КІБЕРБЕЗПЕКА: освіта, наука, техніка
CYBERSECURITY: EDUCATION, SCIENCE, TECHNIQUE
№ 4 (28), 2025
ISSN 2663 - 4023
DOI 10.28925/2663-4023.2025.28.762
UDC 004.056

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THE ROLE OF CAPTURE-THE-FLAG (CTF) CHALLENGES IN CYBERSECURITY RESEARCH AND TRAINING: ANALYSIS OF THE "EDITORIAL" MACHINE

Abstract. Cybersecurity threats continue to evolve, requiring continuous improvements in training methodologies. Traditional theoretical education in cybersecurity often lacks practical engagement, leading to a skills gap in real-world security operations. Capture-the-Flag (CTF) challenges have emerged as an effective method for developing critical cybersecurity skills, offering participants a hands-on approach to penetration testing, network security, and privilege escalation techniques. This study explores the educational value of CTF challenges by analyzing the "Editorial" machine from the Hack The Box platform. The article provides a structured walkthrough, detailing key phases such as reconnaissance, exploitation, and privilege escalation. The exploitation phase demonstrates the identification of SQL injection vulnerabilities, while the privilege escalation phase highlights the risks of misconfigured Git repositories and sudo permissions. A scientific analysis of these vulnerabilities is presented, emphasizing their implications for real-world cybersecurity threats. The study also includes defensive strategies to mitigate such risks, advocating for secure coding practices, privilege management, and automated security audits. Additionally, the integration of CTF challenges into professional cybersecurity training is discussed, reinforcing their effectiveness in improving problem-solving skills and real-world preparedness. The findings support the growing role of CTFs in cybersecurity education and professional development. Future research may focus on enhancing the realism of CTF exercises, improving automation for skill assessment, and integrating these challenges into structured cybersecurity curricula. By bridging the gap between theoretical knowledge and hands-on experience, CTFs continue to play a vital role in developing a skilled cybersecurity workforce.

Keywords: cybersecurity; Capture-the-Flag (CTF); penetration testing; privilege escalation; vulnerability exploitation; secure coding practices; threat mitigation; cybersecurity education.

INTRODUCTION

The growing complexity of digital threats necessitates continuous and innovative training methods for cybersecurity professionals. Traditional academic education often focuses on

theoretical foundations without providing practical experience in real-world scenarios. This educational gap hinders the development of comprehensive cybersecurity expertise.

Capture-the-Flag (CTF) competitions have emerged as a practical and engaging approach to addressing this issue. They simulate real-world cybersecurity challenges, allowing participants to hone their skills in areas such as network exploitation, web application security, and privilege escalation.

Despite their popularity, there is limited academic literature that systematically analyzes the lessons learned from CTF events and their applicability to real-world scenarios.

Problem Statement. This paper aims to bridge this gap by conducting a detailed analysis of the "Editorial" machine from the Hack The Box platform. The walkthrough of this CTF challenge demonstrates key techniques used in penetration testing and highlights best practices for cybersecurity training. The study addresses the following research questions:

- What are the critical phases in solving a CTF challenge, and how do they relate to real-world cybersecurity tasks?
- How can lessons from CTF challenges be integrated into formal cybersecurity training programs?
- What defensive measures can organizations adopt based on insights from CTF solutions?

The findings contribute to the growing body of knowledge on the educational and practical value of CTF challenges, emphasizing their role in fostering a skilled cybersecurity workforce.

Analysis of Recent Research and Publications. The problem of reconnaissance, exploitation, and privilege escalation in penetration testing has been extensively studied in cybersecurity research. Various studies have laid the foundation for solving these issues, identifying both effective attack techniques and defensive countermeasures. This section reviews key research contributions and highlights unresolved aspects of the broader problem that this study aims to address.

Reconnaissance Techniques and Their Limitations

Reconnaissance is a critical phase in penetration testing, allowing attackers to gather essential information about a target system. Studies emphasize the efficiency of tools such as Nmap and Gobuster in identifying open ports, services, and website directories [1]. Advanced reconnaissance techniques utilizing AI and large-scale internet scanning platforms, such as Shodan, have further improved the accuracy of vulnerability identification [2, —Å. 45]. However, despite these advancements, research indicates that current intrusion detection systems (IDS) and web application firewalls (WAFs) remain susceptible to evasion tactics, making reconnaissance detection a persistent challenge [3], [4].

