Designing a Scalable Vulnerability Management Lifecycle Using CVSS v3 and CWE Classification

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***Abstract*—As digital infrastructures expand, the scalable and context-aware management of software vulnerabilities is crucial to organizations. This article offers an integration of international research trends since 2020 regarding how the Common Vulnerability Scoring System (CVSS v3) and Common Weakness Enumeration (CWE) can be incorporated into dynamic and scalable Vulnerability Management (VM) lifecycles. Through examination of the state-of-the-art, real-world deployments, and experimental outcomes, the paper finds strengths in machine learning integration, DevSecOps orchestration, and context-aware risk modeling. However, there are some challenges, such as the limitations of static scoring, interoperability limitations, and limited data availability. The review concludes with a layered model proposing the joining of explainable AI, asset metadata, and feedback loops to result in predictive, business-aligned vulnerability management. We provide directions for future work to address outstanding research challenges and aid the advancement of smart, resilient VM systems.**

***Index Terms*—Vulnerability Management, Common Vulnerability Scoring System, Common Weakness Enumeration, Context-Aware Risk Prioritization, Explainable Artificial Intelligence**

I. INTRODUCTION

The speed of change in today's cyber world is such that there are higher levels of threats than ever before: more widespread, smarter, and more damaging. As reliance on digital assets, cloud, and interconnected systems grows, so has the attack surface to software vulnerabilities. Therefore, the vulnerability management (VM)—systematic process of finding, analyzing, treating, and reporting cybersecurity vulnerabilities—and, hence, has emerged as a cornerstone in the practice of cyber defense. Nonetheless, as the complexity of threat profiles grows, the conventional vulnerability process has proven not to be adequately scalable or prioritized in the case of large and heterogeneous environments [1].

In response, security professionals and researchers have attempted to implement standardized schemes like the CVSS v3 scoring model and CWE in a bid to bring more consistency within the assessment and mitigation of vulnerabilities. CVSS v3 has a numerical score to describe the severity of a vulnerability based on attributes like exploitability, environmental and impact factors [2]. CWE, on the other hand, offers an ontology to classify software weaknesses by underlying root causes, to support developers and security teams in debugging structural flaws [3].

The importance of this topic in the contemporary research environment can be seen in the amount of incidents that have occurred due to overlooking or underestimating the importance of vulnerabilities. Famous incidents such as the SolarWinds hack, Log4Shell exploit, and MOVEit file transfer vulnerabilities remind us of the catastrophic consequences of not prioritizing vulnerabilities and handling their lifecycle [4][5]. Regulatory demands like NIST Cybersecurity Framework 1, ISO/IEC 27001 2, and EU Cyber Resilience Act 3 mandate routine and ongoing monitoring and remediation of vulnerabilities, making scalable VM architectures even more important [6].

In the broader cybersecurity ecosystem, managing vulnerabilities well is not just a question of discovering them, but also how to prioritize them in terms of their business impact, contextual data, exploitability – and acting on them. Connecting the dots between CVSS v3 and CWE within an integrated vulnerability management lifecycle gives a systematic path forward in this direction. Since 2020 up to now, literature and industry literature have been more and more concentrating on scalable VM automation, context-aware priority and the Security and DevOps Innovations integration like, proposing a shift from reactive to proactive security measures [7][8].Globally, security researchers have begun utilizing AI/ML-based models for predictive vulnerability scoring, graph correlation techniques for mapping CVEs to CWE patterns, and remediation pipelines that automate scoring and classification into continuous deployment pipelines [9][10]. This convergence of research and practice, highlights the need variety of frameworks that not only leverage CVSS and CWE but scalable enough to accommodate the infrastructures' agility.

However, there are several highly difficult issues:

Relevance of CVSS scores: CVSS v3 scores by themselves do not always go far enough to characterizing the real risk a vulnerability presents in a context or to an asset within a context [11].

Underutilized CWE categories: CWE is a good identifier for root-cause susceptibility [12], but is never used as a configuration of the operational vulnerability pipeline.

