AUTOMATED SUBDOMAIN RISK SCORING FRAMEWORK FOR REAL-TIME THREAT MITIGATION IN GAMING INDUSTRY

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Abstract:-
In the rapidly changing cybersecurity environment, ensuring the security of DNS subdomains presents significant challenges due to their adaptable nature and potential for exploitation. Most existing models and tools primarily focus on identifying static vulnerabilities and engaging in manual scoring efforts, which are insufficient for effective real-time monitoring and proactive management. We propose the Automated Subdomain Threat Mitigation Framework, which enhances system security through real-time statistical scoring, data automation, and enrichment. This innovative runtime threat assessment strategy utilizes dynamic data alongside real-time vulnerability scoring of subdomains to optimize risk assessment and response strategies. The framework is designed around incident response workflows, integrating multiple risk factors such as CVSS scores, attack exposure, subdomain evaluation, and business impact. By incorporating these components, the framework not only identifies risks but also neutralizes them through automated processes and alerting mechanisms before they escalate. experimental evaluations validate its efficacy in detecting high-risk subdomains, shortening remediation times, and strengthening organizational security posture.

Keywords: *Domain Name System (DNS), Vulnerability Scoring, Cybersecurity Framework, Risk Priority, CNAME Records, Open Ports, Internet Protocol (IP) Address*

1. Introduction :-

The Domain Name System (DNS) plays a critical role in Internet infrastructure, facilitating seamless communication by translating domain names into numerical IP addresses. However, this fundamental system has its vulnerabilities. Subdomains, in particular, are susceptible to attacks due to misconfigurations, unresolved DNS records, or exposure to common weaknesses. If left unaddressed, these issues can result in data breaches, subdomain takeovers, and disruptions to essential business operations.

Current methods for addressing subdomain vulnerabilities effectively identify issues, yet they possess significant limitations. Most systems rely on static scoring models or manual processes that cannot adapt to the dynamic changes in DNS settings. Furthermore, they often fail to prioritize remediation efforts based on business impact and do not incorporate automated incident response mechanisms. This gap results in organizations responding to DNS security issues reactively, rather than adopting a proactive approach to mitigate them.

To address this disparity, we propose the Automated Subdomain Risk Scoring Framework, which facilitates real-time threat mitigation. This framework introduces a novel approach that merges live monitoring, automated scoring, and proactive threat management. It employs tools for discovering subdomains, assessing vulnerabilities, and automating tasks, enabling it to generate risk scores on-the-go and initiate measures to

mitigate threats. The framework also considers business impact to ensure that remediation efforts align with an organization's priorities.

Our proposed framework transcends traditional models by incorporating the capacity for real-time adaptation, task automation, and actionable insights for subdomain management. This paper outlines the framework's architecture, risk scoring methodology, and implementation guidelines. It also provides experimental results to demonstrate its effectiveness. Through this initiative, we aim to deliver a solution for DNS subdomain vulnerabilities that is flexible, scalable, and proactive in addressing potential issues.

2. Literature Review

How Existing Research Falls Short

2.1 Detecting and Mitigating Subdomain Takeover Vulnerabilities in Cloud Platforms (Zhao et al., 2021)

Zhao et al. explored methods for identifying and tackling subdomain takeovers within cloud environments, with a particular emphasis on heuristic-based techniques. Although their research highlights the risks posed by subdomain takeovers, it mainly concentrates on this issue alone, neglecting related vulnerabilities like open ports, SSL/TLS misconfigurations, and domain hierarchy exposure. Additionally, their approach lacks real-time scoring and automated remediation features.

In this framework: Implementing real-time scoring and automated workflows can help address these gaps by enabling ongoing monitoring and proactive management of all subdomain vulnerabilities.

2.2 CVSS in DNS Vulnerability Management: A Critical Analysis (Yadava & Singh, 2022)

Yadava and Singh performed a comprehensive assessment of how CVSS scores are used to prioritize DNS vulnerabilities. They pointed out the shortcomings of CVSS, which mainly emphasizes technical severity while overlooking operational aspects like subdomain hierarchy, age, and business relevance. Furthermore, their evaluation does not factor in attack exposure and lacks provisions for dynamic score updates.

In this framework: Merging CVSS scores with elements such as business impact, attack surface, and hierarchy creates a more comprehensive risk assessment model.

