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Integration of Information Technology in Supporting the Defense Industry: The Role of Cyber Security in Countering Digital Threats and National Protection Strategy

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A B S T R A C T

The integration of information technology in the defense industry covers various aspects, including intelligence data management, military communications systems, and the use of artificial intelligence in strategic decision-making. The objective of this study is to understand the role of information technology integration in enhancing the effectiveness of the defense industry in addressing digital threats, the main challenges faced in implementing cybersecurity in the defense sector, as well as the mitigation strategies and effective national protection strategies against cyberattacks on defense infrastructure. This study employs a qualitative method. The findings indicate that with strong synergy among various stakeholders, the national cybersecurity defense system can become more adaptive, responsive, and capable of effectively countering digital threats.

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INTRODUCTION

In the rapidly developing digital era, the integration of information technology in the defense industry is a key element in strengthening national security. According to (Shaikh & Siponen, 2024) information technology not only increases the efficiency of the defense system, but also provides a strategic advantage in facing various threats, including cyber threats. The role of cybersecurity in supporting the defense industry is very important, considering the increasingly sophisticated digital attack methods that can threaten a country's defense infrastructure. A national protection strategy must be designed comprehensively to anticipate and overcome cyber-attacks that can harm the country's security system.

The integration of information technology in the defense industry covers various aspects, ranging from intelligence data management, military communication systems, to the use of artificial intelligence in strategic decision making. According to (Daengsi, Pornpongtechavanich, & Wuttidittachotti, 2022) one form of significant application of information technology in the defense industry is the digital-based command and control (C2) system. This system allows fast, accurate, and encrypted communication between military units, thereby increasing the effectiveness of defense operations. Big data-based technology and predictive analytics are also starting to be used in threat analysis, helping the military detect potential attacks before they occur.

However, as the reliance on digital technology increases, the defense industry also faces increasingly complex cyber threats. Cyber-attacks can take the form of hacking of sensitive data, sabotage of communication systems, and ransomware attacks that paralyze defense infrastructure.(Christen, Gordijn, & Loi, 2022). Countries with advanced defense industries have realized that cyber threats do not only come from criminal groups, but also from other state actors with certain geopolitical interests. Cybersecurity in the defense sector is a top priority to prevent leaks of confidential information and maintain the stability and sovereignty of the country.

In facing digital threats, national protection strategies must be designed with a holistic and proactive approach. One of the main strategies is strengthening network security systems using advanced encryption technology. Strong data encryption can prevent unauthorized access to classified military information. According to (Kavak et al., 2021) the implementation of intrusion detection systems is also very important in identifying and responding to cyber threats in real-time. Artificial intelligence and machine learning-based technologies can be used to detect suspicious attack patterns and automatically activate established defense protocols.

In addition to strengthening technology, the human resources aspect also plays a crucial role in the cybersecurity of the defense industry. Training and capacity building of military personnel and cybersecurity experts must be carried out routinely to ensure they have a deep understanding of the latest cyber threats.(Naik, Mehta, Yagnik, & Shah, 2022). Cybersecurity is not only a technical responsibility, but also part of a national strategy involving various sectors, including government, academia, and industry. Cooperation between

government, educational institutions, and the private sector in developing defense technology must continue to be improved to provide innovative solutions in dealing with digital threats.

The national protection strategy in dealing with digital threats also includes the development of strict policies and regulations. Regulations on cybersecurity in the defense industry must be updated regularly in accordance with technological developments and the dynamics of global threats. The government must have a clear policy on the protection of critical infrastructure, including military communication systems, defense data centers, and strategic information networks. According to (Catota, Granger Morgan, & Sicker, 2019) International cooperation in cybersecurity is also an important factor in strengthening a country's digital defense. Various cybersecurity forums and alliances between countries can be used as platforms to share intelligence information and develop joint defense strategies against cross-border cyber threats.