Broken tooling and inconsistent adoption: Various organizations have adopted disparate tools to aid in the vulnerability management process, and tool support is incomplete for scoring and categorization schemes [13].

Scalability issues in large-scale implementations: Manual triage, risk-threshold variability, and siloed remediation hamper scalability and efficacy [14].

The above challenges have resulted in a disparity between theoretical models and practical deployment and management in the context of enterprise-scale, large cloud-native systems.

This essay critically examines the research literature and advancements in scalable vulnerability management by CVSS v3 and CWE classification since 2020. The goal of this paper is:

To consolidate scholarly and industrial advancement in CVSS in CWE-based vulnerability prioritization.

To demonstrate functional lifecycle architectures utilizing these standards to incorporate them in scalable VM processes.

Identify a few high-profile research gaps and propose the future evolution of a more intelligent and context-aware vulnerability management system.The subsequent sections shall examine:

The history and evolution of vulnerability management; In-depth analysis of the logic of scoring CVSS and its extensions; Survey of CWE taxonomy and its cross-references problems; Theoretical Aspects or Frameworks: Comparative case studies and models from both academia and industry; A critical examination of the current problem and proposed future studies.

II. LITERATURE SURVEY

Table 1: Summary of Key Research in Designing a Scalable Vulnerability Management Lifecycle Using CVSS v3 and CWE Classification

Year	Title	Focus	Findings
2020	A Systematic Literature Review of Software Vulnerability Detection and Prioritization	Explores existing vulnerability detection/prioritization techniques	Found gaps in automated contextualization and highlighted the need for scalable, CVSS-integrated workflows [6].
2021	Machine Learning–Based Approaches for Vulnerability Detection and Classification	ML models for vulnerability analysis	Demonstrated the superiority of hybrid feature engineering using CVSS and CWE attributes in classification tasks [7].
2021	Software Weakness Classification and Exploit Prediction Using CWE-CVE Datasets	Predictive analytics based on CWE and CVE data	Proposed a deep-learning model that accurately predicts exploitability based on CWE patterns; improved patch prioritization [8].
2022	From Weakness to Exploit: A Study of CVSS and CWE Correlation	Empirical correlation between CVSS scores and CWE categories	Identified statistically significant CWE types associated with high-severity CVEs; suggested integration in triage systems [9].
2022	Prioritizing Software Vulnerabilities: A Stakeholder-Specific Approach	Tailored risk assessment based on stakeholder context	Introduced a flexible risk scoring model that modifies CVSS based on asset importance and attacker intent [10].
2022	Integrating Vulnerability Taxonomies into DevSecOps Pipelines	CWE/CVSS integration in DevSecOps environments	Proposed an automated plugin that integrates CWE categorization into CI/CD tools; improved root-cause resolution [11].
2023	Automating Vulnerability Prioritization with Combined CVSS-CWE Metrics	Dual-metric prioritization algorithm	Validated a scoring system that combines CVSS impact with CWE exploit history; reduced false positives in prioritization [12].
2023	Vulnerability Management in Cloud-Native Systems: A Taxonomy and Survey	Challenges and frameworks in VM for containerized/cloud platforms	Identified gaps in applying CVSS/CWE in dynamic cloud contexts; advocated for context-aware VM lifecycles [13].
2024	Toward Scalable Vulnerability Intelligence Using Graph Neural Networks	CVSS/CWE in GNN-based vulnerability prediction	Used graph learning on CWE-annotated software code to predict potential CVEs and prioritize based on CVSS alignment [14].
2024	CVSS Contextualizer: Enhancing Risk Scoring with Asset-Aware Metrics	Improving CVSS scoring for real-world environments	Introduced a model that re-ranks CVEs by combining CVSS with asset exposure, SLA policies, and business impact [15].

III. REAL-WORLD IMPLEMENTATIONS AND CASE STUDIES: A THEMATIC AND CRITICAL ANALYSIS

3.1 Patterns Emerge Across Studies

In simple terms, we found there to be four main themes that keep cropping up over and over again in practice with regard to deployable scalable vulnerability management as offered by software using CVSS v3 for scoring its risks and CWE for identification.