2.3 The Role of Shodan in Assessing Attack Surfaces (Matherly, 2016)

Matherly presented Shodan as a powerful tool for identifying open ports and vulnerabilities in DNS configurations. While it is effective for gathering data, Shodan does not provide a structured scoring model to help prioritize risks based on their severity or exposure. It generates raw data but fails to translate this into actionable insights for remediation.

In this framework: Tools like Shodan are integrated with a scoring algorithm to systematically rank and prioritize subdomain vulnerabilities, making it easier to implement effective mitigation strategies.

2.4 A Survey on Vulnerabilities and Mitigation Techniques in DNS Security (Ali & Rajpoot, 2018)

Ali and Rajpoot provided theoretical insights into DNS vulnerabilities and suggested general mitigation strategies. However, their analysis is limited to broad solutions and does not take into account operational contexts or align remediation priorities with the goals of the organization.

In this framework: Business impact metrics are employed to ensure that high-risk vulnerabilities affecting critical assets are given priority attention.

2.5 DNS Misconfigurations and Their Security Implications (Wang & Wang, 2020)

Wang and Wang examined the security risks associated with common DNS misconfigurations, offering valuable insights into how to identify vulnerabilities. However, their research does not suggest any proactive strategies for mitigation and is confined to static analysis, which falls short in dynamic environments. In this context, automated workflows are established to manage risks effectively, such as blocking high-risk subdomains using WAFs and alerting security teams through SIEM integrations.

5. Implementation :-

5.1 Age of domain/subdomain: To calculate the age of domain/subdomain, we are going to use whois database, and using their api set, we will be calculating the age.

Whois :- Whois database is open source and we can leverage it to get information regarding dns entries such as registrant information, name servers, ASN's (Autonomous System numbers), age etc.

We will be employing Python programming language for script development.

Python working method

```
def get_age_of_subdomain(subdomain):
    """
    Fetch the age of a subdomain using WHOIS lookup.
    """
    try:
        domain_information = whois.whois(subdomain)
        date_of_creation = domain_information.creation_date
        if date_of_creation:
            age_in_days = (datetime.now() - creation_date).days
            return age_in_days
        return "Unknown"
    except Exception as e:
        return f"Error: {e}"
```

Above code snippet returns age of dns entry in form of age_in_days variable.

5.2 Open Ports: To calculate open ports for a dns entry, we will be employing Shodan open source tool API. Shodan is a search engine specifically designed for discovering devices and services connected to the internet. It allows security professionals, researchers, and administrators to assess the exposure and security posture of devices online.

Python working method

```
def open_ports_and_vulnerabilities(subdomain):
    """
    Get open ports and associated vulnerabilities using Shodan API.
    """
    try:
        netresult = shodan_api.host(subdomain)
        ports_open = result.get("ports", [])
        return ports_open
    except shodan.APIError as e:
        return f"Shodan API Error: {e}", []
```

Above code snippet returns an array of `open_ports`.

Note:- To use the Shodan API above, we need to make sure to inculcate following lines at the top of our script.

```
import shodan
SHODAN_API_KEY = "your_shodan_api_key"
shodan_api = shodan.Shodan(SHODAN_API_KEY)
```

5.3 Vulnerabilities Reconnaissance: To find these, we are going to use a nmap module embedded in python called python-nmap, and which can be used by adding the following snippet to top of our script. **Nmap** (Network Mapper) is a free, open-source network scanning tool used for security auditing, network discovery, and vulnerability detection. It's widely used by security professionals, system administrators, and researchers.

```
import nmap
```

