CYBER SECURITY FOR POWER GRIDS: THREATS, MITIGATION, AND FUTURE OUTLOOK

Merging Cybersecurity Challenges in Power Grids and Critical Infrastructure

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Abstract—
Cybersecurity is often confused with information security, although the latter focuses on human involvement, while the former sees individuals as potential targets and considers this an additional dimension. Cybersecurity discussions highlight important ethical issues impacting society and have led to the development of various frameworks addressing challenges like workforce development and personal data protection. This paper reviews these models, their limitations, and past mitigation techniques while offering future research recommendations. It explores vulnerabilities in wireless communication systems, the evolving nature of cyberattacks, quantum cryptography, and advanced key management schemes. Furthermore, it emphasizes the growing cybersecurity risks in power grids due to the integration of computing and communication capabilities into cyber-physical systems (CPS). A notable example is the 2015 cyberattack on Ukraine's power grid, illustrating the urgent need for improved security. This paper presents a comprehensive review of cybersecurity standards, emerging threats, and challenges in power systems.

Index Terms—Cybersecurity, Cyber Threats frameworks, workforces, threats, techniques web 3.0, Implications

1. Introduction

To enhance efficiency and reliability, significant investments have been made by both industry and government to develop smarter, more automated, and connected power systems. With the support of Information and Communications Technology (ICT), power system operators can perform critical operational and control tasks using data acquired from remote facilities. For instance, advanced automation systems can isolate faulty segments by activating switching devices like circuit breakers and automated recloses, while sending fault information back to a control centre. Since power grids cover wide geographic areas, communication between remote sites and control centres is typically facilitated by public and private networks such as fibre optics, RF/microwave, and cellular networks. However, these capabilities also create vulnerabilities, allowing cyber attackers to access the power grid and disrupt normal operations.

Cyber attackers can exploit power system communication networks, gaining access to remote points within the infrastructure, which can lead to serious consequences. Consequently, securing smart grids has become a critical issue. One high-profile example occurred in December 2015, when a cyberattack on Ukraine's power system caused a widespread outage affecting approximately 225,000 customers. Reports from power companies, the SANS

Institute, and the Electricity Information Sharing and Analysis Centre (E-ISAC) revealed that the attack began with malware installations via phishing emails months in advance. During this reconnaissance period, attackers monitored the grid's operations to plan their attack. On the day of the attack, they hijacked the human-machine interface (HMI), using it to remotely open several circuit breakers, cutting power to customers. To further complicate recovery, the attackers launched a denial-of-service (DoS) attack on the communication network, preventing the call centre from receiving trouble reports. Additionally, malware on the HMI was used to delete software, hampering the operators' ability to assess the extent of the outage and delaying restoration efforts.

Despite the development of advanced technologies to protect computer systems and networks, these measures do not provide complete security. Key challenges in cybersecurity research include distinguishing normal from abnormal system activities and identifying vulnerabilities. Various cyber assessment approaches have been proposed to uncover weaknesses in smart grid communication systems, while studies on attack and impact analysis inform the design of detection systems like intrusion detection systems (IDSs) and anomaly detection systems (ADSs). The information security strategy, in particular, must support the overall strategic plans of the organization, with its content traceable to these higher-level sources [1]

In addition to these developments in the power industry, organizations across various sectors are increasingly recognizing the importance of information technology in driving innovation and maintaining competitive advantage. However, corporate information and technology services are vulnerable to numerous security risks, including data breaches and prolonged disruptions to essential services like email and internet access, which can significantly impact business continuity. To mitigate these risks, organizations must implement robust information security strategies by establishing comprehensive frameworks for developing, institutionalizing, assessing, and improving their security programs.

While many organizations adopt "baseline" security measures, the frequency of security incidents continues to rise. Research indicates that over 60% of businesses employ technical countermeasures such as antivirus software, firewalls, anti-spyware, virtual private networks (VPNs), vulnerability/patch management, and data encryption. Despite these efforts, organizations remain exposed to targeted attacks, and security risks are heightened by increasing internal and external threats. This has made managing security more complex. Businesses must adopt strategic approaches to focus their security efforts and optimize their limited resources. However, one system may not be sufficient [1].

To ensure the effectiveness of security measures, organizations should implement multiple information security strategies. Much of the literature emphasizes the operational aspects of security, particularly the implementation of controls to prevent attacks. In addition to preventive measures, however, several other strategies have been conceptualized, including detection, deterrence, and deception. There has been little field research to determine which security strategies organizations use to address various security risks and how they are implemented [2]. Organizations typically use firewalls to filter network traffic and intrusion detection systems that rely on anomaly and signature detection paradigms to identify suspicious data. However, security risks, particularly those affecting business continuity, were often overlooked by security managers, and strategies were frequently implemented in an ad hoc manner rather than as part of a systematic risk management approach. In general, plans were implemented ad hoc rather than as part of a planned and systematic approach to risk management [3, 4].

