrupting operations, ransomware
Exfiltration	Transferring data out of the network
Collection	Gathering sensitive data
Lateral Movement	Moving across network systems
Discovery	Mapping the network and assets
Credential Access	Stealing credentials for access
Defence Evasion	Hiding malicious activity
Privilege Escalation	Exploiting vulnerabilities for admin rights
Persistence	Deploying backdoors, implants
Executive	Malware execution, malware scripts
Initial Access	Zero-day exploits, spear phishing

5.3. Impact and Consequences

The APT41 "Winnti" Campaign affected several industries mostly because of the advanced and versatile approach to the attacks. However, due to the convergence of state-supported spy activities and financially motivated cybercrime, APT41 became a major threat for organisations all over the world.

APT41 used Initial Access for gaining entry into systems like zero-day, spear-phishing and followed it up by using Collection to gather large data which resulted in data breaches. This led to the theft of intellectual property, which is now more pronounced in fields such as health, games and communication. For instance, in the recent COVID-19 attack, the goal involved the samples of the research endowment in healthcare organisation to halt important medical progress (CrowdStrike, 2021). These breaches also pose national security risks when government and defence-related data are compromised (FireEye, 2022).

APT41's operations frequently involve financially motivated attacks. Their use of Credential Access, Lateral Movement, and Exfiltration techniques enables theft of funds, particularly through ransomware

and cryptocurrency exchanges. This results in direct financial losses and operational downtime as organisations grapple with service disruptions caused by ransomware attacks (FireEye, 2022). The cost of recovery and lost revenue can be substantial, forcing organisations to allocate significant resources to remediation efforts (Mandiant, 2022).

The stealthy nature of APT41, facilitated by Persistence techniques like backdoors and Defence Evasion to avoid detection, often means breaches are discovered long after the damage is done. This leads to severe reputational damage for the affected organizations. Customers and partners may lose trust, and publicized breaches can result in negative media attention, harming the organization's brand image (CrowdStrike, 2021).

According to this study, the major issues in the field will be Rise in Regulatory and Legal Repercussions. Data leakage and leakage of personal information can put organisations in operating compliance risk and legal fines. The infringements that counteract the General Data Protection Regulation (GDPR) or California Consumer Privacy Act (CCPA) include fines and legal consequences. Moreover, organisations may undergo more stringent regulatory inspections converting into mandatory audit and security upgrade (FireEye, 2022).

That is why the correction of all the global attempts of APT41 in the use of Privilege Escalation and Lateral Movement is the most time-consuming and energy-consuming task. Cutting-edge organisations are conditioned to undergo thorough forensic investigation, rebuilding IT infrastructure, and increasing protective measures all at a steep price. In addition, constant demands for new procurements of specialised security solutions, security awareness for employees, threat intelligence, further add to the long-term financial load on organizations (Mandiant, 2022).

APT41 has been infiltrating critical industries including healthcare, telecommunications, and many others and consequently has caused severe service disruptions. Some of the episodes of cyber threats acted against healthcare organisations include the COVID-19 pandemic where their attacks selectively delayed medical research and operational readiness (CrowdStrike, 2021). Equally, gains in telecom networks have led to probable surveillance threats and communication disruption to persons and institutions (FireEye, 2022).

5.4. Mitigation and Strategies

In order to successfully defend against APT41's (Winnti Group) advanced techniques, organisations must take a totalled mitigation strategy (Mandiant, 2022; FireEye, 2022). By reducing the risk of initial compromise, limiting the extent of lateral movement, and increasing overall resilience against advanced persistent threats. One way to mitigate is least privilege access control. This consists of preventing you and the system from surmounting what it's doing with permissions lower than what it needs to do it. Limiting administrative permissions and periodic reviews of permissions assigned to users can help organisations reduce the damage that could result in credentials being compromised (CrowdStrike, 2021).

The final step we implore is that, you implement multi-factor authentication (MFA), if you want to protect against credential theft. But with MFA, it’s an additional layer of security that asks for confirmation from multiple forms of verification before access is granted. For higher security, instead of SMS based MFA, the organisations should use authenticator apps or hardware tokens (Mandiant, 2022). Furthermore, a proper patch management process will protect you from already known vulnerabilities exploitation. For example, organisations should deploy a patch server that picks the updated component from the Internet. To ensure the compatibility of the software update, it must be tested on a test platform to reduce risks

should there ever be a situation like that. The security gaps then are found quickly and are addressed immediately by regular vulnerability scans and assessments (FireEye, 2022).

Another critical step is that Endpoint Detection and Response (EDR) solutions are deployed. EDR tools track endpoints for strange behaviour and programmatically respond to continuous threats. These tools, having been updated with the latest threat intelligence become more effective in picking malicious behaviour (Mandiant, 2022; FireEye, 2022). Network segmentation can also limit the lateral movement within the network by an attacker. Organisations can limit the risk of widespread compromise through the isolation of networks into disparate segments and employing strict controls over what resources can be accessed between them. In addition, traffic monitoring between these segments can detect anomalies too (CrowdStrike, 2021).