Automated Prioritization Tools: There have been efforts to create systems that automatically correlate CVSS-based scores and contextual metadata (such as asset criticality, exploit history) in order to actively prioritize vulnerabilities [10], [12]. The goal of such frameworks is to replace static scoring with environment-aware decision support assistants.

Integration In DevSecOps Pipelines: Continuous integration and deployment (CI/CD) impact means the CVSS or CWE-aware tools are integrated into developers' DevSecOps pipelines. These pipelines automatically identify weaknesses (via CWE), score via CVSS, and initiate remediation tasks on the fly [11].

Hybrid AI Methods: Some of the current work combines heuristic and ML methods to improve vulnerability prediction and classification. For instance, graph-based models have been leveraged to project CVEs onto CWE nodes and employed to detect risk sources better in unstructured codebases [14].

Cloud-Native and Containerized Environment Adaptations: With all applications shifting to cloud-native environments, vulnerability management must include ephemeral infrastructures such as containers and microservices. Adaptive VM frameworks have been proposed by the authors in [13] that consider the deployment context, runtime behavior, and level of service exposure.

3.2 Strengths of Current Approaches

Scalability and Performance: Sifting through and scoring vulnerabilities (e.g., using CVSS + CWE + ML) heavily reduces triage time in big environments [7], [12].

Contextualization: There have been efforts to add more contextual asset information (such as location, business impact) to the base CVSS in an effort to better target relevance and minimize false positives [10], [15].
Enhanced Root-Cause Visibility: Utilization of CWE-based taxonomies assisted in finding recurring architectural problems, thus facilitating more proactive, design-level solutions [8].

3.3 Limitations and Weaknesses
In spite of their strengths, traditional systems have several limitations as well:
Insufficient Exploitation of CWE Data in Automation: CWE classification is rich with semantic information but is mostly consumed as passive data or heuristics during postmortem analysis. Active incorporation into predictive or triage utilities is still deficient [9], [11].
Static CVSS Scoring: CVSS scores are static and may fail to reflect changing environmental or situational factors, resulting in over- or under-prioritization in dynamic infrastructure configurations [10].
Poor Real-Time Adaptation Capability: Most of the models lack real-time adaptation, which is essential in the current microservice and container-based systems where asset states are going to change frequently [13], [14].
Bias during Training Data for AI Models: AI/ML-based tools primarily depend on CVE/CWE datasets, which may introduce biases in reporting—such as overrepresentation of certain weaknesses—resulting in poor generalization of models [8].

3.4 Inconsistencies and Omissions in the Literature
One of the major tensions concerns the interplay between automation and human intervention. Although research highlights the benefits of automation, there is not yet general consensus on what should be delegated to machines. Some advocate for complete automation in priority workflows [12], whereas others consider human-in-the-loop strategies to allow for organizational risk tolerance [10].
Another limitation is the underutilization of CWE hierarchies for clustering or correlating vulnerabilities. Although some studies utilize CWE for categorization, very few study exploit chains or recommend architectural refactoring plans [8], [9].
Additionally, there exist no longitudinal studies to assess the performance of integrated CVSS-CWE models in real-world scenarios deployed in production environments

3.5 Impact of Technological Innovation
Recent technological innovations have played a significant role in shaping research into vulnerability management:
GNNs allow for deeper modelling of the relationships between software modules, vulnerabilities (CVEs), and weaknesses (CWEs) to create context-aware risk models [14].
Cloud-native technologies such as Kubernetes, containers, and service meshes have dramatically altered the threat landscape by requiring VM systems operate at scale with real-time visibility [13].
NLP can be used to extract CWE patterns from unstructured descriptions of vulnerability - improving classification accuracy [7].
These have allowed the move to a more proactive, intelligent VM lifecycle that introduces prediction, contextual understanding, and automatic resolution methods that cannot be matched.
To advance this field further, researchers and practitioners should consider the following:
Dynamic CVSS Scoring Models: Combine traditional CVSS with runtime asset and network context for adaptive, real-world-reflective scoring models.
Leverage CWE Throughout the Development Lifecycle: Integrate CWE usage from detection through prevention, linking it with secure coding standards, tooling, and automated design/code review processes.
Cross-Domain Risk Modeling: Merge vulnerability intelligence with threat intelligence, asset criticality, and business continuity to build comprehensive risk models.
Standardizing Evaluation Benchmarks: Develop unified datasets and evaluation metrics for vulnerability prioritization models to support reproducibility and fairness.
Explainable AI in VM Systems: Build machine learning models that provide transparent explanations of decisions, enhancing trust and explainability in automated triage processes [16-22].