The implementation of a cyber defense strategy must also include aspects of risk mitigation and rapid response to cyber incidents. Cyber-attack simulations and system security tests need to be conducted periodically to identify security gaps that may be exploited by irresponsible parties. The development of a cyber emergency response team (Computer Emergency Response Team/CERT) in the defense industry can help in handling cyber incidents quickly and effectively. This team is tasked with identifying, analyzing, and responding to cyber-attacks in real-time, so that the impact of the attack can be minimized.(Chaudhary, Gkioulos, & Katsikas, 2023). The integration of information technology in the defense industry also includes the development of digital-based weapons technology. Smart weapons equipped with digital control systems and sophisticated sensors are increasingly used in modern military operations. However, with the presence of digital connectivity in weapons systems, the risk of cyber-attacks also increases. A strong security system must be implemented in every component of military technology to prevent manipulation or sabotage by the enemy (Zeadally, Adi, Baig, & Khan, 2020).

In the face of increasingly complex digital threats, countries must have an adaptive and sustainable cybersecurity strategy. Investment in research and development of cyber defense technology must continue to be increased so that the defense industry is able to face various threat scenarios in the future. According to (Pawar & Palivela, 2022) education and awareness of the importance of cybersecurity must be instilled from an early age, both in the military environment and in the general public, so that all elements of the nation can contribute to maintaining the country's digital sovereignty.

THEORETICAL REVIEW

Information Technology in the Defense Industry

Information technology plays an important role in increasing the effectiveness and efficiency of modern defense systems. The concept of *Network Centric Warfare* (NCW) is one approach that emphasizes the integration of communication and data networks to improve military coordination. By utilizing

information technology, decision-making in the defense industry can be done faster and more accurately.

Cybersecurity Theory in the Defense Industry

Cybersecurity in the defense system is based on several main theories, such as:

1. Defense in Depth, which emphasizes layered protection to secure the system from various threats.
2. Zero Trust Security, which is based on the principle that every access to the system must always be verified without relying on implicit trust.

This approach is very important to deal with increasingly sophisticated cyber threats, such as data hacking, *ransomware*, and artificial intelligence-based attacks.

Digital Threats and Their Implications for National Defense

Cyber threats in the defense industry include attacks on critical infrastructure, cyber espionage, and digital propaganda that can disrupt national stability. The theory of Cyber Deterrence is an important part of the protection strategy, where countries develop capabilities to prevent and respond to cyber attacks effectively.

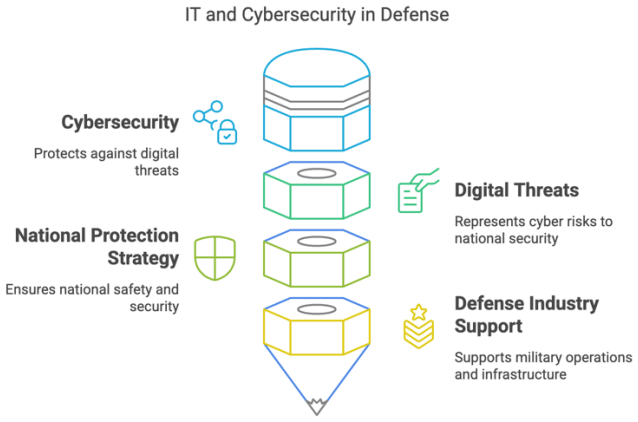
National Protection Strategy against Cyber Threats

In dealing with cyber threats, countries implement various strategies based on security theory, such as:

1. Risk Management Framework (RMF) to identify, assess, and address cyber risks.
2. Cyber Hygiene as a proactive approach to protecting the defense system from potential threats.

By implementing this strategy, the government can build a strong cyber defense system to protect national sovereignty and interests.

Here is a concept map of this article (Picture 1).



Picture 1. Mindmap

METHODOLOGY

Qualitative methods are used in this study to understand in depth how the integration of information technology in the defense industry contributes to cybersecurity in the face of digital threats and the national protection strategies implemented. This approach allows researchers to explore the perspectives of various stakeholders, such as cybersecurity experts, military personnel, and policymakers, to gain more comprehensive insights into the challenges and solutions in the digital defense sector.

Data collection techniques were conducted through in-depth interviews, cyber defense policy document studies, and literature analysis related to defense technology developments. This approach helps identify patterns, strategies, and key factors in strengthening national cyber security. Data analysis was conducted using thematic techniques to explore the relationship between information technology adoption and the effectiveness of cyber security systems.

With qualitative methods, this study not only describes the implementation of technology in the defense industry but also reveals the dynamics of policies and challenges in dealing with digital threats. The results of the study are expected to provide strategic recommendations for the government and defense institutions in optimizing the role of cybersecurity as an integral part of the national protection system.

