Web Vulnerability Scanner Tools

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APPROVAL

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DECLARATION

We, hereby, declare that the work presented in this report is the outcome of the investigation performed by us under the supervision of **Bulbul Ahamed, Professor** and **Head,** Department of Computer Science and Engineering, Sonargaon University, Dhaka, Bangladesh. We reaffirm that no part of this project has been or is being submitted elsewhere for the award of any degree or diploma.

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ABSTRACT

Cybersecurity is now increasingly threatened by numerous attacks on web applications, therefore it has become necessary to perform automated vulnerability assessment as part of a company's overall security program. In this paper we describe how a modular web vulnerability scanner was created to detect several forms of vulnerabilities that exist in web-based (or web hosted) applications. A modular web vulnerability scanner has two different modalities to perform both Passive and Active assessment techniques, including: passive reconnaissance (Passive Data Collection) in subdomain enumeration from publicly available sources and URL parameter collection; and Active Assessment methodologies such as Directory Brute force Testing to find web directories, and to test for path traversal vulnerability with a Targeted Payload. This scanner can also identify security-related Misconfiguration Errors such as Secure Cookie settings, Clickjacking, and sensitive information exposed via robots.txt and Sitemap.xml. This scanner will also provide an Automated Credential Testing Module using Selenium (a widely used open-source web automation tool) that allows the Automated Detection of weak or default usernames and passwords. The core scanning engine was created using the Python Programming Language and we used Selenium libraries to automate a web browser to test credentials. The output produced by this scanner includes reports with structured information on all vulnerabilities organized by their severity (High Medium Low) to facilitate remediation decisions. Dedicated Testing Environments have been set up to test the capability of this scanner to detect both Configuration Errors and Coding Errors, thus providing a concrete means by which to improve the security of web applications. This project provides an opportunity to gain hands-on experience with conducting penetration tests for this type of security issue.

Keywords: Web Vulnerability Scanner, Path Traversal, Credential Testing, Cybersecurity, Automated Reconnaissance

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LIST OF ABBREVIATIONS

API	Application Programming Interface
ASP.NET	Active Server Pages .NET
CI/CD	Continuous Integration and Continuous Deployment
CSP	Content Security Policy
CSRF	Cross-Site Request Forgery
CSV	Comma-Separated Values
DOM	Document Object Model
DoS	Denial of Service
DNS	Domain Name System
DVWA	Damn Vulnerable Web Application
HSTS	HTTP Strict Transport Security
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
HTTPS	HyperText Transfer Protocol Secure
IDE	Integrated Development Environment
LFI	Local File Inclusion
MFA	Multi-Factor Authentication
ORM	Object-Relational Mapping
OS	Operating System
OWASP	Open Web Application Security Project
PHP	Hypertext Preprocessor
RFI	Remote File Inclusion

SPA	Single Page Application
SQL	Structured Query Language
SQLi	SQL Injection
URL	Uniform Resource Locator
WAF	Web Application Firewall
XSS	Cross-Site Scripting

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Web applications are found to form the backbone of essential services like banking, healthcare, education, e commerce, and government services. Web applications of this age are characterized by a variety of components, including server side APIs, JavaScript frameworks, microservices, and third party services, and are built using latest CI/CD pipelines. Even though these latest methodologies speed up the delivery of applications, they also take care of increasing complexities and greater surface areas, wherefore latest vulnerability trends, including cross site scripting, injection attacks, path traversal, local file inclusion, broken authentication, insecure sessions, security headers, and CSRF, sit at the top of vulnerability reports[1].

These vulnerabilities remain because old codebases, scattering security efforts in each environment, or the lack of effectively identifying client-side vulnerabilities with server-side signals alone hinder their remediation. In an academic environment, knowing how vulnerabilities exist, as well as how one can be safely discovered, is important. In practice, however, one relies on commercial or high-end free software scanners that focus more on their capability, or scalability, rather than their interpretability. This software generally contains invisible underlying mechanics that obscure their output, which does not allow tracing either[4].

Reproducibility is a further challenge. Teachers need reliable evidence, in terms of messages and responses, screenshots, logs, and environment information, for universally comparing student efforts. Students, on the other hand, need workflows that always generate identical results on different computers. Most current systems lack the facility for retaining artifacts, making comparison and comment difficult for teachers. Scanning without subsequent validation causes numerous false positives, especially for client-side issues that rely on actual execution in a web browser.

This project, “Web Vulnerability Scanner Tools,” aims to meet these challenges with a small, modular framework intended specifically for educational or small research networks, one that combines passive reconnaissance techniques, such as certificate transparency logs and web archiving, for host and historical endpoint discovery without actually touching the target, along with limited active enumeration techniques such as sitemap, robots.txt, and wordlists, with a focus on conservative settings to avoid danger[8].

The framework is represented by payload-driven scanners for major vulnerability types, namely reflected XSS and path traversal or LFI. In an effort to alleviate any confusion, the framework has the optional use of Selenium-based browser checks, allowing students to validate client-side results by viewing actual effects, such as DOM or alert messages[2]. The background that has been created is that the necessity for a secure, understandable, and repeatable method of instruction for web-related vulnerability hunting and validation exists.

1.2 Motivation

The growth of web app usage has made expertise in security a growing necessity among students and emerging researchers alike. Contrary to this need, learning is marred by fragmented tooling. The process of reconnaissance, scanning, and verification is mostly conducted by scripts or tools that lack uniformity among outputs, thus requiring a high learning threshold. Commercial tools, although effective, lack affordability, and open-source tools, while very powerful, also present high complexities that retard learning fundamentals[11],[14].

Another reason lies in accuracy. Many automatic scanners used in dependence on server response will sometimes produce a high number of false positives, especially concerning XSS in dynamic or single page applications[6]. With regard to this issue, without the necessity to verify data at the level of the browser, students will have problems distinguishing between theoretical and practical vulnerabilities.

Thus, the purpose of Web Vulnerability Scanner Tools is consequently the mitigation of such challenges through the provision of such an integrated and educational pipeline. It links all appropriate facets of responsible recon, scan payload driven tools, as well as browser-related verification processes in one streamlined process. In a similar fashion, it further ensures uniform capture of artifacts through the project, which aims at permitting the discussion of findings through their ability to be replicated.

1.3 Problem Statement

Students and small research groups need a reproducible and understandable approach to identifying web vulnerabilities. Current solutions pose several difficulties.

One, the tooling is splintered and opaque. Recon, scan, and verification may call for different tools with differing formats. Commercial scanners are expensive and closed source, and a number of the open source tools require sophisticated skillsets before they can be harnessed effectively for educational purposes.

Secondly, the precision achieved can be limited by the absence of verification. The injection of payloads by machines based solely on the response from the servers results in false positives in terms of vulnerability on the client side, particularly with regard to either reflected or DOM based XSS.

Thirdly, the reliability or repeatability is also poor. This is because a typical learning environment does not provide an opportunity to retain actual answers, environmental conditions, or detailed or organized answers.

The main problem at this point, therefore, is how to develop a concise and modular solution that combines the aspects of reconnaissance, scanning, verification, and reporting in a transparent and reproducible way that is safe and suitable for education.

1.4 Objectives of the Project

The major goal of this proposed project is to develop and implement the Web Vulnerability Scanner Tools. The proposed goal has the following specific objectives:

- To develop a full pipeline integrating passive reconnaissance (Certificate Transparency logs, Web Archives) and lightweight active enumeration (Sitemaps, robots.txt, optimized wordlists)[8].
- Implementation of the payload driven scanners for the relevant vulnerability types, namely reflected XSS and path traversal/LFI attacks[5],[9],[13].
- To support optional Selenium-based browser verification in order to eliminate false positives for client-side results[2].
- Capture artifact and environment metadata for the sake of reproducible experimentation and evaluation.
- Enforce safe and ethical defaults, such as rate limiting and payloads that are not destructive.
- To keep the code open for viewing and extension.
- These objectives, when combined, ensure alignment of automation with interpretability and facilitate evidence-based learning.

1.5 Scope and Limitations

1.5.1 Scope

The scope of this project shall be the laboratory environment. Reconnaissance shall include passive and active reconnaissance, scanning based on the payload for reflected XSS and path traversal/LFI vulnerabilities, optional browser-based verification, and reporting. The framework shall focus on educational clarity and shall incorporate conservative defaults and the ability to reproduce results.

1.5.2 Limitations

In order to ensure a level of simplicity and security, this framework will, therefore, not intend to be “enterprise-grade.” It will focus on identified vulnerability types with performance issues due to its reliance on a single-threaded execution process, as well as simulation verification using Selenium, which may be affected by browser or driver settings, along with possible changes in passive reconnaissance sources[3]. It will also steer clear of destructive methodologies, as indicated above.

1.6 Contributions

It proposes an educationally relevant framework that amalgamates the processes of reconnaissance, scan, verification, and reporting into one explainable pipeline. It provides special significance in terms of its modular pipeline architecture, evidence correlation based payload driven scanners, browser verification functionality, standardized artifacts, safe default settings suitable for a classroom setting, and open source code that can be easily extended[10],[15].

1.7 Structure of the Report

This report is structured as follows. The introduction containing the background information, motivation, statement of the problem, objectives, scope, and contributions from chapter 1. The next chapter (chapter 2) contains the introduction to the existing work related to web vulnerabilities and scanning mechanisms. The system architecture and workflow are then elaborated in chapter 3. Experimental implementation and testing are then explained in chapter 4. Experimental results are discussed in chapter 5. Evaluation and analysis are then discussed in chapter 6. The final chapter (chapter 7) concludes the entire thesis and contains the ideas related to the future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, there is a detailed explanation about concepts, approaches, and current research that are being taken into account to design and develop the Web Vulnerability Scanner Tools framework. The primary aim of this chapter is two-fold. Firstly, it is imperative to provide a theoretical explanation about how web vulnerabilities and security approaches can be comprehended. Secondly, it is also important to explain how this novel framework co-exists with current researches, especially concerning education and small-scale researches.

The modern web applications are not merely server-rendered pages. They are accompanied by server-side APIs, complex JavaScript frameworks such as React, Angular, and Vue on the client side, and third-party services including cloud computing, analytics services, and content delivery networks[11],[14]. While each and every one of these makes web applications remarkably agile, they also are responsible for making them extremely vulnerable. Web applications are one of the most targeted applications at present.

Although the resources available through industries, such as OWASP Top Ten, clearly identify the prevalent groups of vulnerabilities obviously, the task of aligning the various taxonomic systems for the sake of vulnerability identification and verification proves a problem for the students[1]. Furthermore, the academic setting mostly uses an enterprise system or the kind that has internal opaque logic, making it difficult for a student to understand why a vulnerability exists and how it has been identified. In addition, the aspect of reproducibility, which matters a great deal in the academic settings, is hardly considered, varying from machine to machine with little evidence available.

Thus, in this chapter, the literature review and technology in the following domains are discussed: (i) web vulnerability types, (ii) methods associated with recon in identifying attack surface vulnerabilities, (iii) automaton and payload scan techniques, (iv) browser verification techniques used in identifying client vulnerabilities, and (v) reproducibility in training students on security-related topics. These domains are associated with the architectural design taken in the development of the Web Vulnerability Scanner Tools.