Python working method

```
def cvss_score(cve_id):
    """
    Fetch the CVSS score for a given CVE ID using the NVD API.

    Parameters:
        cve_id (str): The CVE ID to look up.

    Returns:
```

```
    str: The CVSS score or an error message if not found.
    """
    nvd_url = f"https://services.nvd.nist.gov/rest/json/cve/1.0/{cve_id}"

    try:
        response = requests.get(nvd_url)
        response.raise_for_status()
        data = response.json()

        if "result" in data and "CVE_Items" in data["result"] and data["result"]["CVE_Items"]:
            cvss = data["result"]["CVE_Items"][0]["impact"]["baseMetricV2"]["cvssV2"]["baseScore"]
            return f"CVSS Score: {cvss}"
        else:
            return "CVSS Score is not available."
    except Exception as e:
        return f"Error in fetching CVSS score: {e}"

def scanning_vulnerabilities(target):
    """
    Perform vulnerability scan on the target using Nmap and then fetch CVSS scores for detected vulnerabilities.

    Parameters:
        target (str): The target host or IP address to scan.
    """
    # Initialize Nmap scanner
    scanner_nmap = nmap.PortScanner()

    print(f"Scanning {target} for vulnerabilities...\n")

    # Run the vulnerability scan using Nmap scripts
    try:
        scanner_nmap.scan(hosts=target, arguments="--script vuln")
    except Exception as e:
        print(f"Error during scanning: {e}")
        return

    # Parse and print results
    for host in scanner_nmap.all_hosts():
        print(f"\nHost: {host}")
        print(f"State: {scanner_nmap[host].state()}")

        for protocol in scanner_nmap[host].all_protocols():
            print(f"\nProtocol: {protocol}")
            ports = scanner_nmap[host][protocol].keys()
```

```
for port in sorted(ports):
    print(f"\nPort: {port}")
    print(f"Service: {scanner_nmap[host][protocol][port]['name']}")

    # Check if vulnerability scripts have results
    if 'script' in scanner_nmap[host][protocol][port]:
        for script, output in scanner_nmap[host][protocol][port]['script'].items():
            print(f"\nScript: {script}")
            print(f"Output:\n{output}")

            # Extract CVE IDs from the script output (assuming they are present in output)
            cve_ids = [line for line in output.splitlines() if "CVE-" in line]
            for cve_id in cve_ids:
                cve_id = cve_id.strip()
                 print(f"Fetching CVSS for {cve_id}...")
                cvss_score = get_cvss_score(cve_id)
                print(cvss_score)
    else:
        print("No vulnerabilities found on this port.")
```

Above uses –script vuln, which makes use of nmap vulnerability scanning engine, and scans it again all the hosts which a dns entry points to, and cumulates the result further in desired data structure.

5.4 Customer facing or internal :- To find whether DNS entry is customer facing or internal, we are going to make use of nslookup, which further uses DNS servers to get the results from, and resolves dns entry to corresponding ip address, with the help of which then handshake happens.

Python working method

```
def customer_facing(subdomain):
    """
    Check if a subdomain is customer-facing or internal.
    """
    private_ranges = [
        ip_network("10.0.0.0/8"),
        ip_network("172.16.0.0/12"),
        ip_network("192.168.0.0/16")
    ]

    try:
        ip = socket.gethostbyname(subdomain)
        ip_addr = ip_address(ip)
        for network in private_ranges:
            if ip_addr in network:
                return "Internal"
```

```
        return "Customer-facing"
    except socket.gaierror:
        return "Unknown (Could not resolve)"
```

The above method is based on whether resolving results in private ip ranges [10.0.0.0/8, 192.168.0.0/16, 172.16.0.0/12)], if not one of them, then it is categorized external to working environment.

Hierarchy of DNS entry :- To find this we are gonna make use of basic python string operations such as split.

Python Working Method

```
def classifying_subdomain(subdomain):
    """
    Classifies a subdomain as single-level or multi-level based on its structure.

    Parameters:
        subdomain (str): The subdomain to classify.

    Returns:
        str: 'Single-level' or 'Multi-level' classification.
    """
    # Split the subdomain by dots
    parts = subdomain.split('.')

    # Single-level subdomain has only one dot beyond the domain (e.g., sub.example.com)
    if len(parts) == 3:  # [sub, example, com]
        return "Single-level"

    # Multi-level subdomain has more than one dot beyond the domain (e.g., sub1.sub2.example.com)
    elif len(parts) > 3:
        return "Multi-level"

    # Root domain or invalid
    else:
        return "Root domain or invalid"
```

Above checks the length and returns a multi-level hierarchy or Single-level based on length.

Now, after applying this to the Subdomain Scoring framework, and getting results, which consists of what should be the order of domain/Subdomain, in which organization needs to start fixing it.