RESULTS AND DISCUSSIONS

In today's digital era, the integration of information technology has become a key factor in increasing the effectiveness of the defense industry, especially in facing increasingly complex and sophisticated digital threats. The modern defense industry no longer relies solely on physical strength and conventional weapons, but also requires an information technology-based system that can strengthen defense strategies and accelerate responses to cyber threats (Mishra, Alzoubi, Anwar, & Gill, 2022). With the rapid development of technology, various countries have adopted digital-based defense systems to ensure national security is maintained from various threats, both from state and non-state actors. Information technology plays an important role in increasing the effectiveness of the defense industry through various aspects, such as more secure military communication systems, more accurate intelligence analysis, and more efficient strategic data management (Dalal et al., 2022).

One of the prime examples of information technology integration in the defense industry is the development of command and control (C2) systems, which enable more effective coordination between defense units in responding to threats in real-time. With advanced C2 technology, the military can exchange information encrypted and quickly, so that decision-making can be done more precisely and accurately. According to (Cheng & Wang, 2022)The integration of big data and artificial intelligence (AI) in the defense industry is also a key factor in increasing the effectiveness of defense systems. Big data enables predictive analysis of possible threat patterns and cyber-attacks. With AI-based systems, the military can identify emerging threats faster than conventional methods. AI can also be used in air defense systems, autonomous combat vehicles, and in

intelligence data processing to uncover hidden threats that are difficult to detect manually(Sarker et al., 2020).

As the integration of information technology increases, digital threats to the defense industry are also growing. Cyber-attacks on military systems can take the form of strategic data hacking, sabotage of weapons systems, and ransomware attacks that can paralyze a country's defense infrastructure. These threats come not only from cybercriminal groups, but also from state actors with certain geopolitical interests.(Shaikh & Siponen, 2023). One of the most dangerous forms of threats is the Advanced Persistent Threats (APT) attack, where the attacker can infiltrate a country's defense system for a long time without being detected.

APT attacks can steal classified military data, weaken defense communication systems, and disrupt overall military operations. According to(Saeed, Altamimi, Alkayyal, Alshehri, & Alabbad, 2023)Protection against cyber-attacks should be a top priority in a country's defense strategy. To deal with digital threats, the defense industry must implement a comprehensive and adaptive information technology-based protection strategy. One of the main strategies is strengthening the cybersecurity system through the implementation of advanced encryption technology. Strong data encryption can prevent unauthorized access to military confidential information. In addition, the implementation of an AI-based threat detection system can help identify cyber-attack patterns before they reach critical infrastructure. Another important strategy is the use of blockchain technology in military communication systems(Mishra, Alzoubi, Gill, & Anwar, 2022).

Blockchain enables more secure data transfer with an immutable recording system, so the risk of data manipulation can be minimized. With this technology, any changes or access to information can be recorded automatically, so that the integrity of defense data is maintained. According to(Quayyum, Cruzes, & Jaccheri, 2021)development of cloud-based security systems is also one of the solutions in increasing the effectiveness of the defense industry. Cloud technology allows for large-scale data storage and management with a higher level of security than traditional systems. With cloud security, access to defense information can be more flexible but remains safe from the threat of hacking. Although information technology plays a major role in increasing the effectiveness of the defense industry, the human resource factor remains an important element in dealing with digital threats.

Military personnel and cybersecurity experts must have a deep understanding of evolving technology and digital threats. According to (AlDaajeh et al., 2022)training and capacity building of human resources in the field of information technology and cybersecurity must be an integral part of the national defense strategy. In addition to technical training, awareness of cybersecurity must also be instilled throughout the defense organization. Cyberattacks often occur due to human error, such as the use of weak passwords or carelessness in accessing sensitive information (Neri, Niccolini, & Martino, 2024). By increasing cybersecurity literacy, the risk of data leaks and digital

attacks can be minimized. Digital threats in the defense industry are global, so international cooperation is an important factor in improving cybersecurity.

Countries have formed cybersecurity alliances to share intelligence, develop joint defense technologies, and develop mitigation strategies against cross-border cyberattacks. Organizations such as NATO and ASEAN have initiated various cooperation forums in the field of cybersecurity to strengthen digital defenses in each member country. According to (Taherdoost, 2022) cooperation with technology companies is also an important part of dealing with digital threats. Companies engaged in cybersecurity can help the defense industry in developing innovative solutions to protect the national defense system. In the increasingly advanced digital era, the defense sector faces major challenges in implementing cybersecurity (Moreira, Calegario, Duarte, & Santos, 2024).