Proactive threat hunting continues to discover indicators of compromise. In fact, frameworks like the MITRE ATT&CK can actually guide your threat-hunting activities. However, by regularly reviewing system logs and training security teams to recognise APT41's tactics, detection and mitigation of threats becomes much easier (FireEye, 2022; Mandiant, 2022). Also prioritise security and awareness training for employees. Time and again employees fall prey to initial access of attackers to corporate networks (CrowdStrike, 2021). Staffs are also regularly exposed to training sessions and phishing simulations so that suspicious activities can be recognised and reported, decreasing the chances of initial compromises from social engineering attacks.

Finally, a comprehensive Incident Response Plan will help develop and test a staging plan when breaches happen. The plan is refined in relation to Incident Response drills and tabletop exercises which ensure all team members have the role and responsibilities under their belt (Mandiant, 2022).

6. Key Findings and Trends in APT Incidents

6.1. Common Trends

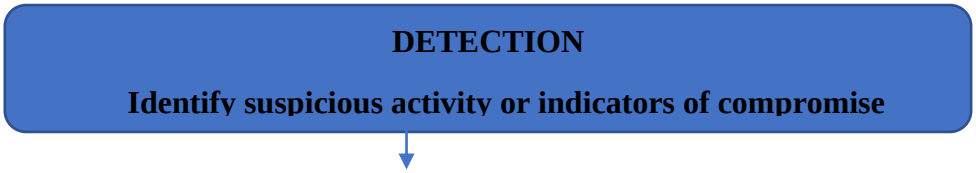
- Advanced Persistence Threats (APTs) are using highly developed stealth tactics.
- Compromising trusted vendors is an effective initial access vector.
- Major APT incidents are often tied to geopolitical interests.

6.2. Implications

- The Kill Chain Model and MITRE ATT&CK can be used together to better understand and anticipate APT activity.
- Continuous training and implementing a Zero Trust Architecture are crucial in ensuring organisational resilience.

Key Recommendations

- Regularly change security postures to reflect threat intelligence.
- Utilise Threat Modelling: Use frameworks such as MITRE ATT&CK for proactive defence.
- Regularly practise incident response drills with all parties to ensure preparedness.
- Zero Trust Security: Assume breaches are inevitable and constantly verify access.
- Secure the supply chain by vetting third-party vendors and software delivery pipelines.



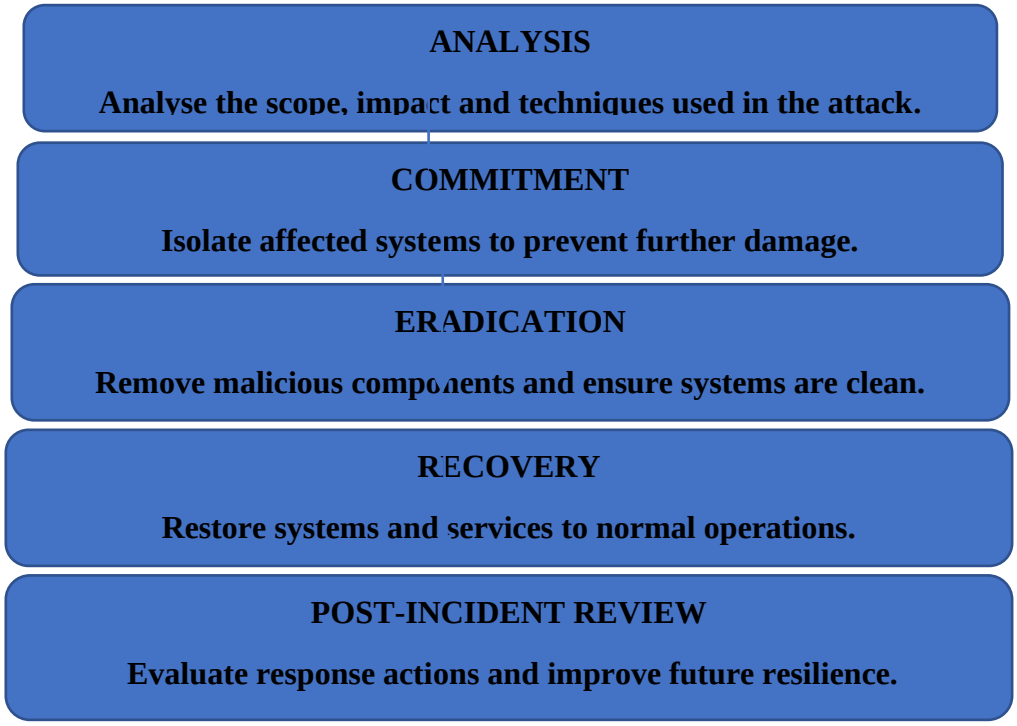


Figure 1: APT Incident Response Lifecycle

Conclusion

Advanced Persistent Threats (APTs) pose significant risks to organizations worldwide. This paper analyses recent APT incidents to identify common tactics, techniques, and procedures (TTPs), as well as the lessons learned from these attacks. By examining case studies, we explore the impact of APTs on various sectors, including healthcare, finance, and government. Key findings include the increasing sophistication of APT groups, their use of advanced techniques like zero-day exploits and supply chain attacks, and their ability to persist within target networks for extended periods. To mitigate these threats, organizations must adopt a layered defence strategy, including strong network security, endpoint protection, and regular security awareness training. Additionally, collaboration with other organizations and sharing of threat intelligence are crucial for effective defence against APTs

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