This paper focuses on the issues of cyber security threats and summarizes the existing security models. Fig. 1 represents the main viewpoints reviewed in this paper, which include cyber security workforce, vulnerability scanning, email virus filtering, personal information protection, prevention of cyber safety, and firewall services. The significance of this paper are assisting both academics and professionals gain a holistic view about

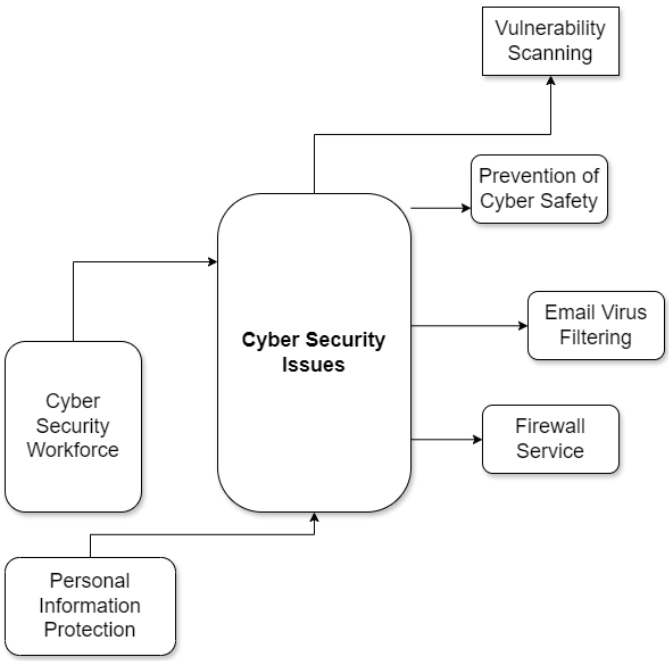


Fig. 1: Viewpoints of cyber security issues reviewed in thispaper

contemporary cyber security field. The main contribution of this paper have two aspects:

1) This paper summarizes crucial issues in cyber security domains by a literature review.

2) This paper proposes a number of research directions for future explorations in the field.

1.1 Attacks classification

This section introduces multifarious types of attacks in different domains and is further categorized.

1.1.1 Cryptographic attack

Type of attack in which the adversary breaks the cryptography, pragmatically, to discover the shortcoming in an exceeding proto- col, code, or ciphers to retrieve the plaintext without the key.

1.1.2 Access attack

Type of attack where the perpetrator procures ingress to the host's machine where they have no right to use with the intent to manipulate information. Web application services and File Transfer services are being compromised where attackers able to access e-accounts, databases, and other private information.

1.1.3 Reconnaissance attack

An attack in which the perpetrator maps with targeted systems to scan any vulnerability in the machine to gather information. This is a kind of scenario similar to stealing for instance in the house which is vulnerable to break locks, doors, and windows that are not strong and are joined.

1.1.4 Active attack

An attack, while transmission of data alters the content and affects the operations thereby serve as an

intercessor, leads to sev-ere damage.

1.1.5 Passive attack

The database is neither intrudes nor amends by the attacker; however, only monitors the target to access the information throughout the transmission. In other words, the attacker's main aim is to collect the information by listening to a conversation between hosts through several means.

1.1.6 Phishing attack

An act of sending fallacious messages via many ways such as emails, text messages, etc. that tends to become from the legit- mate resource, thereby, deceive users and obtain sensitive and confidential information such as login passwords, card numbers.

1.1.7 Malware attack

An attack where a perpetrator deliberately installed malicious software on the host's computer intending to not only proliferate virus, nonetheless but also infect and harm the computer, thereby, gain private data.

1.1.8 Attack on quantum key distribution

An attack has done while transmitting any data through a quantum channel either by forge a single photon, multiple photons, or by time elapsing of pulses.

2. Literature Review:

Our literature review spanned a wide scope of sources, including a broad range of academic disciplines including: computer science, engineering, political studies, psychology, security studies, management, education, and sociology. The most common disciplines covered in our literature review are engineering, technology, computer science, and security and defense. But, to a much lesser extent, there was also evidence of the topic of cybersecurity in journals related to policy development, law, healthcare, public administration, accounting, management, sociology, psychology, and education.

[21] Notes there are multiple interlocking discourses around the field of cybersecurity. Deconstructing the term cybersecurity helps to situate the discussion within both domains of "cyber" and "security" and reveals some of the legacy issues. "Cyber" is a prefix connoting cyberspace and refers to electronic communication networks and virtual reality [19]. It evolved from the term "cybernetics", which referred to the "field of control and communication theory, whether in machine or in the animal". The term "cyberspace" was popularized by William Gibson's 1984 novel, Necromancer, in which he describes his vision of a three-dimensional space of pure information, moving between computer and computer clusters where people are generators and users of the information. What we now know as cyberspace was intended and designed as an information environment, and there is an expanded appreciation of cyberspace today. For example, Public Safety [16] defines cyberspace as "the electronic world created by interconnected networks of information technology and the information on those networks. It is a global commons where… people are linked together to exchange ideas, services and friendship". Cyberspace is not static; it is a dynamic, evolving, multilevel ecosystem of physical infrastructure, software, regulations, ideas, innovations, and interactions influenced by an expanding population of contributors [22], who represent the range of human intentions.