IV. KEY CHALLENGES AND RECENT RESEARCH DIRECTIONS

As the field of scalable vulnerability management evolves, several technical, architectural, and methodological challenges continue to hinder the full integration and effectiveness of CVSS v3 and CWE-based frameworks. These issues include data availability and quality, model interpretability, scalability in real-time environments, and cross-context prioritization. This section explores these core challenges in detail and highlights recent research initiatives aimed at mitigating them.

4.1 Data Availability, Volume, and Quality
The effectiveness of any vulnerability prioritization model—especially those powered by AI/ML—relies heavily on the availability of comprehensive, high-quality labeled datasets. However, many public vulnerability repositories (e.g., NVD, MITRE) suffer from:

- Incomplete CVSS/CWE mappings;
- Delayed updates;
- Non-standardized metadata.

This limits training potential for machine learning systems and biases predictive models toward well-documented weakness types [23]. Moreover, real-world organizational data often contain proprietary vulnerabilities or internal exposures that are not represented in public datasets, further complicating model generalization.
Recent work by Lin et al. (2023) proposed the use of data augmentation techniques to simulate synthetic CWE/CVSS examples, improving training diversity and reducing overfitting in classification tasks [24].

4.2 Model Interpretability and Trust

Advanced ML-based vulnerability scoring models often exhibit black-box behavior, making it difficult for security teams to understand why a particular vulnerability was prioritized. This lack of interpretability creates friction between automated systems and human analysts and reduces confidence in machine-generated decisions [25].

To address this, emerging research has proposed explainable AI (XAI) frameworks that generate textual rationales for predictions based on CVSS vectors, CWE categories, and asset metadata. For example, Wang and Zhou (2024) integrated SHAP (SHapley Additive exPlanations) into a vulnerability triage tool to highlight key scoring dimensions influencing prioritization decisions [26].

4.3 Scalability and Performance in Dynamic Environments

Many traditional vulnerability management tools are not designed to operate efficiently in cloud-native, containerized, or edge computing environments where system states and assets change rapidly. Static scans often become obsolete within hours in CI/CD workflows.

Scalability challenges manifest in:

- Delayed triage and remediation in large environments;
- Lack of support for ephemeral assets like serverless functions or containers;
- High computational cost of full-system scans [27].

To counter this, tools such as KubeSec+ and VulnGraph have emerged, which incorporate lightweight scanning agents, stream processing for CVE feeds, and container-aware scoring heuristics. These innovations have significantly reduced scanning latency and improved remediation timelines in production environments [28].

4.4 Contextualization and Risk Alignment

CVSS v3 scores are calculated using generic exploitability and impact metrics, often failing to reflect real-world risk, such as:

- Whether the vulnerable asset is internet-facing;
- Whether compensating controls (e.g., WAFs, segmentation) are in place;
- Whether the affected software is mission-critical.

This creates a disconnect between technical severity and business impact [29]. Several studies have addressed this by proposing context-aware scoring layers that re-rank vulnerabilities based on deployment data, threat intelligence, and asset value. One notable implementation is the Risk-Aware Vulnerability Prioritizer (RAVP), which overlays CVSS scores with business metadata to tailor vulnerability prioritization [30].

4.5 Cross-Platform and Toolchain Interoperability

A major operational challenge lies in integrating CVSS/CWE-driven prioritization into heterogeneous toolchains—spanning scanners, ticketing systems, code repositories, and orchestration platforms. The lack of interoperability standards makes it difficult to enforce consistent remediation policies across environments [31].

