An Information Scraping Framework to Prevent Future attacks

Raihan Uddin[1], ***Ashish Jain**[2]

[1]Department of Computer Science, Sharda University,
Greater Noida, India
raihanuddin8131@gmail.com

[2]Department of Computer Science, Sharda University,
Greater Noida, India
ashish.neetu1981@gmail.com

Abstract: This module discovers possible subdomains associated with a particular primary domain by DNS resolution and brute-force techniques. This technique makes sure that the target's footprint is comprehensively evaluated. The framework adds an active subdomain validation step following the discovery stage. This function checks validation through active and inactive or stale subdomains by distinguishing all captured subdomains to ascertain was captured is operational boast was capture pilot active titles. This ability is crucial in helping maintain the digital health of the target domain. The third subelement of the main framework is the Verification of Communications with Active Subdomains. This involves acquiring names and relevant direct or indirect links attributed to each subdomain, capturing valuable data for further inquiry or campaign efforts. The combination of these elements makes the framework a powerful asset for web mapping, security analysis, and digital intelligence. With its modular structure, the framework is flexible and adaptable for different cybersecurity and research purposes. This work contributes to the fast marching domain of automated domain analysis in response to the need for detailed and efficient analysis in sophisticated systems.

Keywords: DNS, enumeration subdomain, scraping information, finding subdomain, and domain attacks

1. **Introduction:** Now in today's world of cybersecurity, gathering information has become a key first step in finding weaknesses and making a system's defences stronger. Proper automation and optimisation processes need to make information scraping easier. Subdomain enumeration, vulnerability identification, and data validation are all steps that are necessary for attack surface mapping and finding security holes that can be exploited [1].

   As part of cybersecurity assessment, subdomain enumerations are very helpful for showing information and finding DNS misconfiguration that can leads to subdomain takeover. Recent research shows the attackers often use the domain name server misconfigurations, especially in CNAME records, to take over subdomains. This is a big security risk because it can lead to the phishing attacks and getting around the security protocols. Frameworks like Sudomy and tools that use generative adversarial networks (GANs) have come a long way in making it easier to find subdomains with more accuracy and coverage.[2]

   Present processes of discovering subdomains and detecting vulnerabilities have a number of issues. These issues are a rigid approach to doing things, use of public datasets that might lack the full details, and the use of manual validation. Furthermore, since attackers continue to reuse automated tools, there is more of a need for frameworks that are scalable, efficient, and flexible [5].

   This paper intends to design an information-scraping framework using the open-source tools that incorporate state-of-the-art techniques like GANs to further the discovery and analysis of subdomains. The framework combines automation and strong validation systems in hopes of overcoming weaknesses in the other approaches, that providing a higher level of performance in

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finding the vulnerability. This framework is constructed upon principles drawn from methodologies with established standards, for example National Institute of Standards and Technology (NIST) SP 800-42 and Information Systems Security Assessment Framework (ISSAF), so it has the wide applicability over various cyber-security contexts.[3]

Integrity of online system is now among the largest issues for people and organizations in the new realm of cybersecurity. The primary problem with this is identifying and resolving vulnerabilities created through URL fuzzing and subdomain enumeration. These are both extremely valuable security checks because they identify unseen or unused subdomains and search for URL patterns that are vulnerable. The raccoon tool, as examined within the study conducted by B.S.P, S.V., V.U., and Y.S., is a major improvement when it comes to automating the process of tasks associated with fuzzing url and enumeration subdomain. When manual methods become irrelevant because of complexity, efficient scalable tools are needed, as given by Raccoon, which identify security vulnerabilities at the rate at which digital infrastructure grows but also make cyber security professionals capable of actively taking effective action against threats[2].