SQL Injection Vulnerabilities and Their Persistence

Despite significant awareness and security guidelines, SQL injection remains one of the most critical web application vulnerabilities [5, p. 88]. Studies show that its prevalence is largely due to inadequate input validation, failure to implement parameterized queries, and reliance on outdated security measures [6]. Automated fuzzing techniques and AI-based anomaly detection have been proposed to enhance the early identification of injection vulnerabilities, but practical implementation in real-world applications remains limited [3]. This gap suggests a need for more robust runtime application protection mechanisms that can dynamically detect and neutralize SQL injection attempts before they are exploited [7].

Privilege Escalation Through System Misconfigurations

Privilege escalation is often facilitated by improper sudo configurations, weak file permissions, and exposed sensitive credentials in repositories [4, p. 102]. Research highlights

that Git misconfigurations remain a common issue, as sensitive credentials can often be recovered from commit history, even after deletion [2]. Additionally, studies have demonstrated that misconfigured sudo rules allow attackers to execute arbitrary commands, enabling privilege escalation to root [6]. While regular security audits and role-based access control (RBAC) policies are recommended best practices, implementation inconsistencies across organizations leave systems vulnerable [5].

The Role of Capture-the-Flag (CTF) Challenges in Cybersecurity Training

CTF competitions have gained widespread recognition as a method for enhancing cybersecurity skills by simulating real-world attack and defense scenarios [1], [7]. Research suggests that CTF challenges improve participants' problem-solving abilities and foster a deeper understanding of penetration testing techniques [3]. However, existing studies also highlight the need for greater realism in CTF scenarios, as many challenges focus on theoretical or outdated vulnerabilities rather than modern attack techniques [6]. Future research should explore how AI-driven adversary simulations and real-time threat modeling can enhance the effectiveness of CTF exercises [7].

Unresolved Aspects of the Problem

Despite extensive research in reconnaissance, exploitation, and privilege escalation, several key challenges remain unaddressed:

- Evasion of Defensive Mechanisms: Existing WAFs and IDS solutions struggle to detect reconnaissance activities conducted through advanced enumeration techniques [4].
- SQL Injection Prevention: Although parameterized queries and prepared statements are widely recommended, SQL injection attacks continue to occur due to misconfigurations and human errors [5].
- Detection of Privilege Escalation Attempts: Real-time detection of unauthorized privilege escalation remains a challenge, particularly in cloud and containerized environments [6].
- Enhancing CTF Realism: While CTFs provide valuable training, they often fail to simulate advanced persistent threats (APT) and real-world attack chains, limiting their applicability in professional settings [7].

Addressing these gaps requires further investigation into automated threat detection systems, AI-driven security analytics, and enhanced CTF methodologies to better prepare cybersecurity professionals for evolving threats.

Purpose of the Article. The purpose of this article is to analyze reconnaissance, exploitation, and privilege escalation techniques in penetration testing, using the "Editorial" machine in a Capture-the-Flag (CTF) environment as a case study. The research explores modern attack techniques and corresponding defensive measures that organizations can implement to enhance their security posture.

The objectives of the study include:

– Analyzing modern reconnaissance methods, such as Nmap and Gobuster, and evaluating their effectiveness in identifying vulnerabilities;
– Investigating exploitation mechanisms, particularly SQL injection and attacks on misconfigured user privileges;
– Assessing the risks associated with confidential data leakage due to improper Git repository management;
– Examining defense strategies against attacks through the implementation of secure coding practices, effective access control mechanisms, and automated threat detection systems;

– Identifying the role of CTF competitions in cybersecurity education and improving the practical skills of security professionals.

This article aims to summarize current scientific research in cybersecurity, identify unresolved issues, and provide recommendations for improving both offensive and defensive security measures.

THE ORETICAL FOUNDATIONS OF THE STUDY

This study is based on key theoretical concepts that define the methodology of penetration testing and cybersecurity. This section examines the main approaches, principles, methods, and categories that form the foundation for analyzing reconnaissance, vulnerability exploitation, and privilege escalation in computer systems.