Cyber threats are no longer limited to hacking or data theft, but also include attacks that can paralyze a country's defense infrastructure. The military and defense industry must face attacks from both state and non-state actors, including terrorist groups and criminal hackers. With the increasingly complex technology used in defense systems, cybersecurity has become one of the most crucial aspects in maintaining the stability and sovereignty of the country. However, its implementation is not easy due to various obstacles that arise in technical, institutional, and human resource aspects.(Naughton et al., 2022). One of the main challenges in defense sector cybersecurity is the increasingly sophisticated and difficult-to-detect nature of attacks. Advanced Persistent Threats (APT) attacks, for example, are often carried out by state actors who have the resources to infiltrate military networks in a highly stealthy manner.(Jaggernauth & Rocke, 2021).

These attacks not only steal strategic data, but can also be used to disrupt weapons systems, weaken military communications, and even plant malware that can be activated in a war situation. According to(Copertaro et al., 2020)Another challenge is ransomware attacks that can encrypt important data and demand a large ransom in exchange for restoring access. In many cases, ransomware attacks are not only aimed at financial gain but also as a form of sabotage against a country's defense capabilities. In addition to external threats, internal factors are also a challenge in implementing cybersecurity in the defense sector. One of the main factors is the lack of awareness of the importance of cybersecurity among defense personnel(Neri et al., 2024). Human error, such as the use of weak passwords, lack of training in identifying phishing attacks, and the use of unsecured devices, often provide loopholes for hackers to infiltrate defense systems.

The lack of strict security policies in managing access to confidential information can also increase the risk of data leaks that can be exploited by adversaries. On the infrastructure side, another challenge is the reliance on outdated, legacy technology. Many defense systems still use hardware and software that no longer receive security updates, making them vulnerable to exploitation.(Kovalenko & Sikalo, 2023). In some cases, defense systems use isolated networks to avoid external attacks, but attacks can still occur through

gaps created by infected USB devices or insider attacks. Upgrading defense systems with the latest technology often requires large costs and a long time, making it a challenge for countries with limited defense budgets.

In addition to technical and human resource aspects, another challenge is the lack of coordination between institutions responsible for cybersecurity in the defense sector. Cybersecurity is not only the responsibility of the military, but also requires cooperation with intelligence agencies, related ministries, and the technology industry. Without good coordination, the response to cyber attacks becomes slow and ineffective.(Chiba, Abghour, Moussaid, El Omri, & Rida, 2019). The lack of regulatory clarity in handling cyber incidents can also hamper threat mitigation, as there is often overlapping authority between various agencies involved in cyber defense. To overcome these challenges, a comprehensive and sustainable mitigation strategy is needed. One of the main strategies is strengthening the early detection system for cyber attacks. By using artificial intelligence and big data analysis, the defense system can identify attack patterns faster before the attack reaches its target.

Machine learning technology can be used to learn attack patterns from previous incidents and provide early warning to cybersecurity teams. With this approach, responses to attacks can be made in seconds, so that the impact can be minimized. According to(Sutherland, 2018)In addition to strengthening early detection, other strategies include increasing data encryption and using blockchain technology in managing confidential information. Strong data encryption can prevent unauthorized access to important information, while blockchain can ensure that any changes to the data are clearly recorded and cannot be manipulated. The use of blockchain in military communications can also reduce the risk of eavesdropping, as each information transaction requires validation from various nodes in the network.

From the human resources side, the mitigation strategy that must be implemented is increasing cybersecurity training for defense personnel. Every individual involved in the defense sector must be aware of cyber threats and be able to identify signs of suspicious attacks. Training should include cyberattack simulations, so that personnel can understand how to respond quickly when an incident occurs. According to(Yarovenko, Kuzmenko, & Stumpo, 2020)The implementation of a zero trust policy in data access is also important, where each user must go through strict authentication before accessing sensitive information. Another strategy that is no less important is the modernization of technological infrastructure in the defense system. The government must invest in updating the hardware and software used in military operations. This includes the use of cloud security to manage large-scale data with a higher level of security. The development of a military communication network based on quantum technology can also be a solution to create a communication system that is almost impossible to hack(Maina, 2024).