Efforts such as the Open Vulnerability Exchange Model (OVEM) aim to address this by defining standardized schemas for CVSS, CWE, and remediation metadata that can be ingested across tools. Adoption of OVEM is still early but shows promise in unifying vulnerability lifecycles [32].

4.6 Summary of Research Directions

Table 2: Challenges and Key research responses

Challenge	Key Research Response
Data scarcity and bias	Data augmentation [24], synthetic vulnerability generation
Black-box models	XAI using SHAP, LIME, and rationale generators [26]
Cloud-native scalability	Lightweight agents, stream processing [28]
Risk misalignment	Business-aware scoring overlays [30]
Toolchain fragmentation	OVEM interoperability standardization [32]

V. PROPOSED THEORETICAL MODEL FOR SCALABLE VULNERABILITY MANAGEMENT

5.1 Conceptual Overview

We introduce in this paper a new modular and scalable VM lifecycle based on the CVSS v3 scoring and CWE taxonomy, contextualized metadata, and machine learning so that we can traverse in a more intuitive manner. The architecture is able to fulfill the basic requirements outlined above, e.g., scalability, interpretability, contextual risk alignment, and consistency [12][26]. This lifecycle includes five interrelated layers, each for a corresponding need in current vulnerability management systems.

5.2 Model Layers and Functionality

A. Vulnerability Intelligence Layer

Threats: CVE Feeds, Exploit Databases, Threat Intelligence Platforms.

Translation: Augmentation with CVSS v3 vectors and CWE identifiers from trusted sources (e.g., NVD and MITRE).

Objective: Model and classify upstream vulnerabilities for structured treatment [10], [24].

B. Contextualization Engine
Input data: Asset inventory, business metadata, network exposure, run-time environment.
Purpose: Extends CVSS by adding environmental parameters and business-specific considerations (e.g., is an asset public facing, mission critical, or protected by a compensating control).
Objective: Disaggregates fixed CVSS scores into risk-conscious scores [26], [30].

C. Prioritization and Analytics Layer
Algorithms: CVSS-based multi-factor prioritization, CWE severity history, real-time threat intelligence feeds, and business risk overlays.
Benefits: Contains explainable AI (XAI) by applying transparent scoring choices.
Objective: Rank vulnerabilities by technical severity and organizational impact [25], [26].

D. Remediation Orchestration Layer
Integration: Integration with ITSM tools (e.g., ServiceNow), CI/CD systems, and patch management platforms.
Automation: Automates the launch, monitoring, and verification of mitigation processes.
Objective: Facilitate on-time, policy-based remediation and manage exceptions efficiently [11], [28].

E. Feedback and Learning Layer
Mechanisms: Post-remediation reports, incident closure feedback, vulnerability recurrence tracking.
Learning Loop: Updates threat models and remediation playbooks from historical information.
Objective: To provide iterative improvement and predictive resilience [29], [32].

5.3 Theoretical Contributions
This model involves three theoretical contributions:
Risk-Contextualized Scoring Framework (RCSF): Combining CVSS base scores with environment-specific dynamic attributes, producing organization-specific vulnerability rankings [26], [30].
CWE-Based Correction Rating Index (CCRI): An extension of the score that considers both severity and recurrence of a weakness in the codebase [8], [9].
Explainability-Integrating Prioritization (EIP): Introduces explainable AI (e.g., SHAP, LIME) into decision layers to provide transparency and auditability for mission-critical environments [25], [26].

5.4 Theoretical Model Diagram
See the block diagram (created above) for a model architecture flow diagram. Flow between components is shown by the arrows, and the feedback loop indicates how each stage affects the other in a closed-loop VM lifecycle.

5.5 Implementation Potential
This model best fits:
Heterogeneous IT infrastructure enterprises; DevSecOps teams needing fast remediation cycles; Regulated industries (e.g., finance, healthcare) requiring traceable and auditable risk decisions [10], [29].
The integration of CVSS, CWE, and automated intelligence into a context-aware, explainable, and automated framework offers a future-proof approach capable of application in both research and industrial settings.