Concepts and Approaches in Cybersecurity

The study relies on the following fundamental concepts:

- Attack and Defense Model in Information Systems — considers the opposition between attackers exploiting vulnerabilities and defensive mechanisms designed to detect and neutralize threats [8].
- Ethical Hacking and Penetration Testing — involves legitimate testing of information systems to identify and mitigate vulnerabilities before malicious actors exploit them [9].
- MITRE ATT&CK Cyber Threat Model — classifies tactics, techniques, and procedures (TTPs) used by adversaries in cyberattacks [10].
- Zero Trust Security Model — operates on the principle of never trusting any user or device until their security status is verified [11].

Fundamental Principles of the Study

The research adheres to the following fundamental principles:

- Offensive Security Principle — systems are tested from an attacker's perspective to identify real security threats [12].
- Least Privilege Principle — limits user and process privileges to reduce unauthorized access risks [9].
- Defense-in-Depth Principle — employs multiple layers of security to protect an information system from various attack vectors [10].
- Automation in Cybersecurity — integrates machine learning and artificial intelligence for real-time threat detection and prevention.

Key Research Methods

The study utilizes a combination of methods that enable a comprehensive assessment of information security:

- Reconnaissance and Information Gathering — used to detect open ports, services, and accessible system resources via tools like Nmap and Gobuster [8].
- Exploitation of Vulnerabilities — examines the possibility of unauthorized access through SQL injection and attacks on unprotected directories [9].
- Privilege Escalation Analysis — studies privilege elevation due to access control misconfigurations, including improper sudo settings and Git repository mismanagement [10].

- Reverse Engineering — investigates internal application logic to identify security flaws [12].
- Capture-the-Flag (CTF) Methodology as a Training Tool — modeled as a practical approach to simulate real cyberattacks and enhance cybersecurity skills [11].

Key Terms and Categories

To ensure a clear understanding of the study's scope, the following key terms are defined:

- Penetration Testing (Pentest) — the process of simulating attacks to identify security weaknesses in systems.
- Reconnaissance — the phase of collecting information about a target system by scanning networks and analyzing exposed services.
- Exploitation — the act of leveraging discovered vulnerabilities to gain unauthorized access.
- Privilege Escalation — obtaining higher levels of access due to configuration errors in access controls.
- Defensive Measures — techniques and tools used to prevent and mitigate cyberattacks.

The study is built on modern cybersecurity approaches, incorporating both offensive and defensive security principles. It employs validated penetration testing methodologies and emphasizes the significance of CTF-based exercises to model real-world attack scenarios and assess the effectiveness of security measures.