In terms of coordination between institutions, a mitigation strategy that can be implemented is the establishment of an integrated cyber defense command center. This center is responsible for coordination between the military, intelligence agencies, and the private sector in collectively handling

cyber threats. According to(Bryant, 2021)International cooperation is also an important factor in dealing with global cyber threats. Countries can share intelligence information about emerging threats and develop joint security technologies to strengthen their digital defenses. In the increasingly advanced digital era, cyber threats are one of the biggest challenges for national defense systems. The development of information technology has enabled various innovations in the defense industry, including the use of digital communication systems, military computer networks, and artificial intelligence-based weapons.(Koibichuk & Dotsenko, 2023).

The increasing dependence on this technology also increases the risk of cyber attacks that can disrupt the stability of a country's defense. Cyber attacks on the national defense system can cause various serious impacts, ranging from theft of secret military data, sabotage of weapons systems, to the paralysis of defense infrastructure that has an impact on the sovereignty of the country.(Mizan, Ma'arif, Satar, & Shahar, 2019). One of the most dangerous impacts of cyber threats to national defense is the hacking and theft of sensitive military data. Defense information systems store various classified documents that include war strategies, intelligence, and weapons technology specifications. If this data falls into the hands of irresponsible parties, it can be used to plan attacks on the country concerned.

For example, enemy countries or terrorist groups can use the information to find out weak points in defense, military strategies, or even sabotage certain military missions. In many cases, these hacks are carried out by state actors or groups with certain geopolitical interests, so the impact can be very large for national security. According to(Saragih, Tanziyl, Andhika, & Rulloh, 2019)In addition to data theft, cyber threats also have the potential to cause sabotage of weapons systems and defense infrastructure. Currently, many modern weapons systems are connected to digital networks, including fighter jets, warships, and missile defense systems. If these systems are hacked, the enemy can control or disable the weapons remotely. A real example of this threat is the attack on industrial control systems that have occurred in various sectors, such as the Stuxnet attack that crippled Iran's nuclear facilities in 2010.(Kitler, 2021).

In the context of defense, similar attacks can be used to disrupt communication systems between military units, damage the navigation systems of fighter aircraft, or even disable air defense systems in a war scenario. Other impacts of cyber attacks on national defense include disinformation and psychological warfare that can undermine the stability of the country.(Kraus, Kraus, & Shtepa, 2022). Cyberattacks are not always technical in nature, but can also involve spreading false information aimed at influencing public opinion and creating distrust of the government or military institutions. In a geopolitical context, many countries use this strategy to create tension within the target country, weaken troop morale, or even drive social divisions that can disrupt national stability. Such attacks often occur near elections, military conflicts, or during national crises, so their impact can undermine defense from within without the need for direct military force.(International Telecommunication Union, 2021).

In the face of increasingly complex cyber threats, the readiness of the defense industry is a key factor in maintaining national resilience. The defense industry must be able to adapt to technological developments while building a strong security system to protect the country's strategic assets.(Havryliuk, Yakushev, Prodanova, Yakusheva, & Kozlovs`ka, 2021). One of the main steps that many countries have taken is investing in the development of more sophisticated cybersecurity technologies. Many defense companies are now working with cybersecurity institutions to develop systems that can detect and prevent attacks early on. Artificial intelligence and machine learning technologies, for example, have been used to analyze cyberattack patterns and identify threats before they reach their primary targets.

Defense industry readiness also depends on implementing strict cybersecurity policies in every aspect of operations. This includes increasing data encryption, strengthening authentication systems, and restricting access to sensitive information to authorized personnel only. Many countries have adopted a zero-trust model in their cybersecurity systems, where every user and device must go through strict verification before they can access the defense network.(Urbanovic, 2022). With this approach, the risk of internal attacks or infiltration by enemy agents can be minimized. The readiness of the defense industry in facing cyber threats also depends on increasing the capacity of competent human resources in the field of cybersecurity. One of the biggest challenges in the defense industry today is the lack of cybersecurity experts who have a deep understanding of military defense systems.