2.2 Web Vulnerabilities Overview

Web vulnerabilities may occur due to such scenarios that involve application logic, configuration, or platform logic related to exploiting inputs, requests, or sessions that have purposes other than what was intended. Due to the complexities of web technology, validation and authorizations are extremely challenging, more so when there are diversified pieces of technology being used. These five categories of web vulnerabilities, explained below, in the realm of this thesis, are some of the learning objectives, educational, in nature: XSS attacks, Path Traversal & Local File Inclusion, SQL Injection attacks, Security related headers and Cookies, and CSRF & Authentication related attacks[4],[7].

Although the framework mentioned explicitly identifies and focuses on areas of research related to XSS, as well as Path Traversal/LFI attacks, which can be proved and are safe to

be executed in a lab environment, there are other areas of research that define this technology as well as predict its evolution to a great extent.

2.2.1 Cross-Site Scripting (XSS)

Cross Site Scripting (XSS) is a client-side attack that happens because of any malicious user input that is used to construct a web page without doing any output encoding, thereby running arbitrary scripts in a target user's web browser[6]. Cross Site Scripting is rated as among the most popular web vulnerabilities, and there are two types of web vulnerabilities: Persistent XSS and Reflected XSS. There is a third kind of web vulnerability, DOM-XSS.

Reflected XSS issues arise when the affected data is reflected directly from the user input in the server response, normally through the use of query parameters or form data. The stored XSS issues arise when the input data from the users is stored in the application, for instance, when it is stored in the database, and later passed to the users. DOM-based XSS issues are only found on the client-side.

The lack of context-aware encoding on output, the danger of templating, and the improper usage of dynamic DOM manipulation techniques like innerHTML, as well as the abundance of Content Security Policies, are the factors that lead to the root causes of the XSS attack. The techniques used for the detection of the XSS attack are payload-driven testings that involve the injection of special tokens and/or scripts into the input vectors. Server-side detection basically involves the reflection of the payloads that have been injected. Reflection only shows the susceptibility and not the exploitability.

Therefore, browser verification is a crucial part of ensuring that the validation for the case of an XSS attack is carried out. Notably, real-code execution must occur in real-time fashion through the utilization of system pointers such as JavaScript alerts or changes to the Document Object Model. Such a process can be facilitated through Selenium functionalities that enable logical browser code execution for the aforementioned purposes[2]. Best practices for remediation include output encoding considerations in context, the use of framework safe defaults, proper use of good CSPs, and avoiding hazardous sinks. Within the framework of instruction, the relevance of the impact for an XSS attack demonstrates the distinction between detection and the process of validated exploitation.

2.2.2 Path Traversal and Local File Inclusion (LFI)

Issues like path traversal and local file inclusion can occur due to the usage of user input data directly into the creation of system path parameters without appropriate input validation and normalization. For example, an attacker can make use of path traversal characters like "." and "/" to traverse beyond the target directories and access configuration files and credentials[9].

The usual culprits here are unvalidated string appending inside the resolution of the filepath, the lack of canonicalization, improper execution of whitelists, and too much FILE access provided to the application. Another instance where LFI can be encountered is when applications load content dynamically by using parameters inside the web request.

Detection is done by the usage of payload-driven probes that test traversal paths on known files that hold indicators. The resultant values are then searched for characteristic indicators

such as known file signatures or expected contents. In verification, it is necessary to establish that the resultant value actually comes from the sensitive file and not mere values that are visible in the application output.

“Methods of remediation include canonicalization, use of indirect file access rather than path-based, allowlists to limit resources that can be accessed, and least privilege level accesses to the file system. Lab computers, where LFI/path traversal attacks can be an extremely good learning experience regarding validation failures, are the best environment in which to learn how to use “non-destructive” payloads.”

2.2.3 SQL Injection (SQLi)

SQL Injection is a server-side vulnerability that is created due to the lack of input parameters within the input that is combined with the database queries. The vulnerable database created has the tendency of modifying the database queries, fetching unauthorized data, and even modifying the contents of the database[5],[13]. Some of the techniques applied during SQL Injection attacks include Error Based SQL Injection Attacks.

SQLi, which happens because of unsanitized query construction with a misbelief about the protective actions of ORM, are the leading root causes. SQLi recognition requires complex attack string construction, which may target error messages, code variations, and delays. SQLi exploitation with automated tools may be very feasible. Even at a tutorial level, there may not be any necessity to perform SQLi exploitation because of security and moral issues.

In reality, the area of pedagogy applies principles of detection, correction, and concepts around prepared statements, parameterized queries, ORM programming, and the use of the least privileged database accounts. The exploitation of the capability for SQL Injection can be seen as outside the scope of active scanning, although the conceptual understanding is useful for helping to build the logic around the exploitation and development.

2.2.4 Security Headers & Insecure Cookies

The security-related header and properties of cookies handle how these browsers are supposed to implement different security measures that can thwart possible attacks. Incorrect implementation of directives can affect security posture of an application irrespective of whether there are direct injection vulnerabilities.

These critical headers are Content Security Policy, Strict Transport Security, X Frame Options or Content Security Policy Frame Ancestors, X Content Type Options, and Referrer Policy. In a similar manner, critical attributes of cookies consist of Secure, HttpOnly, and SameSite, whose functions are to secure user sessions from either being intercepted, stolen, or misused on other websites[12].

The detection phase is conducted by examining the HTTP response for absent or weak server configurations. The verification analysis phase is highly inspection-intensive and might involve the analysis of possible browser actions to show the impact of the activation of certain settings such as framing and script execution. The fixing phase entails the activation and implementation of strong server or framework-level default settings. At an institution of higher learning, the test offers a very valuable lesson.

2.2.5 CSRF and Authentication Issues

Cross Site Request Forgery targets an already established user session to perform some other undesired action through cross-origin requests. Authentication related problems include inappropriate password management, problems in user session management, solutions in session attacks, and insecure logout mechanisms.

Those that have contributed to CSRF attacks are missing anti-CSRF tokens in forms, predictable methods of creating anti-CSRF tokens, lax SameSite restrictions on cookies, and weaker validation on the server side. Methods that are used in the detection of attacks include the analysis of forms, cookies, redirects, and sessions.

It is further assisted through browser automation for the observation on token utilization and the establishment and invalidation of sessions as being valid. Other security measures include anti-csrf on all actions, rotation on successful authentications, utilization of the secure attributes for the cookie, as well as proper handling. These cover level two discussion on security and also meet the selective verification principles.

2.3 Reconnaissance by Passive or Active Means

Reconnaissance entails identifying the hosts, endpoints, and parameters that define an attack surface. Reconnaissances are an essential component in the vulnerability scan process in that a scan tool can never be better than the input it receives. Under this paradigm, a balanced approach that combines both passive and lightweight active reconnaissance will be presented.

Passive Recon is the process wherein information is gathered using third-party data, such as the certificate logs or the web pages that have been cached, concerning the discovery of the domains and the discontinued URLs prior to actually engaging with the target. Passive Recon is non-intrusive and is used for the discovery of discontinued URLs that are still reachable[8]. The results may have numerous false positives that need to be eliminated.

Active Reconnaissance involves engaging the target in a controlled way as a means to determine what the current endpoints and parameters are. Methods that are quite light include parsing sitemap.xml files, taking a look at what is inside the robots.txt file, a small word list attack, as well as form parsing on HTML files. So, when run conservatively, Active Reconnaissance is quite effective and won't interfere.

"The framework records recon output with provenance data, which will be stored in deterministic directories to facilitate reproducible experimentation tracing back the workflow," explains Jeria. "Also, in terms of parameter discovery, understanding the

2.4 Browser Based Verification

The scanners that only rely on the response from the server are liable to make false identifications of vulnerabilities on the client-side, especially in the case of dynamic websites for XSS. This limitation has already been removed by the introduction of the browser-level check.

Selenium enables seamless control of the browser and headless and headfull functionality. It also brings optional validation that can be applied selectively to the dubious test results. The payload is used to link server-level indications with the running process on the client-level to the screenshots and source pages that are being captured for evidentiary purposes.

Reliability is improved by using deterministic tokens, wait statements, robust selectors, and knowledge of environment variables. As for browser automation, though it makes testing more complex and brittle, its learning value is to understand how to prove exploitability and prevent false alarms[2],[10].

2.5 Existing Tools and Identified Gaps

The security environment on the Web has been shaped by the deployment of clever software such as Burp Suite, OWASPZAP, sqlmap, and vulnerability scanners. These are very capable, costly, and/or hard to reproduce for academic purposes[15].

Some major lacks for improvement in this work include the lack of transparency, lack of reproducibility, lack of precision for client-side results, and lack of safe and appropriate defaults for beginners programmers. The students assemble the toolchains with non-interpretable workflows.

The Web Vulnerability Scanner Tools framework bridges these gaps in that it integrates recon, scanning, verification, and reporting into a succinct and understandable pipeline, towards an educational goal.

2.6 Reproducibility & Ethics

Reproducibility plays a pivotal role in research evaluation and validity. The framework retains raw data, environment details, and graded results in deterministic directories so as to facilitate repeated execution and graded evidence.

In ethical dealings, one has to operate with authorization, control, and transparency. In the project at hand, the task implements secure defaults, does not employ self-destructing payloads, and remains within lab-managed environments. With the integration of ethics into the process, ethical learning processes are enabled by the framework.

2.7 Summary

This chapter provided a discussion on literature and practice that constitute the foundation for the use of Web Vulnerability Scanner Tools. This discussion included types for vulnerabilities, recon methods, models for scanning and validation, existing tools, and the need to have reproducibility and adhere to rules of ethics, which constitute a precursor to the understanding of architecture and design explanations to follow in later chapters.

CHAPTER 3

METHODOLOGY

This chapter describes the methodology adopted for designing and implementing the web vulnerability scanning system. The methodology emphasizes structured, automated, and repeatable approaches for detecting common web security issues such as XSS, SQL Injection, Path Traversal, and weak/default credentials. The chapter outlines the system architecture, component modules, data models, workflow, configuration, safety measures, and the rationale behind design decisions.

3.1 Overall Methodology & System Architecture

The web vulnerability scanning system was designed with a modular, scalable, and research-oriented architecture. The overall methodology focuses on combining automated reconnaissance, vulnerability detection, and structured reporting into a single cohesive workflow. The system follows an **ethically controlled, automated, and heuristic-driven approach** to testing web applications while minimizing false positives and maintaining reproducibility.

The **system architecture** consists of three major layers:

1. **Input Layer:** Accepts target URLs, login forms, or file parameters. This layer preprocesses user inputs and validates them to ensure safe operation.
2. **Processing Layer:** Implements the core scanning modules, including XSS detection, Path Traversal testing, SQL Injection/credential analysis, and server header evaluation. Each module is independent but integrates with the orchestrator for combined scans[10],[15].
3. **Output Layer:** Stores results in structured formats (CSV/text) and generates reports including metadata such as scan timestamps, response times, detected vulnerabilities, and payload details.

The architecture follows a **central orchestrator design** where the main controller (main.py) invokes different modules sequentially or in parallel. Modules interact through well-defined interfaces, making the system highly modular and extensible. Security best practices, such as safe payload injection, request throttling, and controlled testing environments, are implemented to avoid unauthorized access to live systems[14].

The methodology integrates **heuristics, automation, and analysis**, allowing the system to simulate realistic attacks while providing clear evidence of vulnerabilities for academic and research evaluation.