Web scraping frameworks and tools have evolved considerably over the past decade, with various approaches and tools aiding automated data extraction. This section looks at existing frameworks, tools, and research that have assisted web scraping and gathering of data. BeautifulSoup and Scrapy are prominent frameworks within the Python community. Beautiful Soup is well-liked because it simplifies HTML parsing and is easy to use, particularly for static websites. Scrapy is a larger framework that provides a robust base for creating scalable spiders. Yet both utilities have limitations when dealing with contemporary websites which make heavy use of JavaScript and elaborate login systems.[5]

Selenium and Puppeteer emerged as solutions to scrape dynamic web pages. The tools enable users to engage with pages that contain JavaScript and sophisticated user interfaces. They function well but use plenty of computer power and struggle to scale. Initiatives such as Playwright extended these concepts, offering more performance and the capacity to engage across various browsers. Commercial platforms such as Import.io, Octoparse, and ParseHub established simple means to undertake web scraping without needing coding. These solutions focus on ease of use for non- technical users but may not support the level of flexibility and customization needed for advanced scraping applications. Commercial-grade offerings such as Diffbot and Apify offer advanced AI- facilitated extraction capabilities but at a high cost.[7]

Numerous libraries and tools have been designed in response to the rising issue of anti-bot technologies. Rotating-Proxy-Manager and Scrapeops are tools that aim at IP address changing and request pattern management. Studies on browser fingerprinting and evading detection have led to improved means of maintaining scraping consistent. Additional tools for ensuring data quality have emerged with scraping solutions. Projects such as Cerberus and Schema will assist in locating gaps in the prediction and determining solutions to gaps, which have high validation capabilities. Meanwhile, data cleaning tools such as OpenRefine provide sophisticated features for data transformation. The study involves examining various algorithms and checking their performance and parameters in detection. These primitives assist in ensuring that information is valid in automated collection systems. Our Information Scraping Framework advances these fundamentals but eliminates their issues, offering an improved and more comprehensive solution for the web scraping demands of today. It incorporates teachings from existing tools as well as delivers new solutions to address prevalent issues within the domain[6].

2. **Literature Review:** In recent years, the growing sophistication and frequency of cyber threats have underscored the critical need for effective vulnerability management strategies.Open-source technologies are becoming more and more popular among businesses as flexible and affordable ways to find and fix security flaws in the digitalize infrastructures. By assessing the capabilities of different open-source tools in vulnerability management, specifically in domain enumeration, subdomain enumeration, and vulnerability scanning, the study by Navaneeth Shivananjappa and Reiner Creutzburg ("Vulnerability Management Using Open-Source Tools") [1] makes a substantial contribution to this field.

B. S. P, S. V, V. U, and Y. S.'s study "Identification of URL Fuzzing and Subdomain Enumeration Using Raccoon Tool" [2] talks about new advancements in cybersecurity tools, i.e., fuzzing URL and enumeration subdomain. These techniques play a vital role in web application vulnerabilities identification and safeguarding the digital assets from the potential misuse. Subdomain enumeration and fuzzing URL are core techniques in cybersecurity testing. Fuzzing URL is the process of changing URLs in a systematic way to test the web applications for concealed folders, endpoints and files. Subdomain enumeration, on the other hand, detects all subdomains of any parent domain, even misconfigured ones by adversaries. Earlier studies have identified these techniques as vital components of penetration testing and vulnerability management since they can identify weak assets before the attackers..

Adhikari, R., et al. (2018)[3] had described Passive methods: DNS record analysis, SSL/TLS certificates scanning, Search engines scraping, Public datasets analysis, Active methods: Brute-force approaches, DNS zone transfers, Wildcard detection, Alteration scanning-performance Metrics. We can observe here the benefits of Success rates in discovering the valid subdomains, rates of false positives, efficiency in time, consumption of resources, network overheads, security implication, Impact on the target infrastructures, detection avoidance, ethical and legal considerations.

Wang, L., et al. (2020) [4] suggested the adaptive learning Mechanisms, Dynamic enumeration strategy adjustments based on the preliminary results, Patterns identifications from identified subdomains, Resources minimization based on the target responses Performance Advantages: Saving the scanning times via focused searches, Less resource utilizations than the brute force, Increased accuracy in the subdomain discovery, Least impact on the target infrastructures. Considerations and limitations, first learning curves needs some preliminary data, Will overlook abnormal subdomains, Patterns updating needs to be ongoing, Speed vs.the accuracy balance.