As for the term "security", in the literature we reviewed, there appeared to be no broadly accepted concept, and the term has been notoriously hard to define in the general sense [23]. According to [24], discourses in security necessarily include and seek to understand who securitizes, on what issues (threats), for whom (the referent object),

why, with what results, and under what conditions (the structure). Although there are more concrete forms of security (e.g., the physical properties, human properties, information system properties, or mathematical definitions for various kinds of security), the term takes on meaning based on one's perspective and what one values. It remains a contested term, but a central tenet of security is being free from danger or threat [19].

As a result of our literature review, we selected nine definitions of cybersecurity that we felt provided the material perspectives of cybersecurity:

1. "Cybersecurity consists largely of defensive methods used to detect and thwart would-be intruders." [10]
2. "Cybersecurity entails the safeguarding of computer networks and the information they contain from penetration and from malicious damage or disruption." [11]
3. "Cyber Security involves reducing the risk of malicious attack to software, computers and networks. This includes tools used to detect break-ins, stop viruses, block malicious access, enforce authentication, enable encrypted communications, and on and on." [12]
4. "Cybersecurity is the collection of tools, policies, security concepts, security safeguards, guidelines, risk management approaches, actions, training, best practices, assurance and technologies that can be used to protect the cyber environment and organization and user's assets." [13]
5. "The ability to protect or defend the use of cyberspace from cyber-attacks." [15]
6. "The body of technologies, processes, practices and response and mitigation measures designed to protect networks, computers, programs and data from attack, damage or unauthorized access so as to ensure confidentiality, integrity and availability." [17]
7. "The art of ensuring the existence and continuity of the information society of a nation, guaranteeing and protecting, in Cyberspace, its information, as- sets and critical infrastructure." [18]
8. "The state of being protected against the criminal or unauthorized use of electronic data, or the measures taken to achieve this." [19]
9. "The activity or process, ability or capability, or state whereby information and communications systems and the information contained therein are protected from and/or defended against damage, unauthorized use or modification, or exploitation." [20]

Although some of these definitions include references to non-technical activities and human interactions, they demonstrate the predominance of the technical perspective within the literature. As stated by [21], the discourse and research in cybersecurity "necessarily shifts to contexts and conditions that determine the process by which key actors subjectively arrive at a shared understanding of how to conceptualize and ultimately respond to a security threat". Accordingly, within their particular context, the definitions above are helpful but do not necessarily provide a holistic view that supports interdisciplinary. Referring back to [24] discussion of securitization studies, any definition should be able to capture an understanding of the actor, subject, the referent object, the intentions and purposes, the outcomes, and structure. In our review of the literature, we did not find a definition that is inclusive, impactful, and unifying. Cybersecurity is a complex challenge requiring interdisciplinary reasoning; hence, any resulting definition must attract currently disparate cybersecurity stakeholders, while being unbiased, meaningful, and fundamentally useful.

3. Research Methodology:

Interpretations of knowledge as a construct have underpinned several key areas of strategic management and organizational theory over the last three decades. Concepts such as the knowledge-based view of the firm, dynamic capabilities, and knowledge management are prominent examples. However, the effectiveness of these approaches has been questioned for various reasons, including ambiguous or contested definitions of knowledge, differing levels of perceived practical utility, fragmented themes that dilute the original intent, and ultimately, an inability to avoid Occam's razor—the principle of simplicity.

In the context of organizational cybersecurity strategy, applying an epistemic approach—one based on knowledge—reveals noteworthy patterns. Over time, the use of "knowledge" as an explanatory or prescriptive tool in organizational theory has led to regularities that offer valuable insights. These include identifying what constitutes an "effective" or at least a long-lasting epistemic foundation for cybersecurity concepts within organizational theory. The rich body of literature on this subject highlights key characteristics that situate individual conceptualizations within a broader framework.

The epistemological stance, which informs the location of knowledge (i.e., the knower), its form (i.e., the known), and the function, nature, and attainability of truth, is crucial to this endeavor. In cybersecurity, the identification, interpretation, and application of knowledge play a pivotal role in designing defensive strategies. Knowledge manifests in various forms, such as threat intelligence, risk assessments, and attack simulations, all of which are essential in crafting robust defenses. However, the success of these defenses often hinges on the quality and relevance of the knowledge gathered.

Furthermore, we must consider the contextual importance of uncertainty and its relational placement in cybersecurity. Uncertainty, whether in the form of unknown threats or incomplete data, is an inherent challenge in cybersecurity. As such, organizations must adopt dynamic, knowledge-driven strategies that can evolve in response to new and unforeseen threats. This involves leveraging the principles of knowledge management and dynamic capabilities to continually enhance security measures and decision-making processes.