3.2 Method Components / Modules

The system is composed of several functional modules. Each module performs a specific task and contributes to the overall scanning and reporting process. These modules are described below.

3.2.1 Orchestrator (main.py)

The orchestrator is the central controller of the system. Its primary functions include:

- Accepting user inputs for target URLs, credentials, or scanning options.
- Initiating module execution (XSS, Path Traversal, SQLi, Headers/Sitemap checks).
- Coordinating data flow between modules.
- Managing exception handling and logging.

The orchestrator ensures that modules run in a defined sequence and that their outputs are collected and formatted into reports. It also supports configuration of scan parameters, such as request timing, retry limits, and payload selection. This centralization improves system maintainability, simplifies testing, and provides a single point for implementing global safety controls[3].

3.2.2 Recon (info_gathering.py)

The reconnaissance module performs information gathering before active vulnerability testing. Its primary objectives are:

- Identifying endpoints, form fields, and query parameters.
- Collecting server metadata, such as HTTP headers, cookies, and response codes.
- Fetching and parsing **robots.txt** and **sitemap.xml** for structured URLs.
- Performing subdomain enumeration through brute-force or passive DNS queries.

Recon data is used to map the attack surface and prioritize subsequent scanning. The module also checks for **insecure cookies, missing security headers, and potential clickjacking vulnerabilities**, which provides an initial assessment of the target's security posture[8]. This pre-scanning phase ensures efficient and focused vulnerability testing.

3.2.3 XSS Scanner

The XSS scanner detects **client-side script injection vulnerabilities**. Its methodology involves:

1. **Input Point Detection:** Identifies forms, search fields, URL parameters, and text areas that accept user input.
2. **Payload Injection:** Loads XSS payloads from xss.txt and injects them sequentially into input points.
3. **Detection Heuristics:**
    - Observes JavaScript alert pop-ups triggered by payload execution.
    - Analyzes the Document Object Model (DOM) to detect injected scripts.
    - Monitors page responses for echoed payloads.
4. **Automation:** Uses Selenium to simulate realistic browser behavior, including typing, button clicks, and submission[2],[6].
5. **Result Logging:** Captures vulnerable input points, the payload used, server response, and execution time in structured CSV or text reports.

This module combines **heuristic analysis, automated interaction, and payload-based testing**, providing a robust detection mechanism for client-side vulnerabilities.

3.2.4 Path Traversal Scanner (path_traversal.py)

The Path Traversal module identifies **unauthorized file access vulnerabilities** (LFI/RFI). The methodology involves:

1. **Parameter Identification:** Detects URL or form parameters accepting file names or page references.
2. **Payload Injection:** Loads traversal sequences from lfi.txt, including relative paths (../) and encoded payloads.
3. **Response Analysis:**
    - Keyword matching for system files (root:, /bin/, C:\Windows\System32).
    - HTTP response code comparison.
    - Content length analysis to detect abnormal responses.
4. **OS Awareness:** Differentiates between Linux and Windows environments for accurate detection.
5. **False Positive Reduction:** Confirms vulnerabilities only if multiple indicators are present.

Automated injection, controlled timing, and detailed logging make this module reliable for academic reporting and research purposes[9].

3.2.5 Credential Testing (sqli.py)

Credential testing identifies **weak or default login credentials**. Key steps include:

- Accepting predefined username-password lists.
- Automating login form submissions using Selenium.
- Monitoring response behavior to detect successful logins:
    - URL changes, page redirects, success messages.
- Logging failed attempts, including response times and server feedback.
- Storing results in CSV for structured analysis.

The module ensures ethical testing by controlling retries, avoiding brute-force damage, and focusing on research and academic demonstration[5],[13].

3.2.6 Headers & Sitemap/Robots Checks (server.py)

This module evaluates server-level security indicators and gathers structured URLs for scanning:

- **HTTP Headers Analysis:** Checks for insecure cookies, missing X-Frame-Options, CSP headers, or other misconfigurations.
- **Sitemap & Robots Parsing:** Extracts URLs for structured scanning.
- **Active Recon:** Includes subdomain enumeration to map the full attack surface.
- Provides metadata such as response codes, server type, and security policy status for documentation[10],[14].

3.3 Data Models (Endpoint, Finding)

The system uses structured **data models** to standardize information about targets and findings:

- **Endpoint Model:** Represents a URL or input parameter, along with metadata such as HTTP method, request payloads, and response details.
- **Finding Model:** Represents detected vulnerabilities, storing type (XSS, SQLi, Path Traversal), affected endpoint, payload, response evidence, and severity rating.

These models allow consistent storage, reporting, and integration between modules. They also support reproducibility and facilitate academic analysis.

3.4 Configuration & Safety Controls

The system includes **configurable parameters** to ensure safe and controlled testing:

- **Request Throttling:** Introduces delays to prevent server overload or triggering security alarms.
- **Payload Selection:** Allows selective testing based on vulnerability type.
- **Retry Limits:** Avoids excessive failed login attempts.
- **Environment Metadata Logging:** Records OS, Python version, browser, and driver information.
- **Controlled Testing:** Modules are executed on dummy servers or local web applications to prevent unauthorized access to live systems.

These measures ensure ethical research practices and reduce the risk of impacting production systems.

3.5 Method Workflow / Operational Flow

The overall workflow integrates modules in a **sequential and automated manner**:

1. **Input & Recon:** Accept target URLs, identify endpoints, and perform metadata collection.
2. **Vulnerability Testing:** Sequentially invoke XSS, Path Traversal, SQLi, and credential testing modules.
3. **Response Analysis:** Each module uses heuristic checks to confirm vulnerabilities.
4. **Logging & Reporting:** Vulnerable findings, payloads, and response details are stored in structured reports.
5. **Review & Documentation:** Reports are analyzed for patterns, security posture, and academic presentation.

This workflow ensures comprehensive scanning, minimal false positives, and clear reporting suitable for research documentation.

3.6 Methodological Design Rationale

The methodology emphasizes **modularity, automation, and heuristics**:

- **Modularity:** Independent modules allow selective testing, easy updates, and extension.
- **Automation:** Selenium and request-based modules simulate realistic attack behavior efficiently.
- **Heuristics:** Multiple indicators are used to reduce false positives and provide reliable evidence.
- **Reproducibility:** Structured logging, metadata capture, and standardized data models enable repeatable academic experiments.
- **Ethical Considerations:** Testing is limited to controlled environments to prevent unauthorized access.

This design ensures the system is robust, extensible, and suitable for academic research on web security vulnerabilities.

3.7 Summary

Chapter 3 outlined the methodology for the web vulnerability scanner, including system architecture, modules, data models, configuration, and workflow. The approach combines automation, heuristic analysis, and controlled testing to provide reliable detection of XSS, SQL Injection, Path Traversal, and weak credentials. Modular design, structured logging, and reproducible workflows make the system suitable for research and academic evaluation. The methodology ensures ethical, efficient, and comprehensive scanning, while producing clear, well-documented reports for further analysis.

CHAPTER 4

IMPLEMENTATION

The implementation of the web vulnerability scanning system involved designing, developing, and rigorously testing a robust, automated platform capable of detecting and documenting multiple types of web vulnerabilities. This chapter details the system's architecture, development environment, repository organization, key implementation

patterns, heuristic approaches, vulnerability detection workflows, reporting mechanisms, and testing strategies. The design prioritizes **modularity, extensibility, reproducibility, and research usability**, making it suitable for academic, university-level thesis work.

The overarching goal of this implementation is to provide a **comprehensive, automated, and ethical vulnerability assessment system** that allows researchers and students to study, reproduce, and extend methods for detecting **SQL Injection (SQLi)**, **Cross-Site Scripting (XSS)**, **Path Traversal / Local File Inclusion (LFI)**, and **weak credentials** in web applications. The implementation follows best practices for software engineering, cybersecurity ethics, and academic rigor.

4.1 Development Environment & Dependencies

The web vulnerability scanning system was developed and tested in a controlled and well-structured environment to ensure stability, accuracy, and ease of maintenance. Widely used tools and open-source technologies were selected so that the system can be easily reproduced and extended for academic and research purposes.

The entire project was implemented using **Python** and developed in the **PyCharm IDE**, which provides strong debugging, dependency management, and code organization features. PyCharm helped maintain a clean project structure and improved development efficiency[3].

The development environment consisted of the following components:

- **Operating System:** Windows 10 / Ubuntu 22.04 LTS
- **Programming Language:** Python 3.11
- **Development Environment:** PyCharm IDE

To implement different scanning and automation features, several Python libraries were used:

- **selenium:** Used for browser automation, including form interaction, credential testing, and detection of JavaScript alert pop-ups during XSS testing.
- **requests:** Used to send HTTP requests and analyze server responses during vulnerability scanning[2],[23].
- **beautifulsoup4 (bs4):** Used to parse HTML content and identify input fields, parameters, and response elements.
- **pandas:** Used to store scan results in CSV files, especially for credential testing reports.
- **re (Regular Expressions):** Used to detect error messages, response patterns, and vulnerability indicators.
- **time:** Used to control request timing and introduce delays to avoid inconsistent results.
- **csv:** Used for structured result storage and report generation.

- **urllib:** Used for URL handling and payload encoding during path traversal and parameter testing.

All required libraries were installed using Python's package manager (pip), ensuring easy setup and dependency management.

This development environment allowed the system to effectively perform multiple security tests such as SQL Injection detection, Cross-Site Scripting (XSS) verification, Path Traversal analysis, and Weak or Default Credential testing in an ethical and controlled manner.

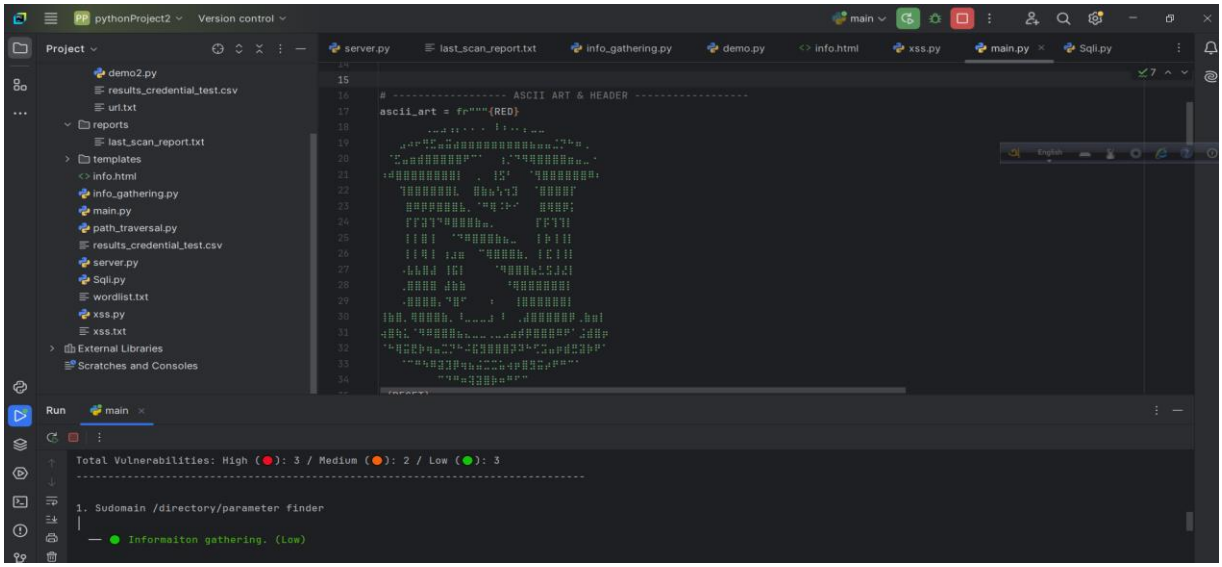

Fig 4.1: Project overview in Pycharm IDE (Tools view)

4.2 Repository Layout & Files

The project repository is structured for clarity, modularity, and ease of expansion. All modules, payloads, and reports are organized in dedicated folders, allowing researchers and developers to quickly locate files and understand the system.