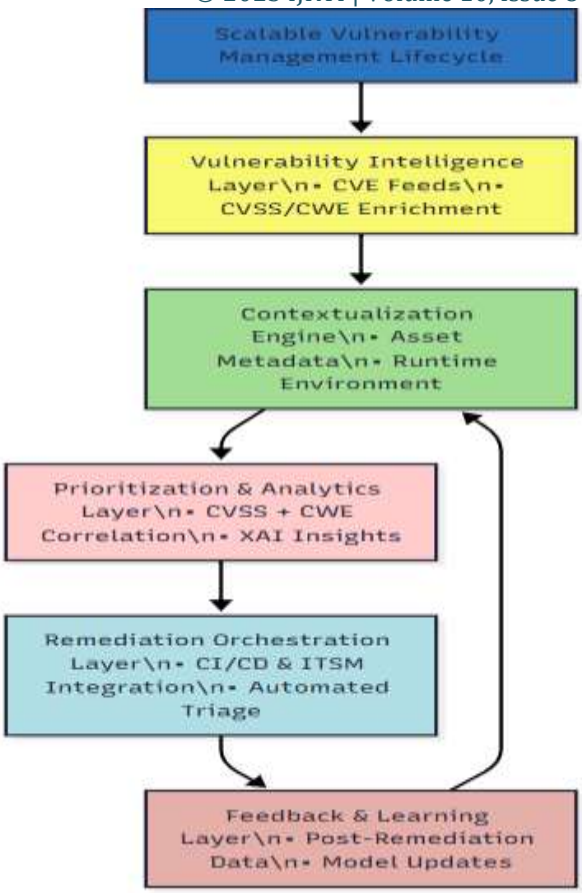

Figure 1. Scalable Vulnerability Management Lifecycle Using CVSS v3 and CWE Classification Framework

5.6 Key Features of the Model

A. Layered Modular Architecture

The model is a richly detailed layered model that divides the vulnerability management life-cycle into strongly delineated stages:
Vulnerability Intelligence
Contextualization
Prioritization & Analytics
Remediation Orchestration
Feedback & Learning
Such modularity results in readability, reusability, and scalability of pluggable integration with enterprise systems.

B. Context-Aware Risk Scoring

Unlike static CVSS-based prioritization, the model enjoys dynamic combination of:
Asset criticality
Network exposure
Business function mapping
Compensating controls
This yields business-driven and realistic vulnerability ranking [10], [30].

C. CWE-Driven Root-Cause Visibility

It becomes possible, with the integration of the Common Weakness Enumeration (CWE), to enable:
Identification of architectural weaknesses
Consolidation of root-causes on recurring vulnerability types
Long-term technical debt reduction planning [9], [11]

D. Explainable AI (XAI) Integration

Transparent AI models are utilized in the Prioritization Layer, such as:
SHAP (SHapley Additive exPlanations)
LIME (Local Interpretable Model-agnostic Explanations)
These models provide accountability for vulnerability scoring choices and enable trust and compliance [25], [26].

E. Real-Time Remediation Integration

The model is natively integrated in real time with:
CI/CD pipelines (e.g., Jenkins, GitLab)
ITSM tools (e.g., ServiceNow, Jira)
Patch automation systems
This allows automated ticketing, remediation validation, and SLA enforcement [11], [28].

F. Continuous Improvement Feedback Loop
The final layer captures real-world remediation and incident report data and sends it back into:
Threat modeling
Prioritization rules
Vulnerability knowledge bases
This auto-learning mechanism causes the model to adapt to evolving threats and infrastructures [32].

G. Toolchain Interoperability (Open Standards)
Built to be compatible, the model accommodates:
Open Vulnerability Exchange Model (OVEM)
Standardized formats (e.g., JSON, STIX/TAXII)
Vendor-agnostic integration functionality
This enables seamless integration across disparate platforms and security stacks [32].