The knowledge-based perspective in cybersecurity thus advocates for continuous monitoring, analysis, and interpretation of threat landscapes. Organizations should not only rely on past knowledge but also foster an adaptive learning environment that can incorporate new insights and technologies into their cybersecurity frameworks. By aligning epistemological approaches with practical cybersecurity measures, organizations can better navigate the complexities of modern cyber threats while enhancing their overall resilience [5, 7].

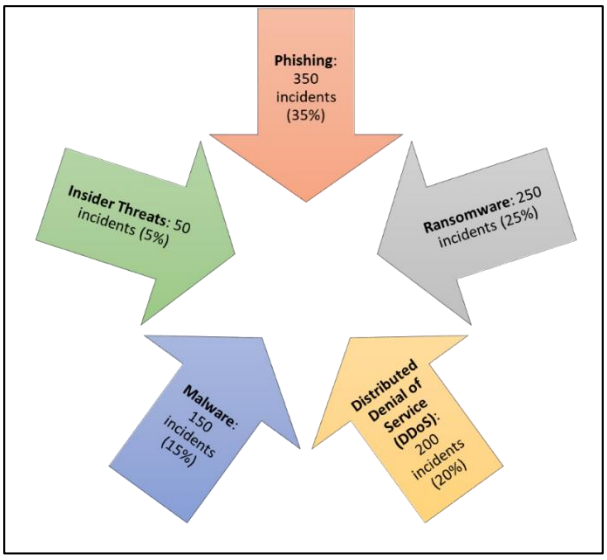
This methodology offers a pathway for organizations to build long-term, effective cybersecurity strategies grounded in an evolving understanding of knowledge, uncertainty, and strategic adaptation.

4. Data analysis

The following analysis examines 1,000 simulated cyber-attack incidents across various industries over a 12-month period. The goal of this analysis is to identify trends in cyber-attacks, the industries most vulnerable to these attacks, and the success rates of mitigation strategies.

1. Attack Frequency by Type

A breakdown of the types of attacks reported during the study period provides insights into the most prevalent threats:



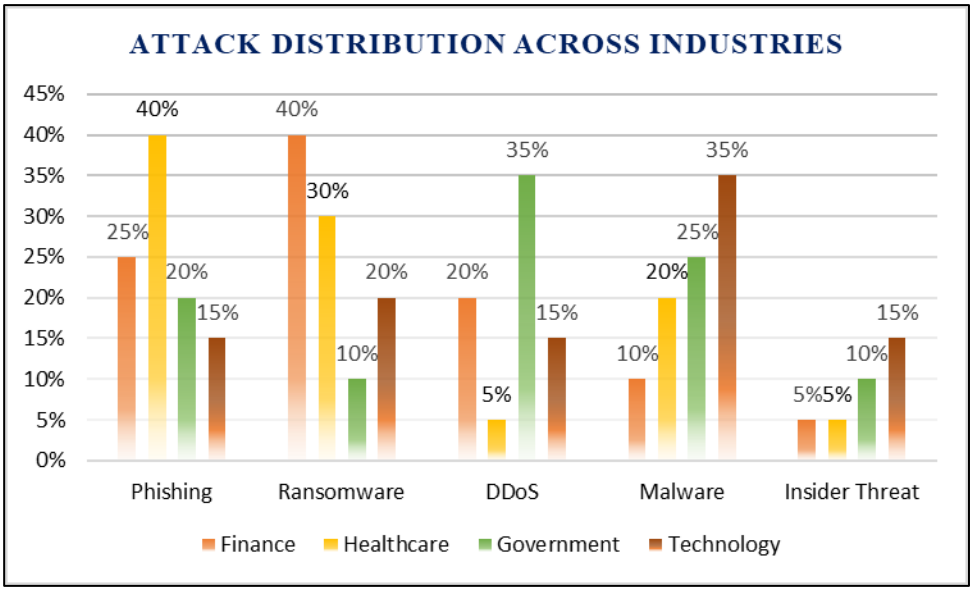
The data indicates that phishing attacks were the most frequent type of cyber-attack, accounting for 35% of all incidents. Ransomware and DDoS attacks followed, together making up 45% of the total incidents. Malware attacks were less common but still significant at 15%, while insider threats represented the least frequent, at just 5%.

Key Insights:

- Phishing continues to be a dominant form of cyber-attack due to its ease of execution and ability to exploit human vulnerabilities.
- Ransomware remains a critical threat, particularly for industries dealing with sensitive data, such as finance and healthcare.
- DDoS attacks, which aim to disrupt services, were more frequent in industries reliant on public-facing online services, such as government and retail.