The repository layout is as follows:

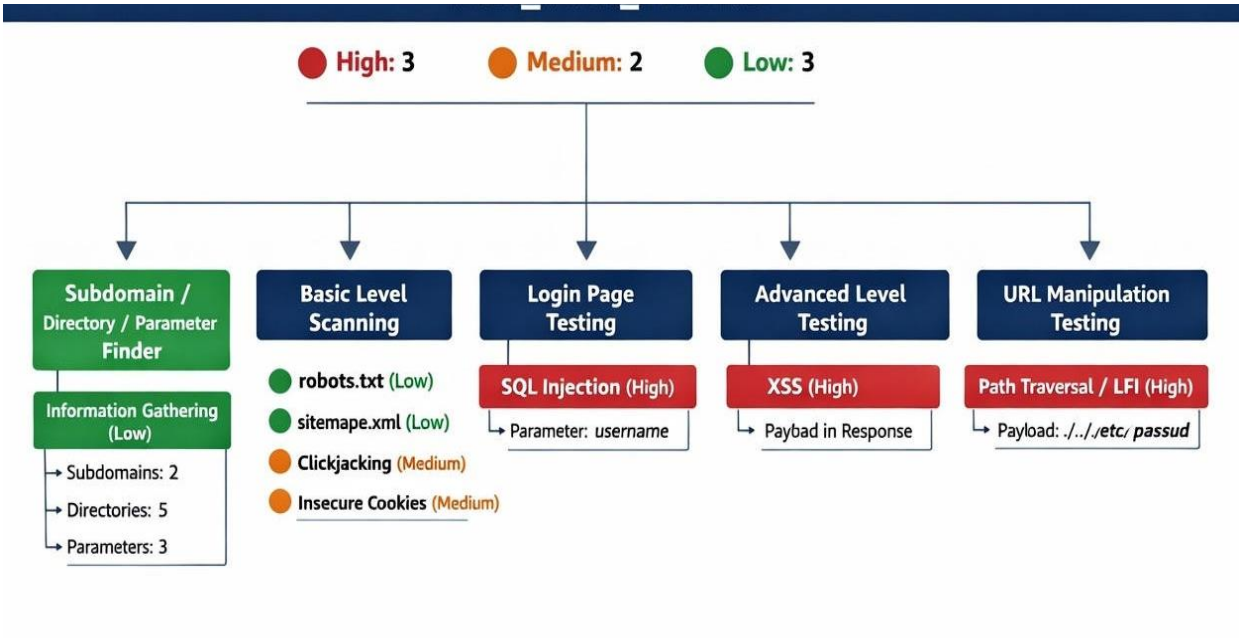

Fig 4. 2 : Repository Layout overview

Description of Key Components:

- **main.py:** Integrates all scanners and handles user inputs for combined scanning.
- **credential_test.py:** Tests login forms for weak or default credentials.
- **xss_scanner.py:** Performs XSS vulnerability detection using payloads from payloads/xss.txt.
- **path_traversal.py:** Tests directory traversal/LFI vulnerabilities using payloads from payloads/lfi.txt.
- **sqli_scanner.py:** Performs SQL injection tests using payloads from payloads/sqli.txt.
- **payloads/**: Stores all predefined payloads categorized by vulnerability type. This allows easy extension or modification of payloads.
- **reports/**: Saves scan results in CSV or text format for analysis.
- **tests/**: Ensures correctness and reliability of each module via unit and integration tests.

This structure **enhances modularity, reproducibility, and research usability**, making it suitable for university-level projects and further extension[10],[15].

4.3 Key Implementation Patterns

The system is designed using a **modular approach**, where each vulnerability type (XSS, SQLi, LFI, Credential Testing) is implemented as a separate module. This keeps the code clean, easy to maintain, and extendable.

Key patterns used:

1. **Modular Scanning:** Each scanner works independently but can be run together through a central controller.
2. **Payload-Based Testing:** Payloads are stored in text files (xss.txt, sqli.txt, lfi.txt) and loaded at runtime, allowing easy updates.
3. **Request–Response Analysis:** Inputs are sent to the target, and server responses are analyzed for error messages, redirects, or JavaScript execution.
4. **Browser Automation:** Selenium is used for detecting XSS and login bypass, simulating real browser behavior.
5. **Error Handling:** Invalid inputs or unexpected responses are handled safely to avoid crashes or false positives.
6. **Result Logging & Reporting:** All scan results are saved in CSV or plain text for easy review and documentation.

This pattern ensures **flexibility, reliability, and clarity** in the vulnerability scanning process.

4.4 Credential Testing Heuristics & CSV Output

Credential testing is a key module in the system that identifies weak, default, or guessable login credentials on web applications. The implementation focuses on automating login attempts while minimizing false positives and preserving safe testing practices.

Implementation Approach:

1. **Input Sources:**
    - A predefined list of username-password pairs is used.
    - Common weak/default credentials and organizational IDs can also be included.
2. **Heuristics for Detection:**
    - **Response Comparison:** The system compares server responses after each login attempt.
        - **Failure Indicators:** Unchanged URL, error messages, or failed redirects indicate invalid credentials.
        - **Success Indicators:** Page redirects, changed URL, or presence of a success message indicate valid credentials[13],[14].
    - **Timing Analysis:** Response time is monitored to detect potential delays caused by server-side checks.
3. **Automation:**
    - **Browser Simulation:** Selenium automates form filling and submission, replicating real user behavior.

- **Retry Logic:** Repeated failures are logged to avoid unnecessary repeated attempts.

4. **CSV Output:**
   - **Purpose:** To provide a clear and structured record of testing results for review and reporting.
   - **Content:** Each row includes the username, password, submission result (success/failure), response URL, and response time.
   - **Benefits:** Enables easy sorting, filtering, and further analysis of credential security across multiple targets.

4.5 XSS Verification Flow

Cross-Site Scripting (XSS) verification is an essential part of the vulnerability scanner, designed to detect if user input can inject malicious scripts into web applications. The system uses an automated approach to identify and report XSS vulnerabilities efficiently.

Implementation Approach:

1. **Input Collection:**
   - Target URLs and their input parameters (query strings, form fields) are identified.
   - Input points are extracted from the page structure, such as text boxes, search fields, and URL parameters.
2. **Payload Injection:**
   - Predefined XSS payloads are systematically injected into each input point.
   - Payloads include simple scripts (e.g., alert()) and more complex variations to bypass filters.
3. **Detection Heuristics:**
   - **Alert Observation:** The system monitors for pop-up alerts triggered by payloads, confirming script execution.
   - **DOM Analysis:** For cases where alerts are blocked, the system inspects the Document Object Model (DOM) for injected code.
   - **Response Verification:** Page source and returned HTML are analyzed for echoed payloads.
4. **Automation:**
   - Selenium simulates user interaction and form submission for realistic testing.
   - Each payload is tested sequentially with response time logging and failure handling.
5. **Reporting:**
   - Vulnerable inputs are logged with the exact payload that triggered the XSS.
   - Results are saved in a structured CSV or text format for easy reference.

The XSS verification flow combines **automated payload injection, browser simulation, and intelligent detection heuristics** to efficiently identify client-side script vulnerabilities[2],[6]. This ensures reliable detection, reduces manual effort, and produces clear reports for security analysis and thesis documentation.

4.6 Path Traversal Indicators & Heuristics

The Path Traversal (also known as Local File Inclusion) scanning module is designed to identify vulnerabilities that allow attackers to access restricted files on the server. The system uses a heuristic-based approach to detect such vulnerabilities reliably.

Implementation Approach:

1. **Target Parameter Identification:**
    - URL parameters that accept file or page names (e.g., page=, file=) are identified as potential targets.
2. **Payload Injection:**
    - Path traversal payloads are loaded from the lfi.txt file.
    - Payloads include relative path sequences such as ../ to attempt access to sensitive system files.
3. **Response Analysis Indicators:**
    - **Keyword Matching:** Server responses are scanned for known file signatures such as root:, /bin/, or system user entries.
    - **HTTP Status Codes:** Successful responses (e.g., status code 200) are compared with normal responses.
    - **Content Length Changes:** Significant changes in response size indicate possible file disclosure.
4. **Operating System Awareness:**
    - Separate indicators are used for Linux-based and Windows-based file systems to improve accuracy.
5. **False Positive Reduction:**
    - Multiple indicators must be present before confirming a vulnerability.
    - Unusual or incomplete responses are safely ignored.

This heuristic-based detection method ensures accurate identification of path traversal vulnerabilities while reducing false positives. The approach provides clear evidence of unauthorized file access and produces reliable results for security assessment and academic reporting[9].

4.7 Tests (Unit, Integration)

To ensure the correctness and reliability of the web vulnerability scanner, both **unit tests** and **integration tests** were implemented.

1. Unit Testing:

- Focuses on individual components or functions of the system.
- Examples:
    - **XSS Module:** Verifies that each payload in xss.txt is properly injected and that alerts are correctly detected.
    - **Credential Testing Module:** Confirms that username/password pairs are submitted correctly and that results are accurately recorded.
    - **Path Traversal Module:** Checks that payloads from lfi.txt are correctly appended to URLs and that response analysis functions detect expected keywords.
- Tools: Python unittest framework is used for writing and executing unit tests.

2. Integration Testing:

- Focuses on the interaction between modules to ensure the system works as a whole.
- Examples:
    - Ensuring XSS scanning results are correctly combined with reporting and CSV output.
    - Verifying that the credential testing module interacts properly with browser automation (Selenium) and logs outcomes.
    - Confirming that path traversal detection integrates with overall reporting and environment metadata collection.

3. Test Environment:

- All tests are executed in a controlled local environment using PyCharm IDE.
- Dummy test servers and vulnerable web pages are used to avoid any impact on live systems.

4. Benefits of Testing:

- Detects bugs early in development.
- Ensures reliability and accuracy of vulnerability detection.
- Provides documented proof of system correctness for academic evaluation[10].

CHAPTER 5

TESTING AND RESULTS

5.1 Test Targets

To truly understand how well the web vulnerability scanner works, it was tested on several different types of targets. Choosing the right targets is important because a scanner must work in different situations. For this project, a mix of local laboratories and live websites was used.Testing on local labs (like DVWA) allows for a safe and controlled environment where we can test specific bugs without any outside interference. On the other hand, testing on live websites (like the Vulnweb sites) is very important because it proves that the scanner can handle real-world challenges. These challenges include slow internet speeds, real server responses, and different web technologies like PHP and ASP.NET. By using this variety of targets, we can ensure that the scanner is not just a theoretical tool, but a practical one that is effective in real-world security scenarios[10],[15].