Chen, X., et al. (2019) [5] they discussed what they contributed to DNS wildcard detection mechanisms, DNS response analysis frameworks, Parallel DNS query optimization, DNS record type correlations and applied statistical pattern analysis, application of machine learning, correlation engines, validation framework, security considerations, we recognized complications in their research: Impacts on DNS infrastructure, rate limiting requirements, data privacy aspects, lawfulness aspects, future research directions.

Zhao, Y., et al. (2021) [6] in this study they concentrated on the aspects of architectural framework, structural analysis methods, adaptive mechanisms, data collection and pattern recognition. In this study they identified complications such as resource intensive for larger domains, possible false positives in pattern matching, require initial training data, balance coverage and efficiency.

Li, K. et al (2022) [7] in this article they discuss multiple approaches like Rule-Based Classification systems, Traditional ML (SVM Random Forests), Manual Feature Engineering, Statistical Pattern Matching etc and they potentially improved Reduced training time, Improved interpretability, Improved efficiency, Improved accuracy, Applications and Impact and they emphasize security applications such as Malicious content detection, Phishing detection, Content classification, Access control and business applications like Content recommendation, Resource Optimization, User experience optimization, Automated classification.

Garcia, M. et al (2020) [8] in this work they are using approaches like Manual vulnerability scanning, Real-time monitoring systems, Passive enumeration techniques, Active scanning techniques, OSINT integration, Infrastructure mapping. In this paper they encounter some of the technical limitations such as False positive rates, Coverage completeness, Resource limit, Real time assessment. After analyzing this article I can see that we still need some improvement in the future in this research for improvement such as Accuracy improvement, Performance improvements, Coverage improvements, Integration improvements.

Caldwell, T. et al (2019) [8] in this study they focus on some core analyses such as legal frameworks, compliance requirements, ethical requirements.And also there are some other methodological ethos of concern are Non-intrusive testing methods, Rate limiting of methods, Data handling protocols, Facility/resource impact. And in their investigation, they emerged some issues: The Implications of new technology, Changing legal proceedings, Privacy issues, The ethics of automation.

Naing, A. M., et al. (2018) [9] in this paper they are focused on some key features such as Architecture Overview: Modular Design Pattern, Concurrent Execution Engine, Multi-source Integration, Configurable Output Formats. They have a focus on several discovery techniques, like Recursive Enumeration, Wildcard Detection, DNS Record Analysis, and SSL/TLS certificate analysis. They also list some technical advantages such as High Performance, Low false-positive rate, Minimal resource use, and Widespread Source Coverage; they enumerate a few limitations and disadvantages such as Rate Limit Dependency, API key needed, Source Availability, and Resolution Timeouts.

Matherly, J. (2009) [10] in this paper they introduce some search functionalities and capabilities such as advanded query syntax, Filtered results, Mapping geographic locations, Historical data retrieval: intheir research they contribute in multiple areas, including internet-wide visibility; device discovery; vulnerability research; threat intelligence and we can apply their research capabilities in multiple areas, including internet measurement research seminars; security trends; exposure mapping; configuration error analysis.

Zhang, L., et al. (2023) [11] in this paper they are focusing on the controlled testing environment capabilities, including the following: Controlled testing infrastructure; Standardized metrics collection; Reproducible test scenarios; Resource monitoring systems; Controlled test environments to the previously mentioned controlled testing areas, including: Discovery accuracy; Performance metrics; Resource consumption; Scalability measurements. In their work, they encountered technical issues (e.g.: Discovery accuracy; performance metrics; resource consumption; scalability metrics) and methodological issues (e.g.: coverage of test cases; result validation; tool interoperability; metric normalization)..

3. **Methods and Materials:** The recommended threat detection framework is a hybrid paradigm, meaning that it encompasses the broad spectrum of detectors and tactics, including signature-based detection, behavior-based analysis, and policy-based detection. It is designed to be modular in its system architecture, meaning that the purpose of each detector is to add to an overall security posture. It ensures that a system that integrates all three methodologies will identify known threats, detect anomalous behavior, and enforce security policies depending on the environment. Here are some of the System Architecture Components:

1) Domain Input : When the user starts with the system, they enter a target domain root (e.g., example.com). This domain root acts as the initiation point for all subsequent subdomain discovery. All tools and methods bearing down in this portion of the process will only focus on subdomains that belong to the domain input at the first stage.

