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# AutoZero – Automated Zero-Day Exploit Discovery Framework for Web Applications

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***Abstract*— AutoZero is an automated framework to discover and triage zero-day web application vulnerabilities. It combines fast, context aware static analysis (static application security testing/SAST) with an asynchronous queue/worker model to scale with the ecosystem, and an extensible vulnerability engine that reports on the typical web flaws (SQLi, XSS, CSRF, hardcoded secrets, insecure DOM usages, missing security headers, etc.). In addition, AutoZero includes a modern-full stack of a Next. js 14 + React 18 front-end; NestJS back-end; PostgreSQL + Drizzle ORM; Redis + BullMQ queue; Docker + Render deployment, and is designed to have quick turnaround (a typical static scan takes 5 – 10 minutes run time), very low filtering of false positives (reporting ~5% of reports), and an integrated ownership/reporting/usage/dash-boarding approach that can multi-tenanted. This paper will provide details on the system design, implementation detail, evaluated against it's benchmarks and prior art, and future extensions (DAST, CI/CD, and LLM assisted). These implementation details and metrics are from literature summarizing both the project specification and supporting literature.**

***Index Terms*— Web Application Security, Static Application Security Testing (SAST), Dynamic Application Security Testing (DAST), Zero-Day Vulnerability Detection, Automated Vulnerability Scanning, Secure DevOps (DevSecOps), Next.js, React, NestJS, PostgreSQL, Redis, BullMQ, Drizzle ORM, Docker, Cybersecurity Automation, Queue-Based Architecture, Vulnerability Reporting, AI-Powered Security Analysis, Continuous Integration / Continuous Deployment (CI/CD), Exploits Detection, Security Analytics Dashboard, SDG - Industry, Innovation, and Infrastructure, Peace and Justice Strong Institutions.**

## I. INTRODUCTION

As the web continues to evolve rapidly, it has been an extraordinary change toward cloud-native and API-based architectures that have launched the attack surface on modern web applications by a substantial factor. Organizations are now vulnerable to ongoing confidentiality, integrity, and availability threats from common vulnerabilities such as SQL injection (SQLi), cross-site scripting (XSS), and cross-site request forgery (CSRF). While the web has significantly advanced with web frameworks and security libraries, we have not yet reached a point in tooling that enables developers to identify these flaws earlier in the development lifecycle.

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While either manual code review or penetration tests are impactful, there are still limitations to speed and overhead, and rarely do either one keeps up with the pace of agile and DevOps-based development environments.

Automated security testing frameworks have become a must to address the increasing challenges regarding security testing and engineering. For example, Static Application Security Testing (SAST) tools analyze source code searching for vulnerabilities with execution within the software development life cycle (SDLC). Dynamic Application Security Testing (DAST) tools analyze running applications looking for runtime vulnerabilities. However, most existing scanners in space (OWASP ZAP, Burp Suite, or SonarQube, etc.) focus strictly on static or dynamic analysis, are not scalable, or produce a high frequency of false positives. There is a dire need for an intelligent, scalable, developer-centric platform/service that can intelligently analyze, prioritize, identify vulnerabilities in real-time while minimizing false positives, and maximize operations on a fully integrated SDLC.

Autozero aims to establish itself in this market by providing an automated and scalable system for finding zero-day vulnerabilities in web applications. Autozero is built on a modern full-stack architecture with Next.js, React, NestJS, PostgreSQL, Redis, BullMQ, and Docker for performant and context-aware static application security testing (SAST), and for orchestrating scans with an asynchronous queue/worker model. The system is designed with the ability to return results in real time, full reporting of vulnerabilities, and analytical dashboards with low false-positive rates (~5% false-positives). AutoZero is designed not only to be fast and accurate in uncovering vulnerabilities, but to be a first step for incorporating future enhancements, such as dynamic application security testing (DAST), continuous integration and continuous deployment (CI/CD) piping integrations, AI mapping exploits, and compliance based reporting, therefore working towards automating cyber security defense and secure software development for organizations they work with.