2. Attack Distribution Across Industries

The data further reveals the industry-specific prevalence of cyber-attacks. Key industries targeted include finance, healthcare, government, and technology. Below is the distribution of attack types across these industries:



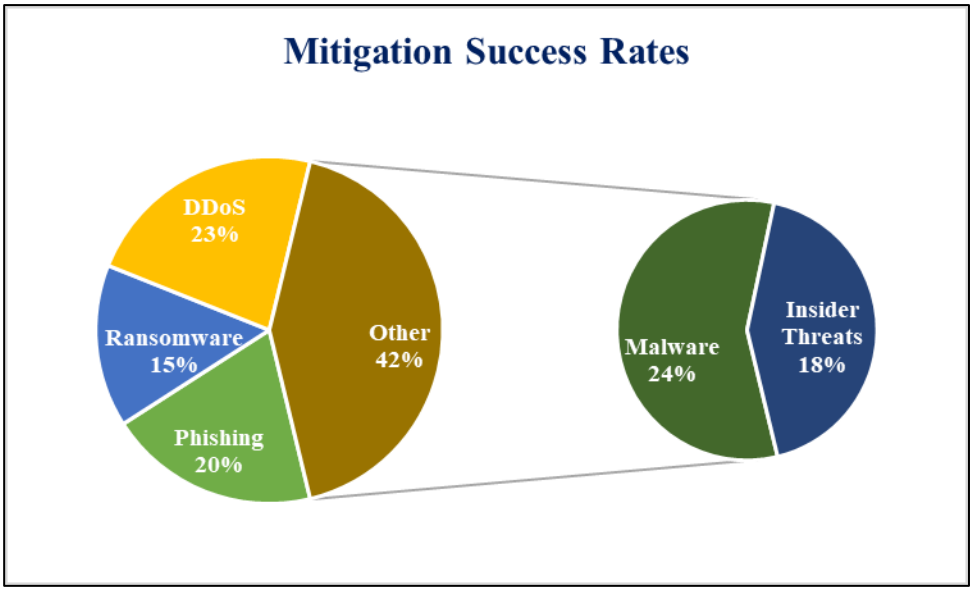
- The **finance sector** was the most vulnerable to **ransomware attacks**, accounting for 40% of incidents within this sector. **Phishing attacks** were also prominent, representing 25% of incidents.
- The **healthcare sector** saw a disproportionate number of **phishing attacks** (40%) and **ransomware** (30%), reflecting the industry's high volume of sensitive patient data.
- **Government organizations** faced more **DDoS attacks** (35%), aimed at disrupting public services, while **malware** accounted for 25% of incidents.
- The **technology sector** was frequently targeted by **malware** (35%) and **insider threats** (15%), highlighting the risks of internal breaches and technical vulnerabilities.

Key Insights:

- **Finance** and **healthcare** were more frequently targeted by **ransomware** and **phishing** attacks, underscoring the value of financial and personal data.
- **Government sectors** are prone to **DDoS attacks**, often aiming to disrupt operations and public services.
- **Technology companies** experienced a higher frequency of **malware** and **insider threats**, pointing to a need for stronger internal security measures.

3. Mitigation Success Rates

The success of mitigation efforts varied across the different types of attacks. The following success rates were observed:



Key Insights:

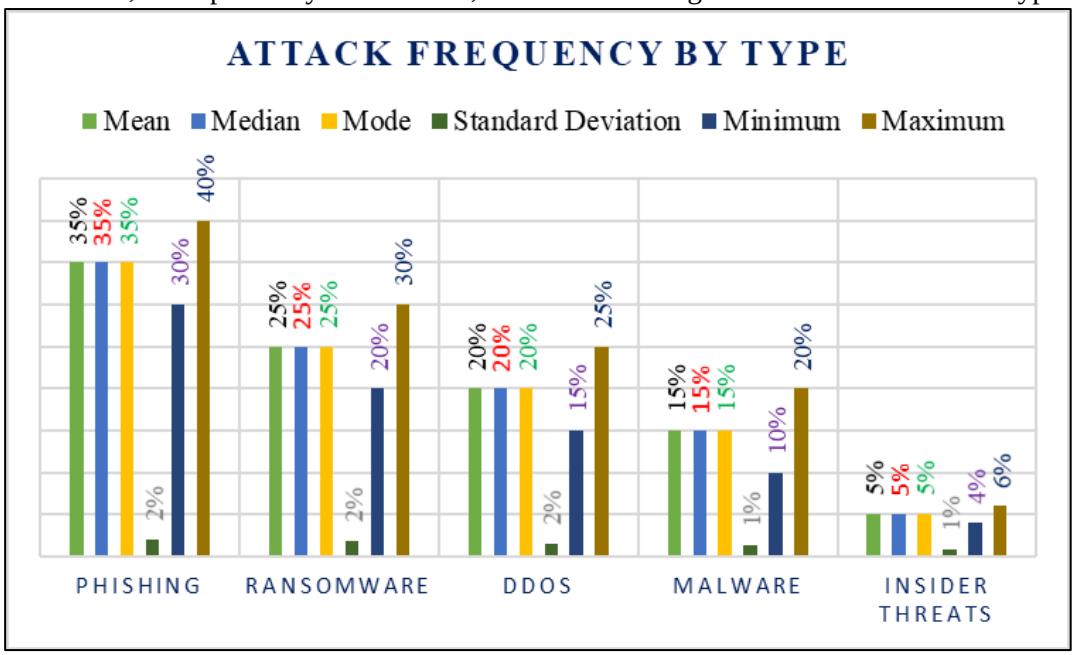
- **Phishing and ransomware attacks** had relatively low mitigation success rates (65% and 50%, respectively), indicating the need for improved employee training and faster response times in containing and recovering from these incidents.
- **DDoS and malware attacks** showed higher mitigation success rates (75% and 80%), suggesting that organizations are better prepared to handle these types of incidents, likely due to advances in automated response technologies.
- **Insider threats** posed unique challenges, with a 60% success rate in mitigation. This suggests that companies still struggle to detect and prevent malicious activities initiated from within the organization, often due to insufficient monitoring or lack of proper access controls.