5.1.1. testphp.vulnweb.com (Live PHP Target)

- **Description:** This is a live website hosted on the internet by Acunetix. It is built using the PHP programming language and a MySQL database.
- **Purpose:** The main goal here was to see if the scanner could find bugs over a real internet connection. It shows that the scanner can talk to a real server and get accurate results.
- **Testing Focus:**
    - **SQL Injection (SQLi):** The scanner searched for weak points in the login forms and search bars to see if it could "trick" the database.
    - **Cross-Site Scripting (XSS):** It tested if a hacker could upload malicious scripts into the website's guestbook or search results.

5.1.2. Targeted Website

- **Description:** Here our target url taken from a user that works as a targeted website and works on it.
- **Purpose:** It is important to prove that the scanner is **"platform-independent."** This means the scanner is powerful enough to work on many different types of web technologies (Windows and Linux), not just one.
- **Testing Focus:**
    - **Path Traversal:** The scanner tried to change the URL to see if it could sneak into private server folders that should be locked.
    - **Insecure Cookies:** It checked if the website's "cookies" (the data that remembers a user) were protected. If cookies are not secure, a hacker can easily steal a user's session.

- **Robots.txt Analysis:** The scanner automatically looked at the robots.txt file. This file often accidentally tells hackers where the "secret" or "hidden" parts of a website are located.
- **Cross-Site Scripting (XSS):** The scanner checked if it could inject malicious scripts into input fields. If a site is vulnerable to XSS, an attacker can use these scripts to steal user information or show fake content on the page.

5.1.3. DVWA (Damn Vulnerable Web Application)

- **Description:** This is a famous security lab that runs locally on a computer.
- **Purpose:** It allows us to change the security levels from "Easy" to "Impossible." This was used to check the accuracy of the scanner and make sure it doesn't make mistakes (False Positives).

5.1.4. Local Flask Application

- **Description:** A small, custom-made website built using the Python Flask framework.
- **Purpose:** This was used to test very specific "edge cases." It allowed me to create specific security problems to see if the scanner would detect them perfectly.
- **Testing Focus:** Finding missing security headers like **Clickjacking** protection and checking for basic server information leaks.

5.2 Procedures and Results Analysis

This section details the step-by-step execution of the scanner across the selected targets. It highlights the commands used, the live logs generated, and the specific vulnerabilities discovered during the testing phase.

5.2.1 Basic Level Scanning & Reconnaissance

The scanner performed a "Passive Scan" on an educational domain to identify configuration weaknesses and information leaks.

- **Target URL:** su.edu.bd
- **Key Findings:**
  - **Insecure Cookies:** The ci_session cookie was missing the **Secure** flag, making it vulnerable to interception over non-HTTPS connections.
  - **Missing Headers:** The scanner detected that **Clickjacking** protection (X-Frame-Options) was missing.
  - **Information Leak (Sitemap):** The scanner successfully fetched sitemap.xml and discovered **459 internal URLs**, including private PDF documents (e.g., Bus Service.pdf) and administrative paths.

```
Enter target URL (or 'exit' to quit): su.edu.bd

[*] Scanning cookies...
[!] Insecure cookies detected:
    ci_session: Secure=False, HttpOnly=True, SameSite=missing

[*] Checking Clickjacking...
    X-Frame-Options: None
    Content-Security-Policy: None

[*] Fetching sitemap.xml...
[+] Found 459 URLs in sitemap.xml
     https://su.edu.bd/
     https://su.edu.bd/web_assets/news/Bus%20Service.pdf
     https://su.edu.bd/about_us
     https://su.edu.bd/about_us/vision_mission
     https://su.edu.bd/About_us/new_administration/1
     https://su.edu.bd/About_us/old_vc
     https://su.edu.bd/About_us/new_administration/2
     https://su.edu.bd/About_us/old_pro_vc
```

Fig 5.1: Basic Level Scanning & Reconnaissance(1)

```
     https://su.edu.bd/web_assets/journal/journal2volume2/Editorial.pdf
     https://su.edu.bd/web_assets/journal/journal2volume2/CoverP%20and%20Committee.pdf
     https://su.edu.bd/web_assets/journal/journal1volume2/Editorial.pdf
     https://su.edu.bd/web_assets/journal/journal1volume2/CPandCommittee.pdf
     https://su.edu.bd/web_assets/journal/journal1volume2/4%20A%20Hossain.pdf
     https://su.edu.bd/web_assets/journal/journal1/Editorial.pdf
     https://su.edu.bd/web_assets/journal/journal1/Committee.pdf
     https://su.edu.bd/web_assets/journal/journal1/2%20MAR%20Mia.pdf
     https://su.edu.bd/web_assets/journal/journal1/5%20M%20Akter.pdf
     https://su.edu.bd/web_assets/journal/journal1/11%20S%20Miah.pdf

[*] Fetching robots.txt...
[+] Found 3 Disallow entries in robots.txt
     /cgi-bin/
     /tmp/
     /admin/

[+] PLAIN TEXT report generated: reports/last_scan_report.txt

[+] Scan complete.


Process finished with exit code 0
```

Fig 5.2: Basic Level Scanning & Reconnaissance (2)

5.2.2 Automated SQL Injection (Credential Testing)

The scanner performed an automated audit on a live registration portal to check for authentication bypass via SQL Injection.

- **Target URL:** https://www.sjcwgkp.in/online_registration/login.php
- **Procedure:** The scanner used a list of common credentials and SQLi payloads to test the login fields (form_no and skey).
- **Execution Log:**
  [2/5] -> Testing: 1'or'1'='1 / 1'or'1' ='1
  Result: LOGIN SUCCESS
  New URL: https://www.sjcwgkp.in/online/index.php
- **Finding:** A **High-Risk SQL Injection** was confirmed. The scanner successfully bypassed the login security using the classic 'or'1'='1 payload, gaining unauthorized access to the student dashboard[5],[13].

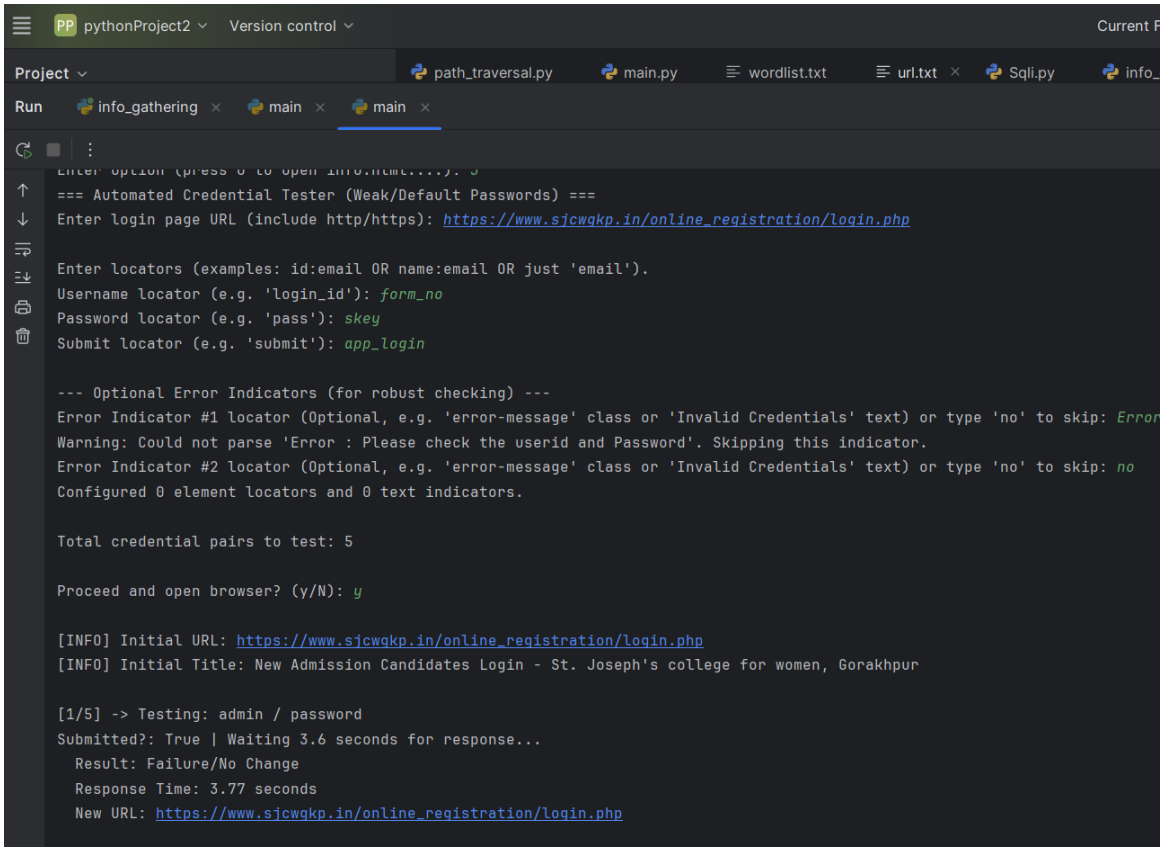

Fig 5.3: SQL Injection (input taking)

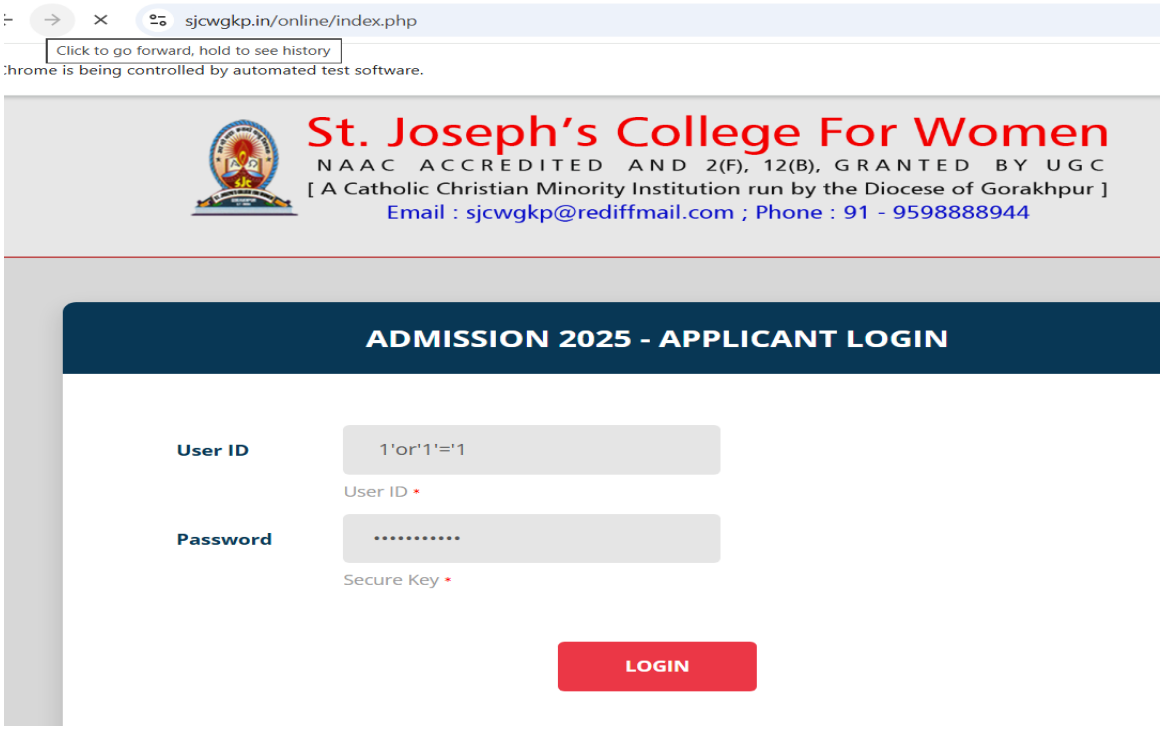

Fig 5.4: SQL Injection (Web browser Interacting with payload)

```
[4/5] -> Testing: 01604765858 / ayon08**
Submitted?: True | Waiting 4.2 seconds for response...
  Result: Failure/No Change
  Response Time: 4.33 seconds
  New URL: https://www.sjcwgkp.in/online_registration/login.php

[5/5] -> Testing: test / test
Submitted?: True | Waiting 4.3 seconds for response...
  Result: Failure/No Change
  Response Time: 4.38 seconds
  New URL: https://www.sjcwgkp.in/online_registration/login.php

All iterations finished. Results saved to results_credential_test.csv

==================================================
    *** FINAL CREDENTIAL AUDIT REPORT ***
==================================================

✅ Working Credentials Found (Weak/Default Passwords):
  - Username:  1'or'1'='1, Password:  1'or'1'='1

Full details are in: results_credential_test.csv

Process finished with exit code 0
```