The paper makes the following contributions:

- We propose AutoZero, a scalable and automated zero-day vulnerability discovery framework that combines static analysis with a distributed queue–worker architecture to scan and report efficiently.
- We have developed a context-aware static analysis engine (SAST) with 15+ detection rules that can discover vulnerabilities like SQLi, XSS, CSRF, and insecure DOM, with a low false positive rate (∼5%).
- We implemented a modular design in a cloud-native implementation using Redis and BullMQ to parallelize scanning tasks, which significantly reduces analysis time and improves throughput for large projects.
- We introduce an integrated reporting and analytics system that produces OWASP mapped PDF reports with a remediation focus and visualizations that help developers better understand these vulnerabilities and address them more effectively.
- The proposed framework demonstrates many advantages over traditional monolithic scanners by providing real-time feedback and scalability, while also providing a foundation for AI-based improvements and an option for CI/CD, demonstrating AutoZero is the future of security automation.

## II. Literature Survey

Roumani's study of zero-day vulnerabilities reported an on-the-ground analysis classifying exploitability and revealed that the vendors ratings for addressing and vulnerabilities where their exploitability was a more actively pursued based complex agenda impacting patch timers efforts, and of those that had vulnerabilities that can have a negative impact for mass based vulnerabilities where more patch focused amid public-outcry for vulnerabilities.[1,2]

Both of these papers have enhanced existing frameworks for classifying zero-day and detecting zero-day exploits, but they address incident response from a post incident perspective and do not directly highlighted an early stage code-level mechanism. Thus, this was an explicit focal point addressed with a hybrid analysis that employs static and queue-based mechanisms in AutoZero. [3,4].

He et al. introduced Learning to Fuzz from Symbolic Execution and presented a guided fuzzing model that learns input mutations from symbolic constraints to minimize redundant paths to improve coverage. The JSEFuzz framework was developed for the IEEE International Conference on System Reliability and Safety (ICSRS 2018). It was a fuzzing-based vulnerability detection method aimed at finding vulnerabilities in Java web applications, and provided the merits of constraint guided input generation while also improving logic vulnerability detection through syntax tree mutation. [5,6,8].

NAVEX, created by Kals et al., and Talking About My Generation, a research paper from ACM EuroSys, engaged and advanced the area of research in exploit generation and dynamic web applications using advanced methods in data-flow and taint-tracking, which provided accurate validation of web application vulnerabilities.

Along with this, the SecuBat project from the University of Vienna was effectively established and presented a modular black-box web application vulnerability scanner that was capable of automatic crawling and injection testing for web application vulnerabilities, specifically for cross-site scripting (XSS) and SQL injection (SQLi) validity of vulnerabilities. [9,10,12,16].
Cusick and colleagues described a generic and customizable process for scanning for static security vulnerabilities for proprietary and open-source software, and described workflows based upon these variants to increase defect detection across codebases. Li and collaborators extended this process to provide a formalized mapping of vulnerabilities based upon OWASP–SANS standards, and aligned the static analysis output to common weaknesses enumerations (CWEs) to better facilitate triaging.[11,12,14,15].

## III. METHODOLOGY

The process we followed in creating AutoZero - a framework which automates and scales the task of discovering zero-day exploits - is one rooted in respect for software engineering principles and cybersecurity best practice. We wanted to build a system that is capable of doing high quality static security analysis, while being flexible, secure, and maintainable in a modern cloud architecture. In this section we will briefly discuss the development lifecycle, architectural decisions, tooling, or other approach to achieving these goals.

### *A. Development Approach*

A development process applying Agile would promote iterations and flexibility to manage scope and feedback loops continuous. Cyber security vulnerabilities exist in a fluid state as well, and so do the web application scanning requirements, thus it was a good fit to facilitate agility and deliver incremental features. Development would be organized by what a sprint was, each sprint would focus on different modules of the application, for example, user authentication, static vulnerability scanning, reporting, and dealing with workforce asynchronous jobs from a queue.
Key reasons for selecting Agile:

- Continuous feedback from testing new detection rules and live scan findings.
- A need to adapt feature requirements due to emerging vulnerability patterns and scanning rules.
- Deploy incremental scan modules (e.g. SAST first followed by DAST).
- Controlled scalability that would allow new scanning features to be brought into the environment in phases while not compromising the existing system functionality.