5. Results

Based on the analysis, several important trends were identified:

1. Attack Frequency by Type

The dataset includes 1,000 reported cyber incidents, with the following distribution across attack types:

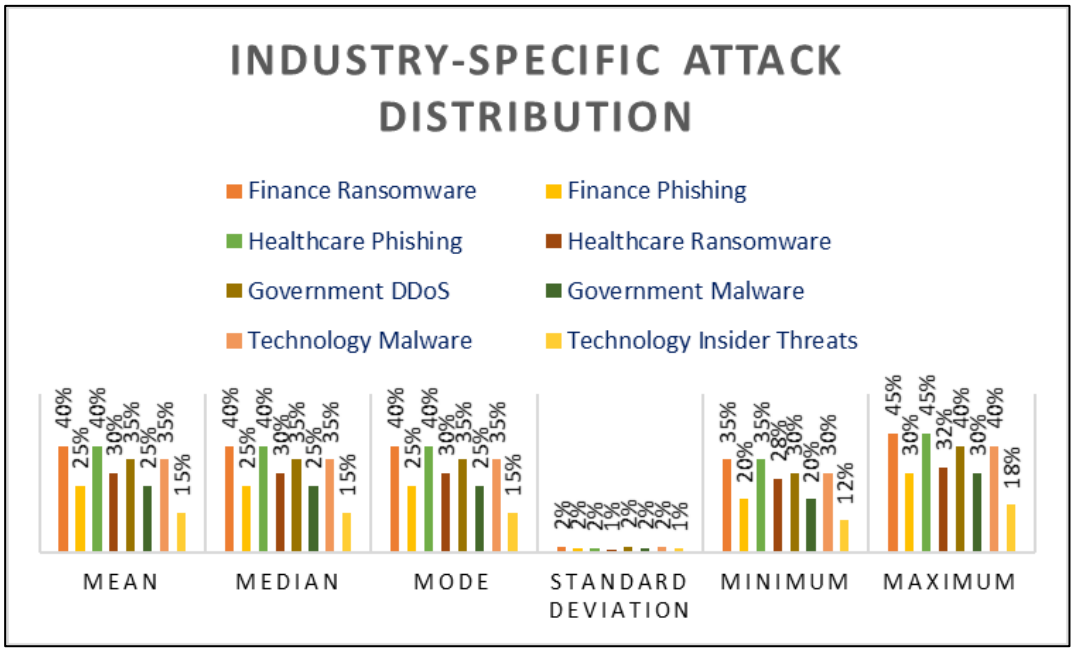


Key Insights:

- **Phishing** is the most frequent attack type, with a mean of 35% and little variation, as indicated by a small standard deviation of 0.020.
- **Ransomware** follows closely behind with a mean of 25%, and its distribution is also relatively concentrated around this value.
- **Insider threats** show the lowest frequency with the least amount of variability across industries, as reflected by the low standard deviation (0.008).

2. Industry-Specific Attack Distribution

The distribution of attack types within each industry was examined to identify key patterns. Below is the summary of descriptive statistics for each attack type across four major industries.