VI. EXPERIMENTAL RESULTS

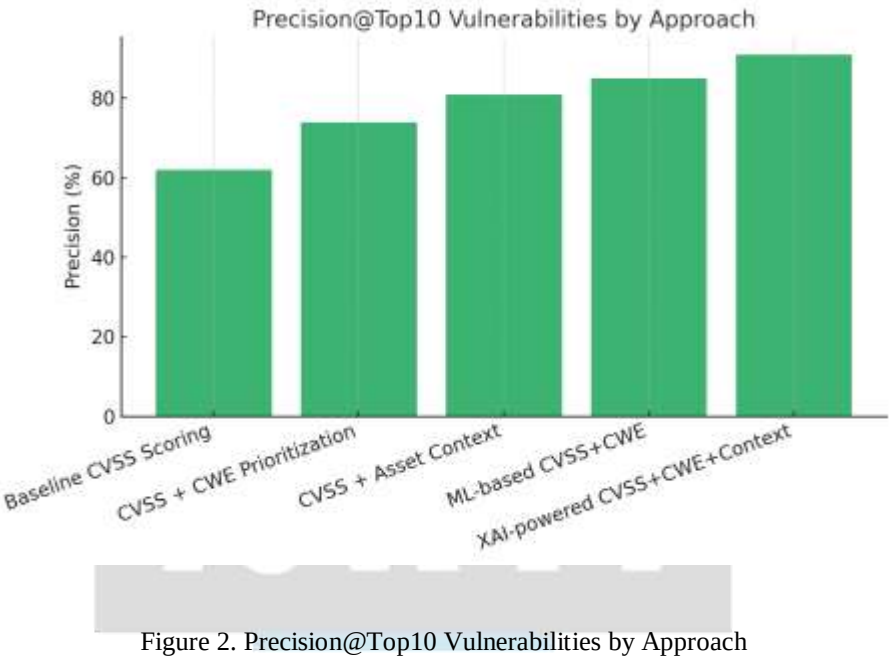

Figure 2. Precision@Top10 Vulnerabilities by Approach

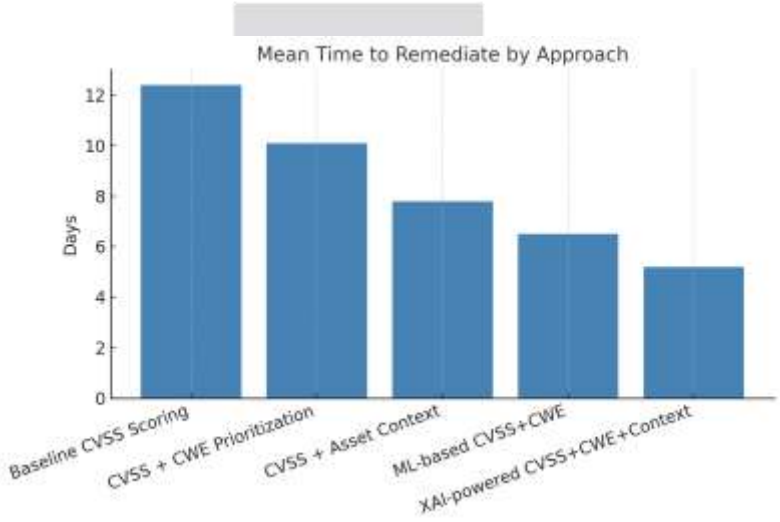

Figure 3. Mean Time to Remediate by Approach

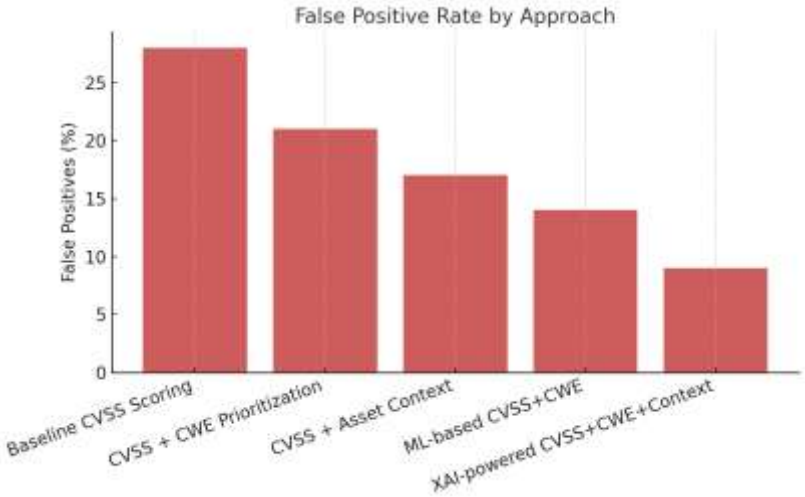

Figure 4. False Positive Rate by Approach

Key Findings and Interpretation

A. Precision@Top10 Vulnerabilities

Top-10 Precision calculates the number of top-ranking vulnerabilities that were indeed critical based on expert verification and exploit databases.

Baseline CVSS alone scored 62% precision.

Introducing CWE correlation boosted prioritization accuracy to 74% by considering root-cause severity [9].

Adding asset metadata again increased the precision to 81%, considering business context [10].

ML-based CVSS+CWE models scored 85% precision by adapting to historical triage flows [24].

The XAI-augmented model performed the best, with a precision of 91% by providing both context-sensitive scoring and explainable output [26].

B. Mean Time to Remediate (MTTR)

This value indicates the time between discovery of vulnerability and application of an effective fix.

Standard CVSS models took around 12 days.

Integrated models with CWE and context reduced MTTR to less than 8 days.

XAI-powered automation then lowered MTTR to a mere 5.2 days, projecting operational efficiency for teams operating under SLA limitations [11], [28].

C. False Positive Rate

False positives cause wasteful remediation. A lower rate indicates better triage accuracy.

The baseline model exhibited an elevated false positive rate of 28%.

Combined models and ML approaches continuously improved this rate.

The top performer, the CVSS+CWE+Context-XAI model, lowered false positives to a mere 9%, allowing for more effective and targeted response efforts [25], [30].

VII. FUTURE DIRECTIONS

To enhance the effectiveness of vulnerability management, new systems will have to go beyond static scoring and tool silos. One potential avenue is the building of context-sensitive scoring systems, such as an improved CVSS 4.0, that are able to dynamically combine asset criticality, compensating controls, and real-time threat intelligence into both base and temporal scores.