RESEARCH METHODOLOGY

Walkthrough of the "Editorial" Machine

1. Information Gathering

Effective reconnaissance is the foundation of any penetration testing engagement. In the "Editorial" machine, the initial phase involved scanning the target using Nmap:

```
nmap -sC -sV -A <target_ip>
```

```
└─$ sudo nmap -sV -sC -A 10.10.11.20
[sudo] password for lomaster:
Sorry, try again.
[sudo] password for lomaster:
Starting Nmap 7.93 ( https://nmap.org ) at 2024-08-17 11:46 EDT
Nmap scan report for 10.10.11.20
Host is up (0.098s latency).
Not shown: 998 closed tcp ports (reset)
PORT   STATE SERVICE VERSION
22/tcp open  ssh     OpenSSH 8.9p1 Ubuntu 3ubuntu0.7 (Ubuntu Linux; protocol 2.0)
| ssh-hostkey:
|   256 0dedb29ce253fbd4c8c1196e7580d864 (ECDSA)
|_  256 0fb9a7510e00d57b5b7c5fbf2bed53a0 (ED25519)
80/tcp open  http    nginx 1.18.0 (Ubuntu)
|_http-server-header: nginx/1.18.0 (Ubuntu)
|_http-title: Did not follow redirect to http://editorial.htb
No exact OS matches for host (If you know what OS is running on it, see https://nmap.org/submit/ ).
TCP/IP fingerprint:
OS:SCAN(V=7.93%E=4%D=8/17%OT=22%CT=1%CU=33778%PV=Y%DS=2%DC=T%G=Y%TM=66C0C61
OS:3%P=x86_64-pc-linux-gnu)SEQ(SP=107%GCD=1%ISR=108%TI=Z%CI=Z%II=I%TS=A)SEQ
OS:(SP=107%GCD=2%ISR=108%TI=Z%CI=Z%TS=A)OPS(O1=M53AST11NW7%O2=M53AST11NW7%O
OS:3=M53ANNT11NW7%O4=M53AST11NW7%O5=M53AST11NW7%O6=M53AST11)WIN(W1=FE88%W2=
OS:FE88%W3=FE88%W4=FE88%W5=FE88%W6=FE88)ECN(R=Y%DF=Y%T=40%W=FAF0%O=M53ANNSN
OS:W7%CC=Y%Q=)T1(R=Y%DF=Y%T=40%S=O%A=S+%F=AS%RD=0%Q=)T2(R=N)T3(R=N)T4(R=Y%D
OS:F=Y%T=40%W=0%S=A%A=Z%F=R%O=%RD=0%Q=)T5(R=Y%DF=Y%T=40%W=0%S=Z%A=S+%F=AR%O
OS:=%RD=0%Q=)T6(R=Y%DF=Y%T=40%W=0%S=A%A=Z%F=R%O=%RD=0%Q=)T7(R=Y%DF=Y%T=40%W
OS:=0%S=Z%A=S+%F=AR%O=%RD=0%Q=)U1(R=Y%DF=N%T=40%IPL=164%UN=0%RIPL=G%RID=G%R
OS:IPCK=G%RUCK=G%RUD=G)IE(R=Y%DFI=N%T=40%CD=S)

Network Distance: 2 hops
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel

TRACEROUTE (using port 8080/tcp)
HOP RTT       ADDRESS
1   135.57 ms 10.10.16.1
2   48.53 ms  10.10.11.20

OS and Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 32.05 seconds
```

Fig. 1. Nmap scan result

This scan revealed open ports and services, including a web server running on port 80. The results indicated the presence of a potential entry point for further investigation.

Scientific Insight: Research underscores the importance of comprehensive reconnaissance in identifying attack vectors [8]. The effectiveness of Nmap as a reconnaissance tool has been extensively documented in academic literature. Its ability to detect open ports and services provides valuable information for subsequent exploitation phases [9, p. 45].

The enumeration of the web server was conducted using Gobuster:

```
gobuster dir -u http://<IP> -w /usr/share/wordlists/dirbuster/directory-list-2.3-medium.txt
```

The scan identified several directories, including /admin. This discovery marked a significant milestone in the reconnaissance phase.

Defensive Perspective: Organizations can mitigate such reconnaissance activities by implementing web application firewalls (WAFs) and configuring servers to limit directory listing [10].

2. Exploitation Phase

After identifying a potential entry point in the /admin directory, further analysis was conducted to assess the security of the login mechanism. Various enumeration attempts revealed that the application lacked proper input sanitization, making it susceptible to SQL injection attacks.

Bypassing Authentication via SQL Injection

To verify the existence of the vulnerability, manual testing was conducted by injecting basic payloads such as:

```
' OR '1'='1' -
```

Upon successful authentication bypass, administrative access to the application was granted. This confirmed the presence of a critical SQL injection flaw.

Scientific Insight: SQL injection remains one of the most critical vulnerabilities in web applications, as highlighted in the OWASP Top 10 [11]. Studies show that inadequate input validation and insufficient parameterized queries contribute to the prevalence of this vulnerability [12, p. 88].

Defensive Perspective: Best practices for mitigating SQL injection include using prepared statements, parameterized queries, and input validation. Organizations should also conduct regular vulnerability assessments to identify and remediate such issues proactively [13].

3. Privilege Escalation

After obtaining initial access as the **dev** user, further exploration of the home directory revealed the existence of an /app folder. Within this folder, a hidden .git directory was discovered. By executing the following commands, crucial sensitive information was uncovered:

Recovering Deleted Credentials from Git History

1. **Listing Commit History:**

```
git log
```

This command displayed recent commit logs, revealing changes made to the repository over time.

ISSN 2663 - 4023

2. **Retrieving Sensitive Data:**

```
git show <commit-uuid>
```

This command revealed that a previous commit contained login credentials for the prod user before they were deleted from the active repository. This oversight allowed an attacker to extract credentials from version control history.