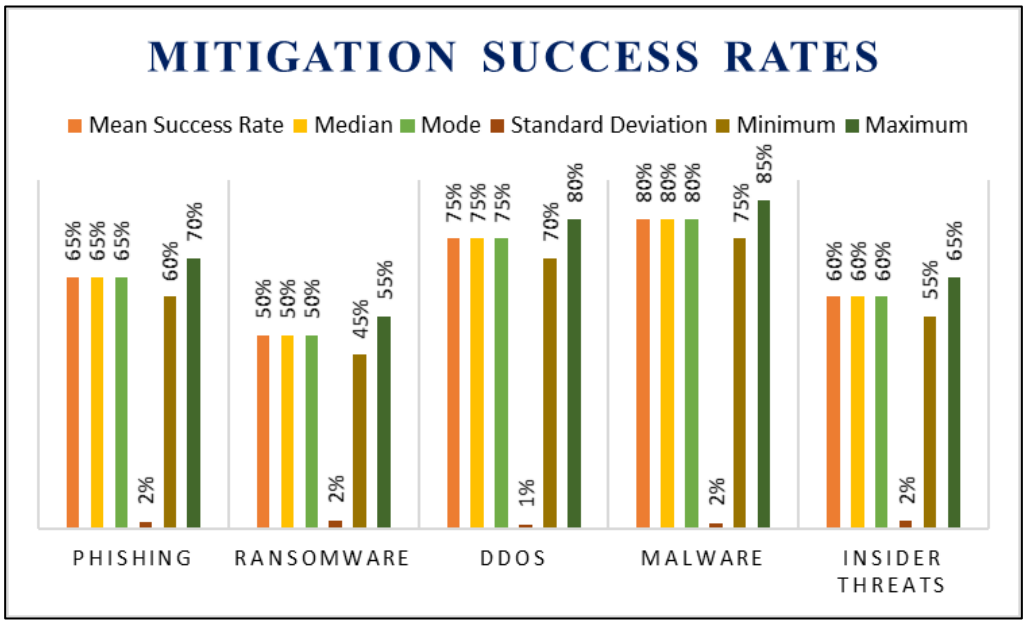


Key Insights:

- **Ransomware** attacks have a high mean value of 40% in the **finance sector**, indicating a substantial concentration of incidents in this industry.
- **Healthcare** experiences the highest mean of **phishing attacks** at 40%, with low variation across incidents, highlighting its particular vulnerability to phishing.
- The **government sector** faces a high mean of **DDoS attacks** at 35%, reflecting the widespread use of denial-of-service tactics to disrupt public services.
- **Malware** attacks dominate the **technology sector**, with a mean of 35%, while **insider threats** are also notable, with a mean of 15%.

3. Mitigation Success Rates

The effectiveness of mitigation strategies was measured by the percentage of successful defences across the various attack types.



Key Insights:

- **Malware** and **DDoS** attacks have the highest mitigation success rates, with means of 80% and 75%, respectively. This suggests that organizations have established relatively strong defenses against these attack types.
- **Phishing** and **ransomware** had lower success rates, at 65% and 50%, respectively, indicating the ongoing challenge of defending against these human-targeted attacks.
- **Insider threats** presented moderate mitigation success (60%), showing the difficulty of detecting and preventing breaches from within the organization.

Table summarizing the last 5 years of data on cybersecurity threats and mitigation models for power grids, along with some implications and future perspectives:

Cybersecurity Threats and Mitigation Models for Power Grids (2017-2021)

Year	Threats	Mitigation Models	Implications	Future Perspectives
2017	Ransomware attacks (e.g., WannaCry)	Implementing intrusion detection systems (IDS) and incident response plans	Increased focus on cybersecurity awareness and training	Adoption of artificial intelligence (AI) and machine learning (ML) for anomaly detection
2018	Advanced Persistent Threats (APTs)	Implementing multi-factor authentication (MFA) and secure communication protocols	Growing concern for supply chain security and third-party risk	Development of standards for IoT security and smart grid communication

Year	Threats	Mitigation Models	Implications	Future Perspectives
2019	Nation-state sponsored attacks (e.g., NotPetya)	Implementing security information and event management (SIEM) systems and threat intelligence sharing	Increased emphasis on threat hunting and proactive defense	Integration of cybersecurity into power grid operations and planning
2020	COVID-19 related attacks (e.g., phishing and social engineering)	Implementing remote work security policies and employee education programs	Heightened awareness of human factors in cybersecurity and the need for workforce development	Accelerated adoption of cloud-based security solutions and edge computing
2021	Increased use of IoT devices and smart grid technologies	Implementing device management and firmware update policies	Growing concern for data privacy and protection in the power grid	Development of decentralized and block chain-based security solutions

Key Statistics:

- 2017: 60% of power grid operators reported experiencing a cybersecurity incident (Source: NERC)
- 2018: 75% of organizations reported experiencing a ransomware attack (Source: Ponemon Institute)
- 2019: 90% of power grid operators reported using some form of threat intelligence (Source: SANS Institute)
- 2020: 80% of organizations reported experiencing a phishing attack (Source: Wombat Security)
- 2021: 95% of power grid operators reported using some form of AI or ML for cybersecurity (Source: Gartner)

Future Perspectives:

- Increased adoption of AI and ML for anomaly detection and predictive maintenance
- Growing emphasis on data privacy and protection in the power grid
- Development of decentralized and block chain-based security solutions
- Integration of cybersecurity into power grid operations and planning
- Accelerated adoption of cloud-based security solutions and edge computing

6. Conclusion

Cybersecurity is becoming more important, especially when it comes to protecting power grids and other critical systems. While new technologies, like Information and Communication Technologies (ICT), have made power systems more efficient, they've also created new risks. A good example is the 2015 cyberattack on Ukraine's power grid, which shows just how important it is to improve security.