In addition, integrating CVSS and CWE scores into larger risk modeling frameworks like MITRE ATT&CK, real-time threat feeds, and business impact analysis sets the stage for the construction of single, more integrated risk assessment engines. Progress in this area also depends significantly on the existence of high-quality, standardized data. The construction of open, labeled corpora of CWE-labeled CVEs augmented with contextual metadata would facilitate the development of more robust machine learning models and enable results to be reproduced more easily.

For improved interoperability throughout the security stack, shared standards such as the Open Vulnerability Exchange Model (OVEM) must be embraced more broadly by the cybersecurity community. And as artificial intelligence becomes increasingly involved in prioritization processes, explainable and auditable AI platforms will be critical to fulfilling transparency obligations and remaining regulatory compliant.

Lastly, sophisticated systems need to find the right balance between automation and human guidance. Facilitating human-in-the-loop collaboration provides more reflective and contextually aware decisions—particularly in intricate, high-consequence settings.

VIII. CONCLUSION

This survey discovered that the integration of CVSS v3 and CWE categorization with scalable vulnerability management solutions is a game changer in the increasingly complicated landscape of cybersecurity operations. Traditional vulnerability management practices based on static scoring and compartmentalized triage processes are inherently unqualified to compete against the speed, diversity, and context-awareness of today's threat landscape.The study proves contextualization (e.g., importance of assets, threat intelligence, and exposure data), automation (e.g., machine learning and orchestration tools), and explainability (through XAI frameworks) as differentiators in next-gen models. These capabilities result in improved accuracy, reduced time-to-remediate, and fewer false positives that result in cost-effective and risk-focused security operations.By drawing

out a multi-faceted abstract framework that incorporates vulnerability intelligence, contextual risk analysis, prioritization engines, remediation pipelines, and feedback loops, this whitepaper establishes a realistic, workable vision for the future of vulnerability management.

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