Many countries have developed special training programs for military personnel and professionals in the defense industry to have the skills needed to deal with cyber threats. According to(Yerina, Honchar, & Zaiets, 2021)Cooperation between the military, universities, and technology companies is also a strategic step in accelerating the development of national cyber capabilities. However, although various steps have been taken, there are still a number of challenges that must be faced in improving the readiness of the defense industry against cyber threats. One of the main challenges is the high cost required to build a strong cybersecurity infrastructure. Developing a cybersecurity system that is capable of facing attacks from state actors or professional hacker groups requires significant investment in technology, research, and human resource training. For countries with limited defense budgets, this challenge can be an obstacle in improving their cyber resilience.

The complexity of cyber threats also continues to grow along with technological advances, so the defense industry must continue to adapt and update its security systems regularly. Today's cyber attacks are not only limited to conventional methods such as malware or phishing, but also include more sophisticated techniques such as artificial intelligence-based attacks and deepfakes that can deceive traditional security systems. According to(Yarovoy et al., 2024)The defense industry must have a flexible system and be able to react quickly to new threats that emerge. In the increasingly developing digital era, cyber attacks on defense infrastructure have become a serious threat that can disrupt national security stability. Defense infrastructure includes various

important systems, such as military communication networks, command and control centers, technology-based weapons systems, and highly classified intelligence data.

Attacks on this infrastructure can have wide-ranging impacts, from theft of strategic data, sabotage of weapons systems, to the paralysis of a country's defense capabilities in the face of external threats. An effective national protection strategy is needed to anticipate and respond quickly to cyber attacks and maintain cyber resilience in the defense sector.(Asmadi et al., 2023). One of the main strategies in protecting defense infrastructure from cyber attacks is to build a layered security system or what is known as defense-in-depth. This concept involves several layers of protection designed to block and detect attacks early before they reach the core system. Each layer has different defense mechanisms, such as advanced firewalls, intrusion detection systems (IDS), and strong data encryption.

By implementing this strategy, if one layer is successfully penetrated by hackers, there are still other layers that can prevent further access to the main system. In addition, this approach allows early detection of suspicious activity, so that attacks can be stopped before they cause major damage to the defense infrastructure.(Abimbola Oluwatoyin Adegbite et al., 2023). The implementation of a zero-trust policy is an important step in strengthening national protection against cyber attacks. Zero-trust is a security concept that assumes that no entity, either inside or outside the network, can be trusted without strict verification. In this system, every access to data or defense systems must go through layered authentication and authorization, such as the use of multi-factor authentication (MFA) and role-based access control. By implementing this principle, the risk of infiltration by unauthorized parties can be minimized, even if there are individuals in the organization who try to abuse their access.(Kitler, 2021).

The government also needs to develop cooperation between defense institutions, cyber security institutions, and the private sector to increase the effectiveness of protection against digital threats. According to(Rawindaran, Jayal, Prakash, & Hewage, 2023)This collaboration allows for real-time information exchange regarding the latest cyber threats, evolving attack techniques, and mitigation strategies that can be implemented. In several developed countries, this collaboration is realized in the form of a cyber security operations center (CSOC) which functions as a coordination center in handling cyber incidents. This center is responsible for monitoring network activity, analyzing attack patterns, and providing a rapid response to potential threats. In addition to cooperation at the national level, international collaboration is also a key factor in maintaining cyber resilience(Rashid, Noor, & Altmann, 2021).

Many cyber attacks are carried out by foreign state actors or cross-border cybercriminal groups, so it is important for governments to work with international organizations to develop global security standards and enforce the law against cybercriminals.(Coenraad et al., 2020). A number of international agreements, such as the Budapest Convention on Cybercrime, have encouraged countries to cooperate in sharing intelligence, tracking down perpetrators of cross-border attacks, and improving collective cyber defense capabilities.

According to(Alsharif, Mishra, & AlShehri, 2021)on the technology side, the application of artificial intelligence (AI) and big data analytics has become a critical element in strengthening cybersecurity in the defense sector. AI can be used to identify anomalous patterns in network traffic, detect ongoing cyberattacks, and automatically respond to threats before they reach their primary targets.

For example, AI-based systems can analyze millions of data points per second to find suspicious attack patterns, such as sudden increases in network traffic or repeated login attempts from unknown locations. With this technology, security systems can respond to threats in seconds, much faster than manual detection by humans.(Almansoori, Al-Emran, & Shaalan, 2023). In addition to technology strategies, strengthening human resources (HR) in cybersecurity is also a crucial element in dealing with digital threats to defense infrastructure. Many cyber attacks are successful not because of system weaknesses, but because of human negligence, such as the use of weak passwords, ignorance of phishing threats, or failure to update security systems regularly.