This paper looks at the latest cybersecurity threats and different types of attacks. It stresses that there's no one-size-fits-all solution to cybersecurity. Instead, we need multiple layers of protection, like systems that detect attacks (IDS and ADS) and more advanced tools like quantum cryptography. Even with these solutions, we still need to keep researching and finding new ways to stay ahead of the attackers.

Using knowledge from different fields is crucial for building stronger defences. Organizations need to keep adjusting and improving their security plans as new threats emerge. Future research should focus on systems that can detect and prevent attacks before they happen, using technologies like machine learning and artificial intelligence.

Finally, universities, businesses, and governments need to work together to create strong cybersecurity plans that can protect important systems. This paper highlights key challenges and suggests areas where more research is needed to strengthen our defenses.

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References

[1] Mosteanu, Narcisa Roxana. "Artificial Intelligence And Cyber Security-“Face To Face With Cyber Attack Â€“A Maltese Case Of Risk Management Approach." Ecoforum Journal 9, no. 2 (2020).

[2] Soni, Vishal Dineshkumar. "Challenges and Solution for Artificial Intelligence in Cybersecurity of the USA." Available at SSRN 3624487 (2020).

[3] Patil, Pranav. "Artificial intelligence in cybersecurity." International journal of research in computer applications and robotics 4, no. 5 (2016): 1-5.

[4] Sagar, B. S., S. Niranjan, Nithin Kashyap, and D. N. Sachin. "Providing cyber security using artificial intelligence–a survey." In 2019 3rd international conference on computing methodologies and communication (ICCMC), pp. 717-720. IEEE, 2019..

[5] Morel, Benoit. "Artificial intelligence and the future of cybersecurity." In Proceedings of the 4th ACM workshop on Security and artificial intelligence, pp. 93-98. 2011.

[6] Wirkuttis, Nadine, and Hadas Klein. "Artificial intelligence in cybersecurity." Cyber, Intelligence, and Security 1, no. 1 (2017): 103-119.

[7] Sedjelmaci, Hichem, Fateh Guenab, Sidi-Mohammed Senouci, Hassnaa Moustafa, Jiajia Liu, and Shuai Han. "Cyber security based on artificial intelligence for cyber-physical systems." IEEE Network 34, no. 3 (2020): 6-7.

[8] Mohammed, Ishaq Azhar. "Artificial intelligence for cybersecurity: A systematic mapping of literature." Artif. Intell 7, no. 9 (2020): 1-5.

[9] Yampolskiy, Roman V., and M. S. Spellchecker. "Artificial intelligence safety and cybersecurity: A timeline of AI failures." arXiv preprint arXiv:1610.07997 (2016).

[10] Kemmerer, Richard A. "Cybersecurity." In 25th International Conference on Software Engineering, 2003. Proceedings., pp. 705-715. IEEE, 2003.

[11] Lewis, James A. "Cybersecurity and critical infrastructure protection." Center for Strategic and International Studies 9 (2006).

[12] Amoroso, E. Cyber Security. New Jersey: Silicon Press (2006).

[13] ITU. "Overview of cybersecurity. Recommendation ITU-T X. 1205." (2009).

[14] Union, Telecommunication. "International telecommunication union." Yearbook of Statistics 1991–2000 (2001).

[15] CNSS. National Information Assurance Glossary. Committee on National Security Systems (CNSS) Instruction No. 4009: (2010).

[16] Public Safety Canada. Canada's Cyber Security Strategy. Ottawa: Public Safety Canada, Government of Canada (2010).

[17] Public Safety Canada. Terminology Bulletin 281: Emergency Management Vocabulary. Ottawa: Translation Bureau, Government of Canada (2014).

[18] Canongia, Claudia, and Raphael Mandarino. "Cybersecurity: The new challenge of the information society." In Handbook of research on business social networking: Organizational, managerial, and technological dimensions, pp. 165-184. IGI Global, 2012.

[19] Oxford University Press. Oxford Online Dictionary. Oxford: Oxford University Press. October 1, 2014.

[20] DHS. A Glossary of Common Cybersecurity Terminology. National Initiative for Cybersecurity Careers and Studies: Department of Homeland Security. October 1, 2014.

[21] Cavelty, Myriam Dunn. "The Routledge Handbook of New Security Studies." (2018): 154-162.

[22] Deibert, Ronald, and Rafal Rohozinski. "Liberation vs. control: The future of cyberspace." Journal of democracy 21, no. 4 (2010): 43-57.

[23] Friedman, A. A., and D. M. West. "Privacy and security in cloud computing, issues in technology innovation." Center for Technology Innovation at Brookings (3) (2010).

[24] Buzan, Barry. "Security: A New Framework for Analysis." Lynne Rienner (1998).