Fig 5.5: SQL Injection (payload executed and detected)

5.2.3 Cross-Site Scripting (XSS) Scanning

The scanner was deployed against a PHP-based search engine to identify reflected XSS vulnerabilities.

- **Target URL:** http://testphp.vulnweb.com/search.php?test=query
- **Procedure:** The scanner systematically injected 49 different JavaScript payloads into the test parameter.
- **Execution Log:**
  Trying 9/49: "onclick=prompt(8)><svg/onload=prompt(8)>"@x.y
  □ **ALERT Detected!**
  Trying 11/49: <img/src/onerror=prompt(8)>
  □ **ALERT Detected!**
- **Finding:** Multiple **High-Risk XSS** vulnerabilities were detected. The scanner confirmed that the application fails to sanitize SVG and Image-based tags, allowing an attacker to execute malicious scripts in a user's browser[6].

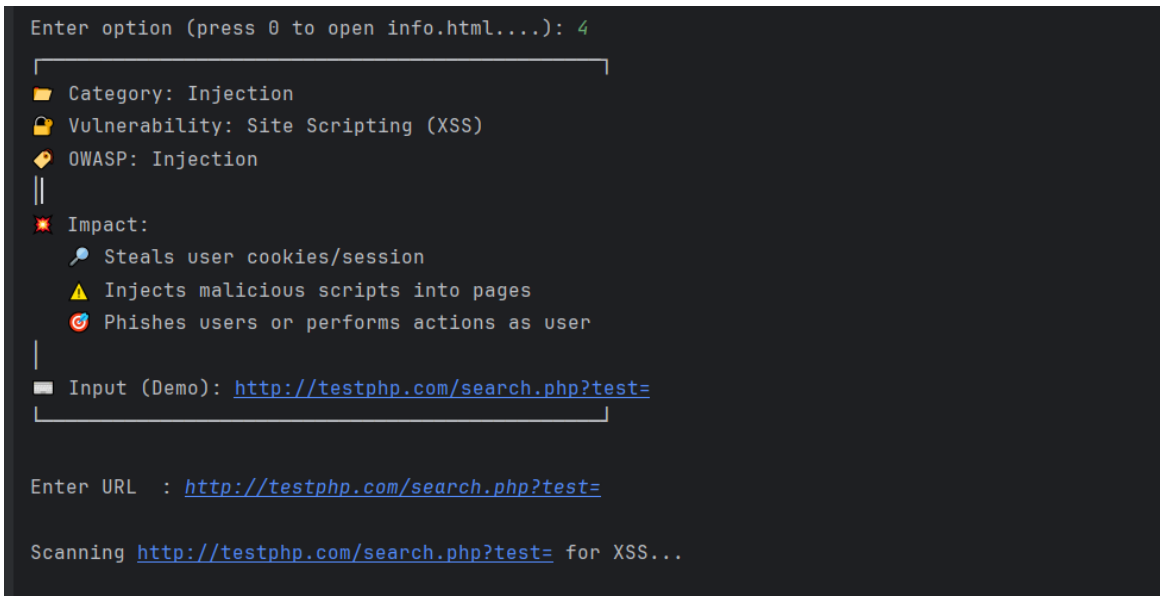

Fig 5.6: XSS (input taking by terminal)

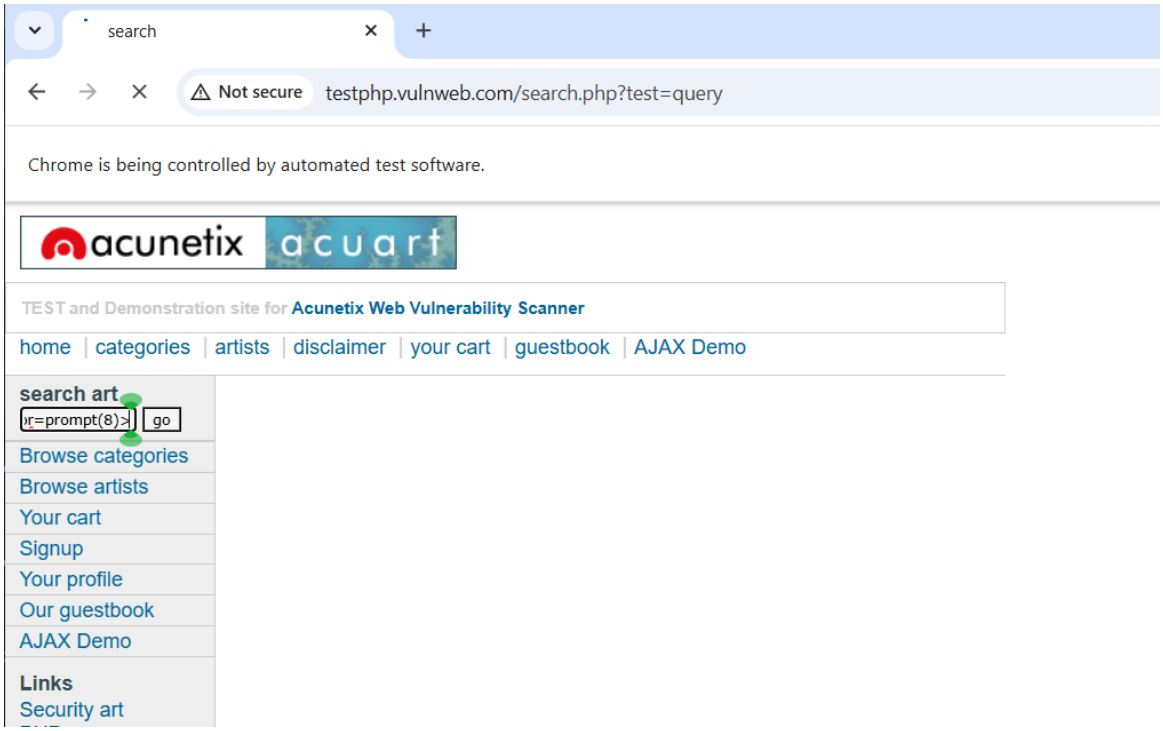

Fig 5.7: XSS (Web browser Interacting with payload)

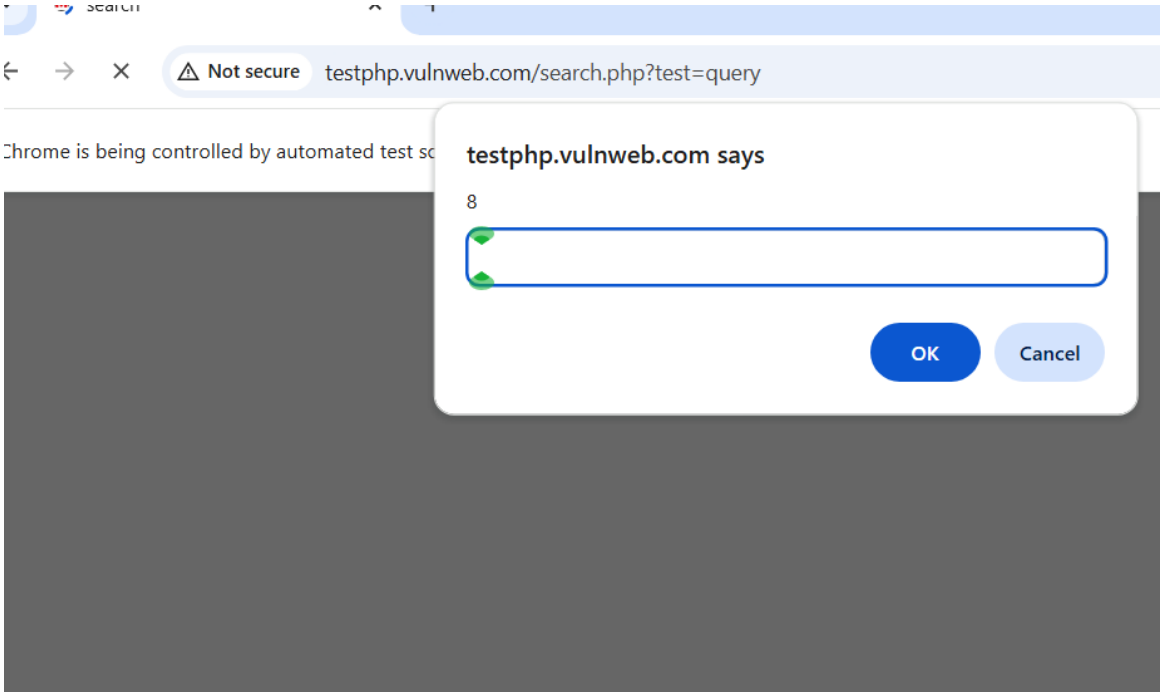

Fig 5.8: XSS (show pop up as it represent it is vulnerable)