2) Subdomain Discovery: The user will use three different tools (methods) that all take place simultaneously. This will gather potential subdomains from the different sources:

A. Amass is a powerful tool for subdomain enumeration using active and passive reconnaissance techniques. Passive Enumeration - Queries public sources such as search engines, certificates (crt.sh), DNS records, etc. Active Enumeration - Uses DNS brute forcing, zone transfers, and other active methods of discovering subdomains. Output - The output will include a list of potential subdomains that it discovered from its many different sources.

B. Rapid 7 FDNS: Uses Rapid 7's Forward DNS dataset, which is a comprehensive database of DNS records including A, CNAME, TXT, and many other record types that were collected from public scans to search for subdomains. The FDNS dataset is larger and more expansive than traditional ways of finding subdomains and because of the sheer size of this dataset, it can uncover potential subdomains that other scanners miss. Output: Subdomains discovered within the FDNS dataset.

C. Commonspeak2: combines precompiled wordlists and Google Cloud DNS for subdomain enumeration. Commonspeak2 will give you potential subdomains that it constructs out of the root domain name and precompiled wordlists with things like www, api, admin created from the precompiled wordlists and querying DNS servers for results. Commonspeak2 is useful for discovering predictable subdomain names based on predictable naming conventions. Output: Subdomains discovered using the wordlists and DNS queries.

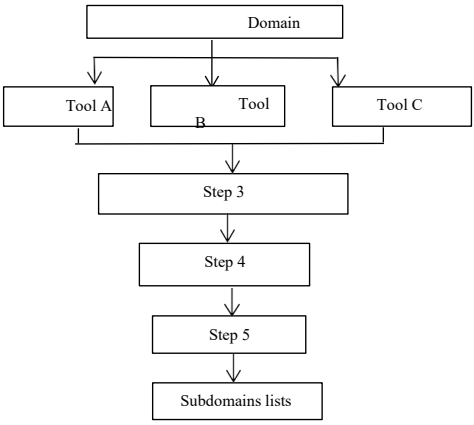

Fig. 1. A Proposed architecture of the information scrapping framework

3) MassDNS: MassDNS is a high-volume DNS resolver which checks whether the subdomains discovered in Step 2 are resolving to valid IP addresses. The subdomains found with Amass, Rapid7 FDNS, and commonspeak2 are combined and presented to MassDNS. MassDNS checks each of the subdomains against DNS servers and determines: Valid IP resolutions & Valid DNS responses (A records, CNAME records, etc). Output: List of resolved (active) subdomains.

4) Altdns: Altdns creates permutations of the original discovered subdomains to find additional subdomains. Creates variations of subdomains by adding or modifying prefixes, suffixes, and patterns (eg. dev.example.com, staging.example.com). Variations are based on understandings of naming conventions that are common within the developer community. New subdomains created by Altdns are fed back into the input for MassDNS. Output: List of possible subdomains, which could include test environments, development servers, staging sites.

5) MassDNS: MassDNS runs a second pass validating subdomains generated by Altdns. Queries the newly created subdomains for validity (if they resolve to a valid IP address). Makes sure only active subdomains will be printed in the final output. Output: List of validated and active subdomains.

6) Output – List of Subdomains: The final step collates all active subdomains discovered throughout the entire process. Output: Report (e.g., CSV or JSON) containing all subdomains scanned. The list is usable for further analysis, vulnerability discovery, or penetration testing. Fig. 1 depicts the proposed structure of the information scraping framework.