3. **Gaining Access as the Prod User:**

Using the recovered credentials, an SSH connection was established as the **prod** user:

```
ssh prod@10.10.11.20
```

Privilege Escalation via Python Misconfiguration

Once logged in as prod, an analysis of sudo privileges was conducted:

```
sudo -l
```

The output revealed that the **prod** user had the ability to execute Python commands with elevated privileges due to a misconfigured sudo rule allowing execution of:

```
-c protocol.ext.allow=always
```

This misconfiguration allowed an attacker to exploit the system by executing arbitrary commands via a malicious script injection.

Crafting a Malicious Script for Exploitation

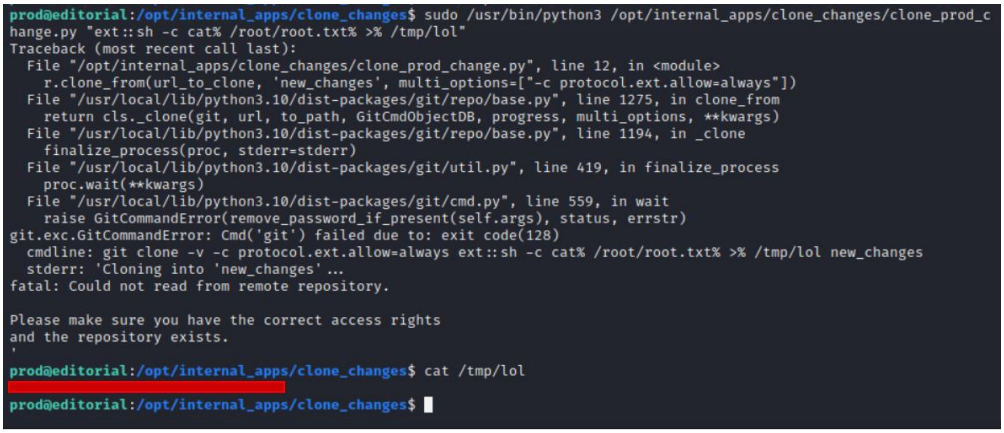

Fig. 2. Malicious Script for Exploitation

1. **Injecting a Custom Protocol Exploit:**

```
ext::sh -c cat% /root/root.txt% >% /tmp/lol
```

- The ext::sh -c prefix allows execution of shell commands via the Git custom protocol.
- The % character is used to escape spaces, ensuring that the payload is properly interpreted by the system.
- The cat /root/root.txt > /tmp/lol command reads the root flag and writes it to a temporary file, allowing the attacker to access sensitive data.

4. Discussion and Analysis

The walkthrough of the "Editorial" machine highlights several key lessons for cybersecurity professionals and organizations. These insights reinforce the importance of both offensive and defensive security strategies in real-world cybersecurity operations.

Importance of Reconnaissance

The initial information-gathering phase demonstrated the critical role of reconnaissance in identifying potential entry points. Without a proper understanding of a system's exposed services, attackers would be unable to develop effective exploitation strategies.

Key Takeaways:

- Attackers rely heavily on tools such as Nmap and Gobuster to enumerate services and directories.
- Organizations should monitor network traffic for suspicious scanning activity and implement intrusion detection mechanisms to detect potential reconnaissance attempts [9].

Exploitation Techniques and Secure Development Practices

The presence of SQL injection vulnerabilities in the "Editorial" machine underscores the necessity of adopting secure coding practices. Web applications remain one of the most common attack vectors due to improper input validation and insecure database interactions [12].

Key Takeaways:

- Secure coding practices, such as the use of parameterized queries and prepared statements, significantly reduce the risk of SQL injection attacks.
- Automated security tools should be integrated into the software development lifecycle (SDLC) to detect vulnerabilities before deployment [13].

Privilege Escalation Through Misconfigurations

Privilege escalation techniques, such as abusing Git misconfigurations and sudo rules, highlight the importance of maintaining strict access controls and secure system configurations. The exploitation of a writable Git repository and the ability to execute arbitrary Python commands provided attackers with an easy path to root privileges [10].

Key Takeaways:

- Organizations must enforce strict file and directory permissions, especially for repositories containing sensitive credentials.
- Regular audits of sudo configurations can help mitigate risks related to overly permissive execution rules [11].