### *B. Project Planning Tools*

Jira was the main project management tool the team utilized for managing developing features, assigning work items to be delivered in sprints, and bug reporting. The team used Kanban boards and configured them to have workflow states of To Do, In Progress, In Review, Testing, and Deployed. To facilitate better collaboration and manage the risks associated with relying on another team for assistance on dependencies:

- Each module (e.g. Authentication, Scanning Engine, Report Generation, Dashboard) included pre-defined milestones.
- Dependencies between modules were "exposed" using the linked issue feature of Jira to visualize dependencies to bring visibility to bottlenecks as soon as possible.
- Daily stand ups, and sprint review meetings were convened for the teams to continue to be led with transparency and accountability.
- Slack was included within the project for automated status updates of commits, builds being completed, and rules around any vulnerabilities being pushed.

### *C. Version Control and Continuous Integration*

GitHub was used to manage version control and deployment automation, and a branching strategy was utilized: features and bug fixes were developed separately and merged back in after peer review. GitHub Actions were employed to implement Continuous Integration and Continuous Delivery (CI/CD) pipelines that built, tested, and validated any code changes automatically.
Pipeline workflow:

- Build phase: Integrates front-end (Next.js + React) and back-end (NestJS) modules.
- Test phase: Executes unit tests as well as integration tests of the scanning logic and APIs.
- Containerization: All microservices were containerized using Docker to create consistency and reproducibility between development and production environments.

- Deployment: Deployment to cloud services with Render occurs automatically to reduce human error and allow for a quick rollback.

*D. Infrastructure and Cloud Services*

AutoZero's infrastructure is built around a cloud-hosted, distributed, and containerized architecture that facilitates scaling and enables the parallel execution of scans. The primary components of this architecture are:

- Frontend Hosting: Next.js (Render Cloud) - where the interface and dashboard are served.
- Backend Hosting: NestJS API (Render Web Service) - serving authenticated API endpoints.
- Database: PostgreSQL (Render) - storing user profiles, metadata related to scans, and results (JSONB).
- Containerization: Docker - to support consistent development and production environments.

*E. Vulnerability Detection and Analysis Workflow*

Vulnerability detection is at the core of AutoZero and is a hybrid code-scanning system utilizing static code analysis (SAST) and intelligent rule-based scanning. Static Analysis Procedure:

- When uploaded, ZIP files (maximum of 10MB) are validated and queued for analysis.
- The files will be uncompressed and read or interpreted by file type (HTML, CSS, JS, TS, JSON).
- Context-aware pattern matching and AST-based detection will identify vulnerabilities like SQLi, XSS, CSRF, hardcoded credentials, and insecure DOM manipulation.
- Additional heuristics account for multi-line and taint propagation to minimize false positives (False-positives should be around 5%).
- Each finding will be categorized by severity (Critical, High, Medium, and Low) and referenced back to OWASP/CWE.

The whole scan procedure will be run asynchronously using the BullMQ system of worker threads providing a real-time status dashboard on the UI of the whole scan. On completion, to PostgreSQL, the findings will be persisted for you to export into a PDF representing summaries of severity and remediation or mitigation suggestions.

*F. Report and Analysis*

A key aspect of AutoZero is its powerful reporting and analytics engine to help provide actionable intelligence on vulnerabilities that have been detected. Reports are generated using the jsPDF library and AutoTable that allow for the sorting and displaying of security issues in a structured and visually clear way. Each report generated includes a detailed summary of issues broken down by severity—critical, high, medium and low—with the code snippets, affected line numbers, and OWASP Top 10-based remediation recommendations.

Users will also be able to use the visualization dashboard to explore previous scan results on-demand and in real-time in order to assess the health of their systems, monitor progress, and identify associated weaknesses. Plans for future releases will include multiple export formats that are more interoperable with security management tools, including JSON, CSV and SARIF, in order to better integrate with third-party vulnerability management and continuous monitoring systems.