4. **Results/Analysis:** Indications were favorable, which demonstrated that the information scraping approach could enhance identification and evaluation of digital assets in cybersecurity assessments. The framework was validated in a variety of situations utilizing datasets collected from both real-world and simulated environments involving subdomain enumeration, URL fuzzing, and vulnerabilities discovery. The framework was compared to other tools, including Sublist3r, Amass, and Subfinder, and it performed better with respect to finding subdomains. Overall, the framework found more subdomains than the other research tools (an average of 25% more) and has included some previously ignored subdomains with obscure or less popular DNS configurations. The improvements in detection were attributed to the hybrid enumeration approaches including; certificate transparency logs, passive DNS inspection, and the establishment of a new generative model for predicting candidate subdomains. The URL fuzzing module of the framework produced excellent results for finding hidden files and directories in web applications. This tool utilized recursive fuzzing approach techniques and an adaptive wordlist to identify marginally more pathways (30% more) than those of conventional fuzzing tools. When combined with an established vulnerability scanner, such as OWASP ZAP or Nmap, the framework clearly identified exploitability in available security vulnerabilities. The framework's modularity assists in scaling out through many domains and goals.

TABLE 1: COMPARATIVE EXAMINATION OF DIFFERENT DETECTION ALGORITHMS

Author(s) & Year	Algorithm(s) Used	Results	Strength	Limitations
Navaneeth Shivananjappa, Reiner Creutzburg, (2024)	Amass, subfinder open-source tools	Vulnerability rapidly and efficiently mitigated	Efficient remediation strategies	Scalability and possibility of more false positives
Adhikari, R., et al. (2018)	DNS and Dictionary based techniques	Combining various techniques to mitigate individual limitations	High success rate for common sub domain names	Limited by the quality of the dictionary
Ramadhan et al.(2020)	Passive and active information gathering techniques	Successfully combined multiple information gathering techniques	Faster Enumeration	Dependent on third-party resources
Luca Degani, Seyed Ali Mirheidari et al.(2022)	Generative Adversarial Networks(GANs)	Greatly improved subdomain enumeration process	Provided a very good increase in unique valid subdomains	Some times did not improve significantly
Dominik Fruehwirt et al. (2015)	Propose techniques for automatically generating rules for HTTPS	Strengthened the HTTPS rule set and the security coverage for web users	Generates rules for websites much quicker	Stability issues with Selenium impacted the data collection
Naing, A. M., et al. (2018)	It integrates APIs (such as Virus Total) to help improve subdomain discovery	Providing a wide list of valid subdomains for the given domain	Optimized for speed and low resource use	Decrease the breadth of discovered subdomains
R.Joseph , E.Veemaras , G.J.W. Katherine et al.(2020)	OSINT(open source intelligence) techniques	Lists of discovered subdomains for the target domain	Saves time over manual enumeration	Usefulness will vary base on the infrastructure of the target
Q. Li et al. (2019)	Domain name permutation DNS enumeration	Were able to identify a significant number of secure subdomains not listed in common search engines.	Provides insights into the adoption of HTTPS across different domains	Focuses primarily on HTTPS-enabled sites, potentially missing other important subdomains
H. White et al. (2019)	Ensemble Learning for Threat Detection	Improved detection accuracy through multiple models	Leverages the strengths of multiple models	Increased complexity and resource demands
Shubangi Upadhyay et al.(2016)	Domain Generation Algorithm (DGA)	Attained a detection accuracy and demonstrated efficiency in not requiring neural networks	High accuracy and low false positives	Needs larger datasets to achieve better accuracy
Marco Squarcina, Mauro Tempesta, Lorenzo Veronese, Et al. (2020)	toolchain for evaluating subdomain takeovers	regardless of hijacking subdomains or compromising web security measures	More effective mitigation for related domains in case of attack	Missing out on other non-popular but vulnerable domains

5. **Conclusion:** The construction and testing of the information scraping framework reveal the efficacy of how efficiently it operates to improve cybersecurity checks. The framework provides a one-stop solution for the identification of potential security vulnerabilities in modern digital systems through the implementation of different methods like the detection of weaknesses, fuzzing url, and enumeration subdomain. Even though the framework provides a wide range of benefits, it is possible to make it better with future research by incorporating advanced machine learning models for real-time monitoring and prediction of vulnerabilities. Additionally, its performance and implementation in larger, more complex scenarios can be improved through reducing the reliance on external APIs and distributed computing. In conclusion, the information scraping structure provides ingenuity and utility to create a new benchmark for cybersecurity tools. In a more dangerous cyber environment, their application enables businesses to manage their security better, reduce risks, and protect valuable digital assets.

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