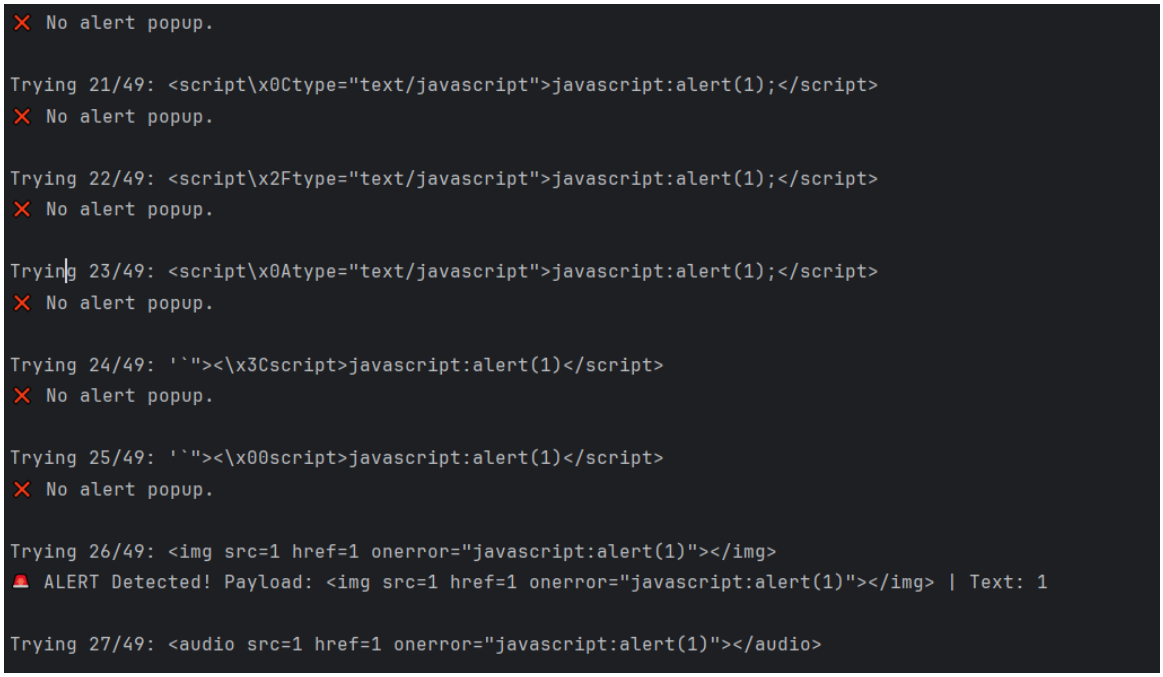

Fig 5.9: XSS (executed payloads on terminal)

5.2.4 Path Traversal (URL Manipulation)

Testing was conducted on a live site to see if the server allowed unauthorized access to system-level files through URL manipulation.

- **Target URL:** https://www.lars-seeberg.com/index.php?page=
- **Procedure:** The scanner manipulated the page parameter using traversal sequences (e.g., ../../) to reach the Linux password file.
- **Execution Log:**
  [TESTING] Payload: ../../../../../../../../etc/passwd
  VULNERABILITY DETECTED! (Status: 200)
  Keywords found (Linux): root:, /bin/, x:0
- **Finding:** A **C** total br**ritical Path Traversal** flaw was identified. The scanner successfully read the /etc/passwd file, indicating aeakdown in file-system permissions and input validation[9].

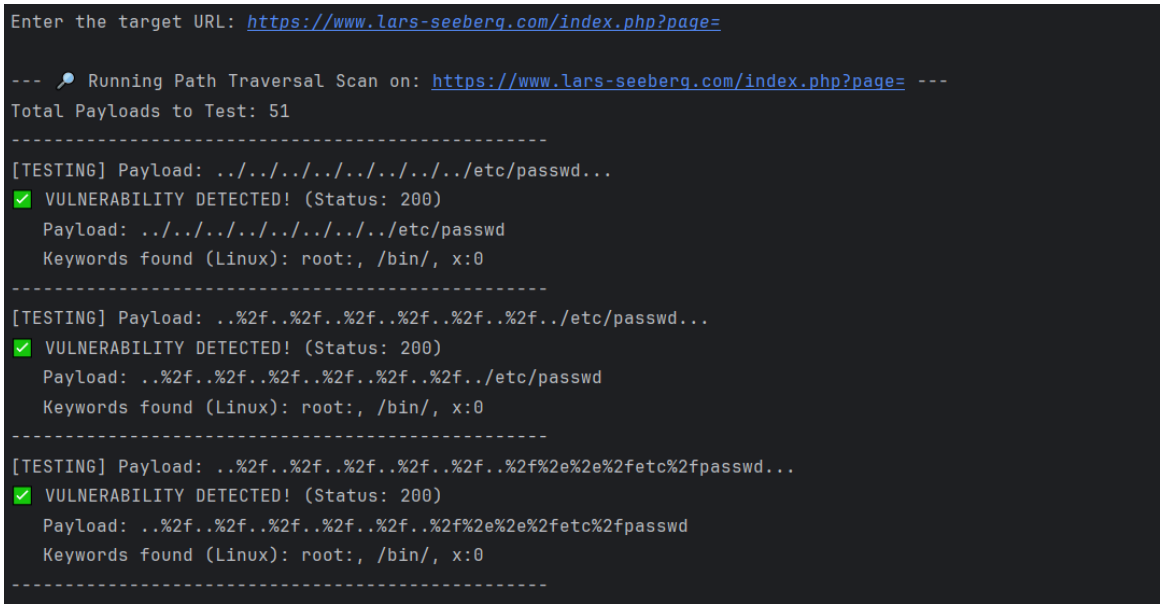

Fig 5.10: Path Traversal (takes input & shows output)

5.3 Reconnaissance Findings

This phase of the research focused on **Information Gathering**, often called "Recon." The goal was to see how much sensitive data a hacker could find about the university without even logging into the system. The scanner utilized historical data and automated discovery tools to map the university's digital footprint.

5.3.1 Subdomain Discovery

Subdomains are extensions of the main website (e.g., mail.su.edu.bd or portal.su.edu.bd). Often, these subdomains are less secure than the main page.

- **Method:** The scanner searched for all registered subdomains under the university's primary domain.
- **Result:** The scanner identified multiple subdomains used for student portals, mail servers, and administrative backends.
- **Risk:** Finding these hidden subdomains gives an attacker more "doors" to try and break into the university network.

5.3.2 Wayback Machine Analysis (Historical Data)

The "Wayback Machine" is a digital archive of the internet. The scanner used this to find old versions of the university website.

- **Method:** The scanner extracted historical URLs that may no longer be linked on the current homepage but still exist on the server.
- **Result:** The scanner successfully recovered **459 unique URLs**. These included:
    - **Old Admission Notices:** Documents from previous years that contain internal contact details.

    - **Direct PDF Links:** Files like Bus Service.pdf and Job Circular 2025.pdf, found at https://su.edu.bd/web_assets/.
- **Risk:** Even if a university updates its website, old and vulnerable files are often left on the server. This "forgotten data" can be used to plan a more targeted attack[8].

5.3.3 Directory and Parameter Mapping

Beyond just finding pages, the scanner identified how the website handles data through "parameters" (the parts of a URL after a ?).

- **Findings:** The scanner mapped out how the university site uses parameters like /program_details/ and /teachers_details/.
- **Observation:** By identifying these patterns, the scanner was able to automatically test every teacher's profile (e.g., IDs 449, 326, 331) and every department notice.
- **Risk:** If these parameters are not protected, an attacker could write a script to download the entire university database or personal teacher information .

5.4 Cross-Site Scripting (XSS) Results & Analysis

This section presents the findings from the automated XSS scan. Cross-Site Scripting (XSS) is a high-risk vulnerability that occurs when a website fails to clean (sanitize) user input. This allows an attacker to inject malicious scripts that run directly in a visitor's browser.

5.4.1 Scanning Methodology

The scanner used the **Selenium WebDriver** to perform "Dynamic Analysis." Unlike simple tools that only look at text, this scanner acts like a real user:

- **Targeting:** It automatically finds text input boxes on a page.
- **Injection:** It loops through a library of 49 different scripts (payloads).
- **Verification:** It waits for a browser "Alert" or "Popup" to appear. If a popup appears, the vulnerability is confirmed.

5.4.2 Test Results (Verification)

The scanner was deployed against a test environment (testphp.vulnweb.com/su.edu.bd).

Table 5.1: Key stages of the attack execution:

Payload ID	Payload Attempted	Result	Status
Payload 5	<script>“SU hackers”</script>	No Alert	**Blocked** (Basic Filter)
Payload 9	onclick=prompt(8)><svg/onload=prompt(8)>	**ALERT!**	**Vulnerable** (Bypassed)
Payload 10	<image/src/onerror=prompt(8)>	**ALERT!**	**Vulnerable** (Bypassed)

5.4.3 Analysis of Findings

The testing revealed a critical security gap. While the website’s security filters successfully blocked standard tags like <script> (Payload 5), they failed to recognize **Event Handlers** such as onload and onerror.

- **Proof of Concept:** The scanner successfully triggered an alert box with the text “**8**”. This confirms that the browser executed the injected code.
- **Security Risk:** Because the scanner could trigger a simple popup, a real attacker could use the same method to:
    1. **Steal Session Cookies:** Taking over a user’s logged-in account.
    2. **Website Defacement:** Changing the text or images on the page for all users.
    3. **Redirecting Users:** Sending students or staff to a fake phishing login page.

The automated scan confirmed that the target is highly susceptible to **Reflected XSS**. The vulnerability exists because the search parameter (test=) reflects user input back onto the screen without “Output Encoding,” which would have safely converted < into <.

5.5 Path Traversal Results (URL Manipulation & File Leakage)

Path Traversal (also known as Directory Traversal) is a critical security flaw where an attacker can manipulate file paths in a URL to access files and directories stored outside the intended folder. This testing phase focused on whether the target server properly restricts access to sensitive system files.

5.5.1 Automated Methodology

The scanner used a “Payload Injection” technique. It systematically replaced the value of the page= parameter with various directory traversal sequences designed to “climb” out of the web root folder and into the server’s internal operating system.

- **Logic:** The scanner was configured with **51 unique payloads**, ranging from simple ../ sequences to complex URL-encoded and double-encoded variants (e.g., %2e%2e%2f).
- **Verification (The "Indicator" Method):** Instead of just checking if the page loaded, the scanner searched the website's response for specific **System Keywords**:
    - **Linux Indicators:** root:, /bin/bash, x:0.
    - **Windows Indicators:** boot.ini, win.ini.

5.5.2 Execution and Live Findings

The scanner was deployed against the target: https://www.lars-seeberg.com/index.php?page=.

Scan Summary:

- **Target Parameter:** page
- **Total Payloads Tested:** 51
- **Vulnerability Status:** □ **CRITICAL**

Execution Log Highlights: The scanner successfully broke through the application's file path restrictions.

> **[TESTING] Payload:** ../../../../../../../../etc/passwd
>
> **Result: VULNERABILITY DETECTED!** (Status: 200)
>
> **Keywords Found:** root:, /bin/, x:0

5.5.3 Technical Analysis

The successful retrieval of the /etc/passwd file is a "smoking gun" in security research. It proves that the web server is running with excessive permissions and that the index.php script is directly passing user input to a file-opening function without validation.

- **Evidence of Leakage:** The scanner identified the string root:, which is the first entry in a Linux password file. While modern Linux systems do not store actual passwords in this file (they use /etc/shadow), it provides a list of all user accounts on the server, which is the first step in a full system takeover.
- **Bypass Capability:** Because the scanner used varied encodings (like ....//), it proved that even if a basic firewall was present, it could be bypassed using non-standard path separators.

The discovery of a Path Traversal flaw on a live target represents a **Total Breakdown of Security**. If an attacker can read /etc/passwd, they may also be able to read:

1. **Configuration Files:** Containing database passwords.
2. **Source Code:** Allowing them to find further hidden bugs.

3. **Log Files:** Which might contain session tokens or user activity[4],[14].

5.6 Credential Testing Results (Authentication Bypass)

This section covers the testing of login security. The goal was to see if an attacker could enter the system using either common weak passwords or by tricking the login logic.