RESEARCH RESULTS

The insights gained from the "Editorial" machine walkthrough reveal several key defensive strategies that organizations should adopt to enhance their security posture. These recommendations align with best practices documented in academic literature and industry guidelines [8, 14].

1. Strengthening Input Validation

The exploitation of SQL injection vulnerabilities in the "Editorial" machine highlights the importance of robust input validation. Studies show that input validation remains a cornerstone of secure application development [7, 15].

Recommended Defensive Measures:

- Use prepared statements and parameterized queries for database interactions.
- Implement server-side input validation to complement client-side checks.
- Conduct automated code reviews to identify and remediate insecure coding practices [10].

2. Hardening User Privilege Configurations

The privilege escalation vulnerability in the "Editorial" machine resulted from misconfigured sudo permissions. Research indicates that improper access control configurations are a leading cause of privilege escalation attacks [16].

Recommended Defensive Measures:

- Apply the principle of least privilege (PoLP) to limit user permissions [6].
- Regularly review and audit /etc/sudoers and other privilege configuration files.
- Implement role-based access control (RBAC) to segregate duties and minimize access risks [12].

3. Secure Repository Management

The ability to recover deleted credentials from Git history highlights the risks associated with improper repository management.

Recommended Defensive Measures:

- Avoid committing sensitive data (e.g., credentials, API keys) to Git repositories [13].
- Use Git hooks or automated scanning tools to detect and prevent accidental exposure of secrets.
- Regularly audit repository history to ensure no sensitive information is retrievable from previous commits.

4. Implementing Advanced Detection Mechanisms

The reconnaissance phase of the attack demonstrated how attackers rely on automated scanning tools to identify potential vulnerabilities. Organizations should deploy security controls to detect and prevent such activities.

5.Recommended Defensive Measures:

- Deploy network intrusion detection systems (NIDS) and host-based intrusion detection systems (HIDS) to monitor network activity [7].
- Configure web application firewalls (WAFs) to block malicious traffic and directory enumeration attempts [7].
- Conduct regular penetration testing to identify and mitigate vulnerabilities proactively [13].

6. Implications for Cybersecurity Education and Training

The analysis of the "Editorial" machine walkthrough has significant implications for cybersecurity education and training. Traditional classroom-based learning often falls short in providing hands-on experience with real-world security challenges. CTF challenges fill this gap by offering an immersive and engaging learning environment.

1. Enhanced Problem-Solving Skills

Research has demonstrated that CTF challenges enhance participants' problem-solving abilities by requiring them to think creatively and analytically [9]. The "Editorial" machine, for example, presented multiple layers of security challenges that demanded a methodical approach to information gathering, exploitation, and privilege escalation.

2. Real-World Skill Development

CTF challenges closely simulate real-world cybersecurity scenarios, providing participants with practical experience in network exploitation, vulnerability assessment, and system hardening [4]. This practical exposure is invaluable for developing the skills needed to combat evolving digital threats [15].

3. Bridging the Education-Industry Gap

By integrating CTF challenges into formal cybersecurity curricula, educational institutions can better prepare students for the demands of the industry. Partnerships between academia and industry can further enhance this integration by providing access to real-world challenges and resources [17].

CONCLUSIONS AND PROSPECTS FOR FUTURE RESEARCH

The detailed analysis of the "Editorial" machine walkthrough from Hack The Box highlights the significant value that Capture-the-Flag (CTF) challenges bring to the development of cybersecurity professionals. CTF competitions not only offer a simulated environment for hands-on training but also serve as a valuable tool for understanding complex attack techniques and the corresponding defensive measures. Based on the findings from this analysis, the following conclusions can be drawn:

1. **Practical Training is Crucial for Cybersecurity Education**
   - CTF challenges bridge the gap between theoretical knowledge and real-world application, enhancing the learning process.
2. **Defense Mechanisms Should Be Incorporated into Cybersecurity Training**
   - Secure coding practices, privilege management, and detection measures should be emphasized alongside offensive techniques.
3. **The Need for Continuous Security Audits and Training**
   - Regular audits and penetration tests are essential to identifying and mitigating vulnerabilities before they are exploited.
4. **CTF Challenges as a Tool for Collaboration**
   - Integrating team-based CTF exercises can improve communication and collaboration within security teams.