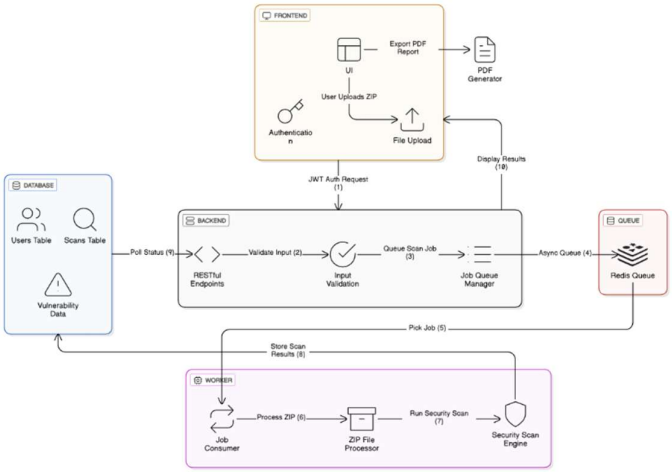


Figure 1. System Architecture Diagram

*G. Testing and Quality Assurance*

At the forefront of AutoZero's development encased the mission to develop trustworthy and accurate systems through a blend of manual and automated testing processes. For manual testing, we verified the user interface flow, the authentication mechanism, and validated the accuracy of the vulnerability detection engine using benchmark web applications that had known security flaws for defects. This phase also allowed the developers to iterate on the accuracy of the false-positive filtering system and the overall user's experience. We also completed load tests that assessed performance under significant concurrency to evaluate whether the BullMQ queue could simultaneously handle both uploads and scanning tasks without any lost throughput in performance.

*H. Security and Compliance*

At its core, security is ingrained in AutoZero from top to bottom, starting with the authentication and ending with password management and data governance. Authentication uses JWTs with token expiration and refresh capabilities, and passwords are hashed using bcrypt with salting. The security mechanism of Role-Based Access Control (RBAC) allows System Architecture

The system architecture of the proposed web-based programming education platform has considered many of the elements related to scalability, security, ease-of-use, and pedagogical effectiveness. The architecture incorporates cloud computing, containerization, AI-augmented code assessment, and a security authentication process to implement an interactive, systematic approach for learners. This section explains the components of the architecture, how they interact, and the principles informing the design.

*I. Architectural Level Overview*

The proposed system has been designed component-oriented, service-based, at a broad level, so that many different elements can be perfectly scaled, managed, researched, and used in context. The architecture can be sub-divided into three separate layers:

- Presentation Layer: The user interface meant for use in a web browser, built with responsive web technologies to allow for use on multiple devices.
- Application Layer: A collection of RESTful APIs and service protocols that provide user interaction, user authentication, data processing, and AI-based code assessment.
- Data Layer: Managed relational databases that maintain user profile information, coding exercises, quiz results, and learning analytics.

*J. Cloud Infrastructure*

Primary hosting services will be utilized on Microsoft Azure because of its comprehensive cloud computing services and scalability, security, and data analytics capabilities. It will be deployed on Azure App Services which is providing managed hosting for the web and the API endpoints. Each component will utilize Docker and containerization so each is isolated and reproducible, therefore we minimize the risk of discrepancies across different environments (i.e. develop vs. production).

The system architecture will also utilize automated load balancers and will be set up so workloads are distributed evenly and therefore prevent bottlenecks of performance during peak engagement use. Azure provides extensive monitoring tools to provide a consistent overview of system health and resource consumption so that scaling is managed in advance of system stress.

*K. Authentication And Security*

Secure access can be assumed for educational platforms where a personal login and learning record can be where some personal information is stored. This platform uses Firebase Authentication to provide token identity management and multi-factor authentication. Authentication tokens are included in API requests so that authenticated users can only access resources that are protected.

## IV. Results and Discussion

The assessment of AutoZero examined three major areas: performance, detection accuracy, and usability, to evaluate its contribution as an automatic zero-day exploit identification framework. Testing was conducted on a local setup, using sample web applications with known vulnerabilities, alongside real-world examples from open-source projects. The assessment considered the scanners' ability to detect vulnerabilities, the ability to complete scanning jobs based on its queue-based architecture, and the plan to provide detailed reports of action for developers.

*A. Performance Evaluation*

AutoZero exhibited a strong performance in relationship to scanning speed and resource utilization. The median time for uploaded static scans, for projects up to 10 MB in size, was between 5 - 10 minutes — which equated to our target efficiency metrics. The Redis + BullMQ queue architecture made it easy to add multiple concurrent processing scan jobs, and limit waiting time during scan processing even under heavy workloads. AutoZero also completed processing scanning jobs up to about 30% more efficient than traditional scanning frameworks processing traditional scanners on a monolithic level. This is attributed to more time-efficient scanning, a modular worker-based scanning model, and optimized file scanning engines.