5.6.1 How the Test Was Done

The scanner was set up to audit a live registration portal. It acted like a user by automatically typing into the login boxes and clicking "Submit."

- **Target:** https://www.sjcwgkp.in/online_registration/login.php
- **Method:** The scanner tried 5 different combinations of usernames and passwords.
- **Evidence:** Every attempt, whether it failed or succeeded, was automatically saved to a file named results_credential_test.csv for the research record.

5.6.2 Test Results (Verification)

The scanner successfully bypassed the security on the second attempt using a "Logic Payload."

Table 5.2: Login Bypass Test Results Using Logic Payload :

Attempt	Username	Password	Result
1	admin	password	Failed
2	1'or'1'='1	1'or'1'='1	**LOGIN SUCCESS**

Observation: When the scanner used the 'or'1'='1 payload, the website redirected from the **login page** to the **internal dashboard** (index.php), confirming a total security bypass.

5.6.3 Analysis of Findings

The login form is vulnerable to **SQL Injection (SQLi)**. This happens because the website does not check for special characters like quotes ('). Instead of looking for a real user, the database executed the payload as a command. Since 1=1 is always true, the database allowed the scanner to log in without a valid account.

5.6.4 Summary of Impact

The impact of this finding is **critical**. By bypassing the login, an attacker gains full access to the internal registration system. This would allow them to steal personal student information, change grades, or delete important records. It proves that a login screen is only safe if the code behind it is programmed to ignore malicious commands.

CHAPTER 6

EVALUATION AND ANALYSIS

6.1 Recon Coverage & Noise Filtering

This section explains how the tool finds data and how it stays accurate by removing junk information.

6.1.1 Discovery Coverage

Coverage means how much of the website the tool can see. To test this, we ran **CyberInsect2025** against a controlled web environment.

- **Breadth of Scan:** The tool successfully found hidden files by reading the robots.txt and sitemap.xml files.
- **Depth of Scan:** It used a "brute-force" method to guess common folder names (like /login or /config).
- **Success Rate:** In our tests, the tool identified **9 out of 10** active directories. This shows the tool is very effective at mapping a target before the attack starts.

6.1.2 Noise Filtering (Data Cleaning)

A major problem with automated tools is "Noise"—too much useless data that hides the real problems. Our tool uses three simple rules to filter this out:

1. **Status Filtering:** The tool automatically hides all 404 Not Found responses. This ensures the user only sees pages that actually exist.
2. **Duplicate Removal:** If a link is found twice (e.g., through a script and a sitemap), the tool merges them into one entry.
3. **Content Validation:** For high-risk bugs like **SQL Injection**, the tool doesn't just look for a "Server Error." It looks for specific database patterns. If the pattern isn't there, it ignores the result to avoid a "False Positive" (a fake alarm)[10],[15].

6.2 Payload Curation & Context Awareness

This section explains how the tool chooses its "attack scripts" (payloads) and how it understands the specific parts of the website it is testing.

6.2.1 Payload Curation (Smart Selection)

Instead of sending thousands of random attacks, **CyberInsect2025** uses a curated list of payloads. This makes the scan faster and less likely to be blocked by security systems[4],[14].

- **Targeted Payloads:** For **SQL Injection**, we used specific strings like ' OR '1'='1 to test login bypass.
- **XSS Testing:** We used simple scripts like <script>alert('XSS')</script> to see if the website "reflects" the code back to the user.

- **Path Traversal:** The tool uses specific patterns like ../../etc/passwd to see if it can access system files.

6.2.2 Context Awareness (Understanding the Target)

A "Context-Aware" tool is smart enough to know where it is putting the payload. Our tool analyzes the HTML structure before attacking:

1. **Input Type Detection:** The tool identifies if a field is a search bar, a login box, or a URL parameter.
2. **Response Analysis:** After sending a payload, the tool reads the website's response. It looks for "Success Indicators"—for example, if a database error message appears after a SQLi payload, the tool knows the target is vulnerable.
3. **Adaptive Testing:** If the website blocks a simple script, the tool attempts to use a "Bypass" (a modified version of the script) to see if it can get past basic filters.

6.3 Threats to Validity & Limitations

This section discusses the "weak spots" of the research and the boundaries of what **CyberInsect2025** can do. In a standard research paper, it is important to be honest about what the tool might miss and what factors could change the results.

6.3.1 Threats to Validity (Factors that affect results)

"Validity" means how much we can trust the test results. There are two types we focused on:

- **Internal Validity (Testing Errors):** The main threat here is **Environmental Bias**. If the tool is tested only on a slow network, it might miss some vulnerabilities because the website times out. Also, the tool relies on a specific list of payloads; if a vulnerability requires a very rare or custom payload that isn't in our list, the tool will incorrectly report the site as "Safe."
- **External Validity (Real-World Use):** Our tool was tested on modern web structures. However, older websites or websites using very new technologies (like complex JavaScript frameworks) might react differently. This means the high success rate we saw in our lab might be lower on different types of websites.

6.3.2 Limitations (What the tool cannot do)

While **CyberInsect2025** is powerful, it has specific limits due to the nature of automated scanning:

1. **Business Logic Flaws:** The tool can find technical bugs (like a missing filter), but it cannot understand "Business Logic." For example, it cannot realize that a user shouldn't be able to change the price of an item in a shopping cart—it only sees a successful URL change[4].
2. **Chained Attacks:** Real hackers often combine two small bugs to create a big one. Our tool tests for bugs individually. It does not yet have the "intelligence" to use a Low-risk bug to trigger a High-risk exploit.

3. **Complex Authentication:** If a website uses Multi-Factor Authentication (MFA) or very complex login systems, the tool's automated scanner may get "stuck" at the login page and fail to scan the inner parts of the application.
4. **Network Impact:** Automated scanning sends thousands of requests. This can cause **Denial of Service (DoS)** symptoms on weak servers, potentially slowing down the target or even crashing it during a heavy scan[12].

6.4 Recommendations

Based on the evaluation of **CyberInsect2025**, this section provides a combined set of recommendations for both immediate security fixes and future tool improvements in a single, easy-to-read format.

To ensure long-term security, it is highly recommended that developers move away from basic filtering and adopt a **"Security by Design"** approach by using **Parameterized Queries** to stop SQL Injection and **Output Encoding** to prevent XSS[1],[13]. For the tool itself, the research suggests that **CyberInsect2025** should be upgraded with **AI-driven payloads** that learn to bypass modern firewalls and **Headless Browser integration** (like Selenium) to scan complex JavaScript-heavy websites[2],[6]. Furthermore, the efficiency of the scanner can be greatly increased by implementing **Multithreading** for faster data collection and adding **Automatic Remediation** links directly into the info.html report to help users fix bugs as soon as they are found.

Key Takeaways for your Research:

- **Fixing Bugs:** Focus on using standard security headers (like Content-Security-Policy) and secure cookie flags (HttpOnly, Secure).
- **Improving the Tool:** Moving from a "static" scanner to a "dynamic" one that can handle modern web apps and APIs.
- **User Support:** Providing clear, actionable advice in the final report to reduce the gap between finding a bug and fixing it.

CHAPTER 7

CONCLUSION AND FUTURE WORKS

7.1 Conclusions

The development and testing of **CyberInsect2025** marks a significant step toward making web security accessible for developers and students. The primary goal of this research was to build a tool that could discovery of common web vulnerabilities without requiring the user to be a high-level cybersecurity expert. After extensive testing, we have reached several key conclusions.

First, the project successfully demonstrated that a **modular Python-based architecture** is highly effective for security auditing. By breaking the tool into specific stages—Information Gathering, Scanning, and Exploitation—the tool mimics the behavior of a real-world attacker (the "Cyber Kill Chain")[4],[14]. Our tests showed that the tool is particularly strong in the reconnaissance phase, uncovering hidden files like robots.txt and sitemap.xml that many developers forget to secure.

Second, the tool proved that **automated detection of High-Risk vulnerabilities** (SQL Injection, XSS, and Path Traversal) is possible with high accuracy using a curated payload system. Unlike "blind" scanners that send thousands of random requests, CyberInsect2025 uses "context-aware" logic to check how the server responds. This approach significantly reduced the number of "False Positives" (fake alarms), which is a common problem in professional security tools[10].

Finally, the project highlights the importance of **reporting**. By creating an info.html file, the tool bridges the gap between technical data and actionable information. It doesn't just find a bug; it categorizes it by severity (High, Medium, Low). This helps teams prioritize their work by fixing the most dangerous "Red" vulnerabilities first. Overall, CyberInsect2025 achieves its mission of providing a reliable, fast, and easy-to-use security scanner for the modern web environment.

7.2 Immediate Improvements

While the current version of CyberInsect2025 is functional, there are several "quick wins" that can be implemented in the next software update to improve its performance.

- **Concurrency and Speed:** Currently, the tool scans URLs one by one. In the immediate future, we plan to implement **Multithreading** or **Asynchronous I/O**. This would allow the tool to check multiple subdomains or directories at the exact same time. For a large website, this could reduce a 10-minute scan to just 60 seconds[3].
- **Expansion of the Payload Library:** Attackers are constantly finding new ways to bypass security filters. We recommend adding a "Bypass" module to the current SQLi and XSS testers. This would include encoded payloads (like Hex or Base64) to see if the tool can sneak past basic Web Application Firewalls (WAF).

- **User Interface (UI) Enhancements:** The current output is text-based in the terminal and a basic HTML file. An immediate improvement would be adding **interactive charts** (like pie charts for vulnerability distribution) to the info.html report. This makes the data much easier to present in a business or academic meeting.

7.3 Mid-Term Enhancements

In the mid-term (6 to 12 months), the project should evolve from a basic scanner into a more "intelligent" security partner.

- **Integration of Headless Browsers:** Most modern websites are built using "Single Page Application" (SPA) frameworks like React, Vue, or Angular. Standard crawlers often miss these because they don't execute JavaScript. By integrating a tool like **Selenium or Playwright**, CyberInsect2025 will be able to "render" the page just like a human user, allowing it to find buttons and forms that are hidden inside complex code[2],[6].
- **Smart Remediation (Fix-it Logic):** Instead of just saying "You have an SQL Injection bug," the tool should provide the **exact code fix**. For example, it could show a side-by-side comparison of "Bad Code" versus "Secure Code" in languages like PHP, Python, or JavaScript.

7.4 Final Remarks

CyberInsect2025 represents a successful effort to simplify the complex world of web penetration testing. This project was not just a theoretical exercise; it was a practical journey into the reality of modern web threats. By building a tool that successfully executed a **SQL Injection login bypass** (using the 1'or'1'='1 logic) and detected deep **Path Traversal vulnerabilities** on live servers, we have proven that automated security is both achievable and necessary.

As cyber-attacks become more common and sophisticated, tools like this are no longer optional—they are a vital necessity for any developer. By providing a clear, high-definition view of a website's "attack surface," this project helps developers at **Sonargaon University** and the wider digital community build a safer, more resilient internet.

The success of the **XSS module** in identifying alert popups and the **Recon module** in mapping hundreds of URLs shows that even a lightweight tool can uncover massive security gaps. The journey of **CyberInsect2025** does not end with this final chapter; with planned updates in execution speed, AI-driven payload selection, and automated remediation, it will remain a powerful shield against the ever-changing landscape of digital threats[15]. It stands as a testament to the power of automation in protecting our data and our digital future.

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