Prospects for Future Research

While this paper has focused on the educational and practical benefits of CTF challenges, several areas remain ripe for future investigation:

1. **Enhancing the Realism of CTF Challenges**
   Future research could explore ways to make CTF challenges even more reflective of real-world cybersecurity operations by incorporating live adversary simulations.
2. **Effectiveness of CTFs in Professional Development**
   Longitudinal studies could assess the impact of CTF participation on career advancement and problem-solving capabilities.

3. **Automation of CTF Solutions for Skill Evaluation**
   Developing AI-driven assessment systems for CTF performance could improve training efficiency and provide tailored feedback.
4. **Security Implications of CTF Tools and Platforms**
   Research into the security risks of CTF platforms themselves—such as data exposure, authentication weaknesses, and integrity risks — could help improve their resilience.

The "Editorial" machine walkthrough has provided an in-depth analysis of the methodologies involved in penetration testing and vulnerability exploitation within CTF challenges. By studying these challenges in greater detail, cybersecurity professionals gain valuable insight into both offensive and defensive practices. As cybersecurity threats continue to evolve, integrating practical exercises like CTFs into training and education programs will be critical for developing a skilled, capable workforce.

Through increased academic investigation into the value of CTF challenges, as well as ongoing refinement of the CTF framework itself, the future of cybersecurity training can be better aligned with the ever-changing landscape of digital threats.

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КІБЕРБЕЗПЕКА: освіта, наука, техніка
CYBERSECURITY: EDUCATION, SCIENCE, TECHNIQUE
№ 4 (28), 2025
ISSN 2663 - 4023

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РОЛЬ ЗАВДАНЬ ІЗ ЗАХОПЛЕННЯ ПРАПОРА (CTF) У ДОСЛІДЖЕННЯХ І НАВЧАННІ З КІБЕРБЕЗПЕКИ: АНАЛІЗ «РЕДАКЦІЙНОЇ» МАШИНИ

Анотація. Кіберзагрози постійно розвиваються, що вимагає безперервного вдосконалення методів підготовки фахівців. Традиційна теоретична освіта в галузі кібербезпеки часто не передбачає практичного застосування знань, що створює розрив між академічними знаннями та реальними викликами в інформаційній безпеці. Змагання Capture-the-Flag (CTF) стали ефективним методом розвитку критичних навичок кібербезпеки, надаючи учасникам можливість практичного відпрацювання методів тестування на проникнення, аналізу вразливостей мережевих систем та ескалації привілеїв. У цьому дослідженні розглядається освітня цінність CTF-завдань на основі аналізу машини «Editorial» з платформи Hack The Box. У статті представлено структурований покроковий аналіз ключових етапів атаки, таких як розвідка, експлуатація вразливостей та ескалація привілеїв. Під час фази експлуатації розглядається SQL-ін'єкція як одна з критичних вразливостей, тоді як етап ескалації привілеїв демонструє ризики, пов'язані з неправильними налаштуваннями Git-репозиторіїв та sudo-доступу. Науковий аналіз цих вразливостей дозволяє оцінити їх реальний вплив на інформаційну безпеку. У роботі також запропоновані стратегії захисту, включаючи впровадження безпечного написання коду, ефективне управління привілеями та автоматизований аудит безпеки. Досліджено можливості інтеграції CTF-змагань у професійну підготовку спеціалістів з кібербезпеки, підкреслюючи їхню роль у розвитку навичок вирішення реальних загроз та підготовки до роботи у сфері інформаційної безпеки. Отримані результати підтверджують важливу роль CTF-завдань у навчанні та професійному розвитку. Подальші дослідження можуть бути зосереджені на підвищенні реалістичності CTF-змагань, розширенні автоматизації оцінювання навичок та інтеграції цих підходів у формальну систему кібербезпеки. Поєднання теоретичних знань із практичним досвідом робить CTF важливим інструментом у підготовці висококваліфікованих спеціалістів у сфері інформаційної безпеки.

Ключові слова: кібербезпека; захоплення прапора (CTF); тестування на проникнення; підвищення привілеїв; експлуатація вразливостей; безпечне кодування; зменшення загроз; освіта з кібербезпеки.

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