Training and education programs for defense personnel must be strengthened so that they have a good understanding of cybersecurity protocols, are able to recognize potential threats, and can respond to cyber incidents quickly and effectively. Several countries have developed special academies that train cybersecurity experts in the military field, so that they can be at the forefront of protecting national defense systems from digital attacks.(Corallo, Lazoi, Lezzi, & Luperto, 2022). In dealing with cyber attacks, strengthening national regulations and policies must also be a priority. The government needs to set strict cybersecurity standards for all entities involved in the defense sector, including the defense industry that produces military hardware and software. These regulations should include provisions related to data protection, regular security audits, and the obligation to immediately report cyber incidents to the relevant authorities.

In some countries, strict regulations have been implemented to ensure that any vendors working with defense institutions must meet high security standards, to avoid the risk of infiltration by foreign parties or hacker groups that could potentially endanger national security. Although various strategies have been developed, the challenges in protecting defense infrastructure from cyber attacks remain complex and continue to evolve.(Ramírez, Ariza, Miranda, & Vartika, 2022). Actors involved in cyber attacks, whether individual hackers, criminal groups, or countries with political interests, are always looking for new loopholes to exploit defense systems. National protection strategies must be dynamic and adaptive, by regularly updating security technologies and developing new, more effective approaches to address evolving threats.(Khader, Karam, & Fares, 2021).

In an increasingly complex digital era, cyber attacks have become a serious threat to national defense infrastructure. Cyber attacks not only have the potential to steal sensitive data, but can also paralyze military command and control systems, disrupt strategic communications, and threaten national stability. Building a resilient cyber defense system requires a comprehensive

approach and involves various stakeholders. According to(Gupta, Akiri, Aryal, Parker, & Praharaj, 2023)Collaboration between government, industry, and security institutions is key to strengthening a country's cyber resilience, as each party has a strategic role in creating a security ecosystem that is adaptive and responsive to digital threats. The government has a primary role in formulating policies, regulations, and building an integrated cybersecurity infrastructure.

As a policymaker, the government must develop clear regulations regarding cybersecurity standards for all entities operating in the defense sector, including industries producing military hardware and software. These regulations must include minimum security requirements, regular audits, and the obligation to immediately report cyber incidents to the relevant authorities. According to(Lee, 2020)The government needs to form a special agency or institution responsible for overseeing national cyber security, such as the National Cyber Security Center (NCSC) in various developed countries. This institution functions as a coordination center in handling cyber threats and providing a rapid response to attacks that can disrupt national stability.

In addition to regulations, the government must also invest in cybersecurity infrastructure by building a Cyber Security Operations Center (CSOC). This center functions to monitor network activity in real-time, detect potential threats, and provide a quick response to ongoing attacks. According to(Mijwil, Unogwu, Filali, Bala, & Al-Shahwani, 2023)with the support of advanced technologies such as artificial intelligence (AI) and big data analytics, CSOC can analyze attack patterns, identify anomalies, and develop more effective mitigation strategies. The government also needs to provide an adequate budget for research and development (R&D) in cybersecurity, to ensure that the country's defense system is always at the forefront of increasingly sophisticated digital threats.

On the other hand, industry plays a vital role in providing innovative technologies and solutions to support cyber defense systems. Companies engaged in information technology, cyber security, and defense manufacturing must work with the government in developing hardware and software that is safe from potential exploitation.(Pranggono & Arabo, 2021). One of the main challenges in cyber defense is the use of technology that is vulnerable to attack, either due to weaknesses in design or due to failure to update systems regularly. The industry must ensure that the products they produce have undergone rigorous testing processes and have protection mechanisms that can prevent exploitation by malicious actors.

Industry can also support the government in building a stronger cybersecurity ecosystem through training and certification programs for the defense sector workforce. With increasing cyber threats, the need for cybersecurity experts is increasingly urgent.(Gordon, Loeb, & Zhou, 2020). Technology companies can collaborate with governments and educational institutions to provide training and certification for defense personnel, so that they have the skills needed to deal with various forms of digital threats. Several countries have implemented this model of cooperation successfully, with major

technology companies such as Microsoft and Google working with governments to train cybersecurity personnel for the military and defense sectors.