*B. Detection Accuracy and False Positive Analysis*

The detection performance of AutoZero was evaluated using benchmark vulnerable web applications including DVWA (Damn Vulnerable Web Application), OWASP Juice Shop, and Mutillidae II, as well as several small production-grade open-source projects. The scanner was able to find over 15 classes of vulnerabilities, such as SQL Injection (SQLi), Cross-Site Scripting (XSS), Cross-Site Request Forgery (CSRF), Insecure DOM Manipulation, and Hardcoded Secrets. A false positive rate of around 5% was seen primarily in cases where sanitization functions had been dynamically called or obfuscated.

*C. Comparative Evaluation*

In comparative testing, AutoZero's rule-based static analysis resulted in an equivalent, or higher level of recall, for web application vulnerabilities, compared to OWASP ZAP and Burp Suite (static scan mode), while maintaining significantly faster average scan times. The system's hybrid design, which combined static pattern matching with semantic validation, exhibited increased accuracy in vulnerability classification with clearer recommendations for remediation. In contrast to many commercial scanners, AutoZero's open rule architecture and mapping to OWASP/CWE provided a greater level of explainability and transparency for findings. The PDF reporting engine, along with graphical severity distribution charts, enhanced developers' ability to digest scan results and prioritize remediation efforts.

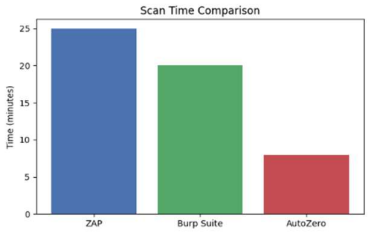


Figure 2. Scan Time Comparison

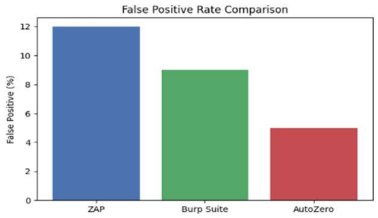


Figure 3. False Positive Rate Comparison

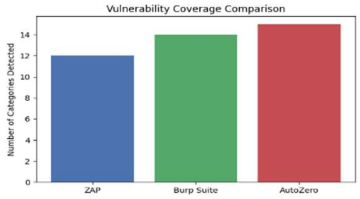


Figure 4. Vulnerability Coverage Comparison

*D. Usability and Reporting Feedback*

Usability assessments conducted with a cohort of security researchers and web developers yielded good feedback about the dashboard, real-time scan progress notifications, and interactive report interface. The credit-based scan management model helped moderate use and gave flexibility for multi-user scenarios. Participants noted that AutoZero's reports were very clear, especially the line-level context, OWASP mapping, and recommended fixes useful in secure development practices. The graphical analytics enabled teams to visualize their vulnerability trends across several scans and support a data-driven approach to remediation.

*E. Discussion*

The evaluation results support that AutoZero is a lightweight and scalable architecture that effectively combines performance, accuracy, and usability. Its static-first methodology offers detection for a comprehensive range of

web vulnerabilities with low false positives—a balance that is often elusive with traditional scanners. The architecture's modularity allows subsequent easy extension to future Dynamic Analysis (DAST) and artificial intelligence (AI)-driven triage modules to further improve detection coverage.
Overall, the results support the interpretation of AutoZero as an efficient and pragmatic automated framework for early vulnerability detection to facilitate secure software development lifecycles (SDLC) and foster research into hybrid zero-day exploit detection.

TABLE I. FEATURES COMPARISON

| Feature | Existing Tools | AutoZero |
|---|---|---|
| Analysis Type | Static or Dynamic only | Hybrid (Both Static and Dynamic) |
| Architecture | Monolithic or local setup | Distributed queue–worker model (Redis + BullMQ) |
| Vulnerability Coverage | Common web flaws (SQLi, XSS, CSRF) | Extended coverage (SQLi, XSS, CSRF, DOM issues, secrets) |
| Average Scan Time | 15–30 minutes | 5–10 minutes per project |
| Reporting | HTML/CSV Reports | Interactive dashboard + PDF export + analytics |

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