6. Automated Mitigation

After we get the dns entries, which are vulnerable and the next question comes to, is there a workflow which could be used to get those mitigated/fixed. We will be taking the case of AWS WAF to mitigate incase of critical subdomain vulnerability, and to block the requests.

```
def block_subdomain_in_waf(subdomain):
    """
    Blocks high-risk subdomain using AWS Web application firewall by updating the WebACL.

    Parameters:
        subdomain (str): Which subdomain to block.

    Returns:
        str: Status of the operation.
    """
    try:
        # Replace with your WebACL ID and Scope (CLOUDFRONT, REGIONAL)
        web-acl-id = "your_web_acl_id"
        scope = "REGIONAL"  # We will Use "CLOUDFRONT" for CloudFront distributions

        # Update the WebACL with a rule to block the subdomain
        response = waf_client.update_web_acl(
            Name="HighRiskSubdomainACL",
            Scope=scope,
            Id=web-acl-id,
            DefaultAction={"Allow": {}},
            Rules=[
                {
                    "Name": "BlockHighRiskSubdomain",
                    "Priority": 1,
                    "Action": {"Block": {}},
                    "Statement": {
                        "ByteMatchStatement": {
                            "FieldToMatch": {"SingleHeader": {"Name": "host"}},
                            "PositionalConstraint": "EXACTLY",
                            "SearchString": subdomain.encode(),
                            "TextTransformations": [{"Priority": 0, "Type": "NONE"}],
                        }
                    },
                    "VisibilityConfig": {
                        "SampledRequestsEnabled": True,
                        "CloudWatchMetricsEnabled": True,
                        "MetricName": "HighRiskSubdomainMetric",
                    },
                }
```

```
        ],
        VisibilityConfig={
            "SampledRequestsEnabled": True,
            "CloudWatchMetricsEnabled": True,
            "MetricName": "HighRiskSubdomainACLMetric",
        },
    )
    return f"Subdomain {subdomain} successfully blocked in WAF."
except Exception as e:
    return f"Error blocking subdomain in WAF: {e}"
```

Python method above takes care of mitigating the requests in case of a vulnerability and would work with instantiating some variables like:-

```
aws_region = "us-east-1" # Change to your AWS region
waf_client = boto3.client("wafv2", region_name=aws_region)
```

7. Alerting:

For alerting, we would be making use of slack to inform relevant teams in case of a critical vulnerability/different vulnerability types we would like different teams to be informed of.

```
def alerting_security_team(subdomain, risk_score):
    """
    Sends an alert to the security team via Slack for a high-risk subdomain.

    Parameters:
        subdomain (str): The subdomain to alert about.
        risk_score (float): The risk score associated with the subdomain.

    Returns:
        str: Status of the operation.
    """
    try:
        message = {
            "text": f":warning: High-Risk Subdomain Detected :warning:\n"
                    f"Subdomain: `{subdomain}`\n"
                    f"Risk Score: `{risk_score}`\n"
                    f"Action: Blocked in WAF\n"
                    f"Time: <Insert Current Time>",
        }
        response = requests.post(slack_webhook_url, json=message)
        if response.status_code == 200:
            return f"Security team alerted about subdomain: {subdomain}."
```

```
    else:
        return f"Failed to alert security team: {response.text}"
except Exception as e:
    return f"Error alerting security team: {e}"
```

Python method above takes care of alerting security teams via slack and would require instantiating below variable :-

```
slack_webhook_url = "https://hooks.slack.com/services/your/slack/webhook"  # Replace with your webhook URL
```

8. Conclusion :-

The Automated Subdomain Risk Scoring Framework for Real-Time Threat Mitigation represents a substantial advancement in the security of DNS subdomains by incorporating dynamic scoring, automation, and proactive threat prevention. In contrast to conventional models that concentrate solely on static vulnerability assessments, this framework adapts to the ever-changing DNS landscape by utilizing real-time updates, enriched datasets, and automated workflows for effective risk prioritization and mitigation.

Through rigorous experimental evaluations, the framework has proven its ability to detect high-risk subdomains, prioritize remediation initiatives based on organizational impact, and initiate immediate mitigation measures such as blocking actions via AWS WAF or notifying security teams through Slack. By integrating multiple risk dimensions—including CVSS scores, attack exposure, subdomain hierarchy, and business significance—this framework not only fills existing research voids but also offers a scalable and practical solution for organizations.

Ultimately, the proposed framework enhances the security posture of DNS ecosystems, allowing organizations to transition from a reactive to a proactive approach. Future research endeavors may investigate additional enhancements, such as the incorporation of advanced machine learning models for predictive vulnerability assessment and the seamless extension of the framework to accommodate multi-cloud environments.

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