Security institutions such as the military, police, and intelligence agencies have a critical role in implementing cybersecurity strategies in the field. These institutions are responsible for detecting, analyzing, and responding to cyber attacks that could threaten the country's defense system. According to(AL-Hawamleh, 2023)One of the steps that can be taken by security institutions is to build a cyber emergency response team (Computer Emergency Response Team or CERT) which is tasked with handling cyber incidents quickly and efficiently. This team works with the government and industry sectors in developing early detection methods, conducting digital forensic investigations, and developing recovery strategies after an attack occurs. Security institutions also need to develop a cyber intelligence system to anticipate threats before an attack occurs. Cyber intelligence involves collecting, analyzing, and interpreting data related to suspicious cyber activity(de Bruijn & Janssen, 2017), whether originating from foreign state actors, criminal groups, or terrorist organizations.

By utilizing big data analysis techniques and artificial intelligence, security institutions can identify attack patterns and take preventive measures to prevent large-scale cyber attacks. One successful example of collaboration between government, industry, and security institutions in building a robust cyber defense system is the cooperation between the United States and technology companies in improving the cyber resilience of their defense sector.(Hijji & Nature, 2022). Through initiatives such as the Cybersecurity and Infrastructure Security Agency (CISA), the US government is working with private companies to develop advanced security solutions, provide training for defense personnel, and test their systems' resilience to various types of cyberattacks. This model of collaboration shows that synergy between various stakeholders can significantly improve the effectiveness of a country's cyber defense.

However, despite the many benefits of this collaboration, there are still some challenges that need to be overcome. One of the main challenges is the lack of coordination and synchronization of policies between the government, industry, and security institutions. In many cases, policies made by the government are not always aligned with the needs of the industry or the capacity of security institutions to implement the strategies that have been designed.(Kaur, Gabrijelčič, & Klobučar, 2023). A more effective coordination mechanism is needed, such as the establishment of a communication forum involving representatives from all stakeholders to ensure that the policies taken can be implemented well in the field. Another challenge is the lack of human resources with expertise in cybersecurity.(Capuano, Fenza, Loia, & Stanzione, 2022). To address this, the government needs to work with universities and educational institutions to develop a special curriculum in cybersecurity, in order to produce experts who can fill the needs in the defense sector. Scholarship programs, industry-based training, and internships in technology companies can be solutions to accelerate the increase in human resource capacity in this field.(Cookson et al., 2024).

CONCLUSION AND RECOMMENDATION

Collaboration between government, industry, and security institutions is a key element in building a resilient cyber defense system to deal with increasingly complex digital threats. The government has a role in designing policies, regulations, and providing a robust cybersecurity infrastructure. Industry contributes to the development of technology, innovation, and training of experts in the field of cybersecurity. Security institutions are responsible for implementing protection strategies, threat detection, and rapid response to cyber attacks. Although this collaboration brings many benefits, there are still challenges that must be overcome, such as lack of policy coordination, limited cybersecurity experts, and evolving cyber threats.

Joint efforts are needed to strengthen coordination mechanisms, increase investment in cybersecurity research and technology, and accelerate the development of competent human resources in this field. With strong synergy between various stakeholders, the national cyber defense system can become more adaptive, responsive, and able to deal with digital threats effectively. Cybersecurity is not just the responsibility of one party, but requires close and continuous cooperation to ensure the stability and resilience of national defense in facing the increasingly dynamic digital era.

FURTHER STUDY

The rapid advancement of information technology in the defense industry requires continuous research, particularly in cybersecurity. One crucial area for further study is advanced cyber threat intelligence in military systems. With the increasing sophistication of cyberattacks, particularly those driven by artificial intelligence, research should focus on developing predictive models to detect and mitigate threats before they occur. Case studies on recent cyber warfare incidents could provide valuable insights into how nations respond to cyber threats and improve their defense mechanisms.

Another important aspect is the implementation of Zero Trust Architecture in military networks. While Zero Trust Security has proven effective in corporate environments, its application in highly classified and legacy defense systems presents unique challenges. Further studies should examine the feasibility, benefits, and potential limitations of Zero Trust in military contexts. A comparative analysis between Zero Trust and traditional cybersecurity models would help determine the best practices for enhancing defense security.

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