Combinatorial Fault Localization for Web Security Testing

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SBA Research

MATRIS

Combinatorial Testing & Combinatorial Fault Analysis

Motivation

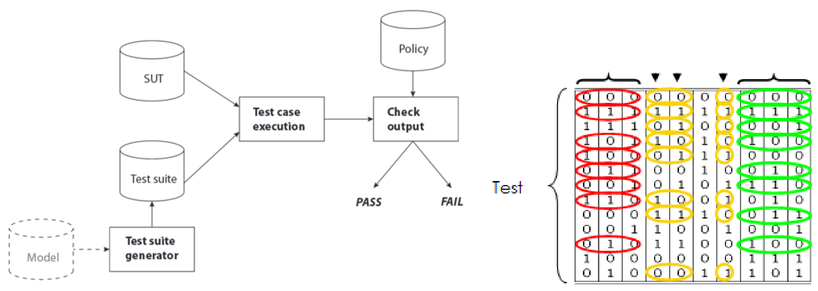
- We cannot test everything.
- Exhaustive search of problem space increases time needed exponentially.
- Automated detection of security vulnerabilities.

Combinatorial Security Testing (CST)

- Parameters and values provide abstract models of attacks
- Generated test sets provide 100% coverage of t-way parameter value combinations.
- Automated test set generation, execution and evaluation via dedicated test oracle.

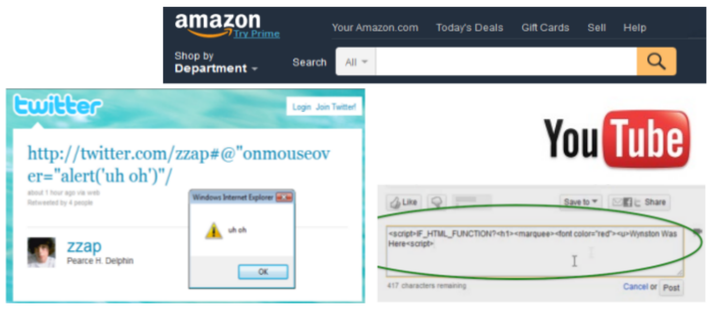
Technical Challenges

- Generation of minimal t-way test sets is a hard combinatorial optimization problem.
- Modelling of parameters, values and constraints is domain-specific.
- Deploy CST to all application layers of information security.



Cross-Site Scripting (XSS)

- **Vulnerability**: Response from web server contains parts of unsufficiently sanitized user input.
- **Threat**: Attacker can execute malicious JavaScript.
- **Goal**: Automatically generate XSS attack vectors for testing purposes.
- **Targets**: HTTP parameters of web applications.
- **Model**: Parameters map to parts of the URL.
- **Example**: `<scr<script> ``> onLoad(;\>.`



Combinatorial Analysis of XSS Vulnerabilities

- XSS attack vectors generated with CST.
- Successful vectors are analyzed for their combinatorial structure
- Identification of XSS-inducing combinations provides insights.
- Approach evaluated against four sanitization functions from the Web Application Vulnerability Scanner Evaluation Project (WAVSEP).
- Results show effective identification of XSS-inducing combinations.

JSO	WS1	INT	WS2	EVH	WS3	PAY	WS4	PAS	WS5	JSE
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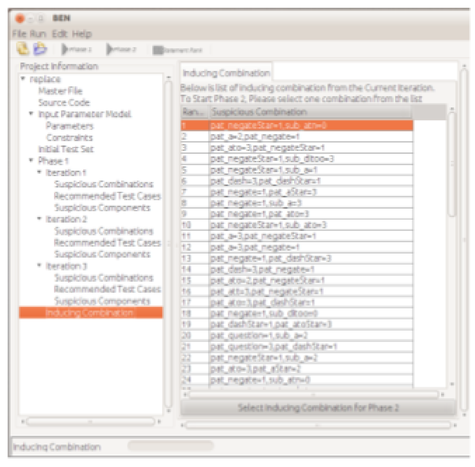
Combinatorial Fault Analysis (FLA)

Theory

- A combination is called suspicious if it appears only in a failing test case.
- A combination c is failure-inducing if any test f in which c is contained, fails.
- Identification of minimal failure-inducing combinations.
- Active research area in CT.

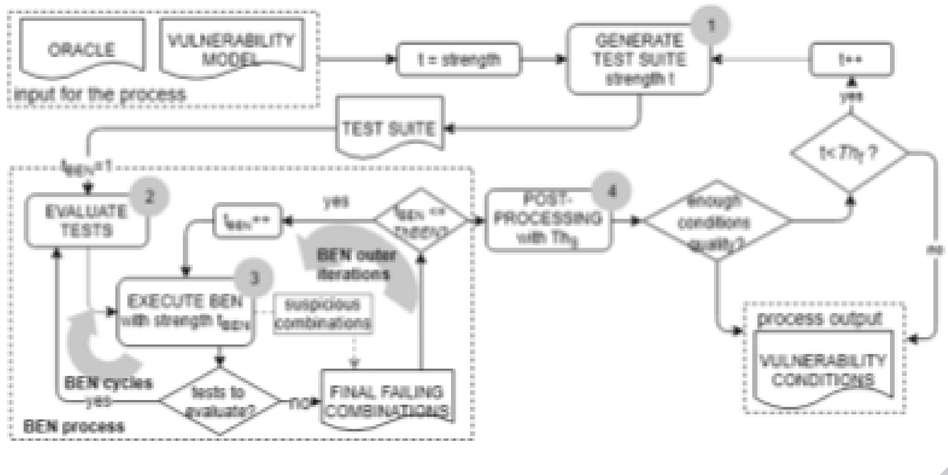
BEN Tool

- CT-based fault analysis tool.
- Input: executed t-way test set with pass/fail assignments.
- Output: ranking of combinations in terms of their likelihood to be failure-inducing.
- Adaptive approach: small number of additional tests might required.
- Written in Java and provides both GUI and CLI interfaces.



Fault-driven Combinatorial Process for Model Evolution in XSS

- Knowledge base (KB) contais model for XSS.
- Iterative evolvement of KB for XSS security testing of web applications.
- KB gives rise to attack strings for exploiting XSS vulnerabilities.
- Testing results are annoted and added back to KB.
- Process uses BEN tool internally.
- Increases capabilites of KB for subsequently requested attack models.



Bernhard Garn, Marco Radavelli, Angelo Gargantini, Manuel Leithner, and Dimitris E. Simos. A fault-driven combinatorial process for model evolution in xss vulnerability detection. In Franz Wotawa, Gerhard Friedrich, Ingo Pill, Roxane Koitz-Hristov, and Moonis Ali, editors, *Advances and Trends in Artificial Intelligence. From Theory to Practice*, pages 207–215, 2019.
Dimitris E. Simos, Kristoffer Kleine, Laleh Shikh Gholamhossein Ghandehari, Bernhard Garn, and Yu Lei. A combinatorial approach to analyzing cross-site scripting (xss) vulnerabilities in web application security testing. In Franz Wotawa, Mihai Nica, and Natalia Kushik, editors, *Testing Software and Systems*, pages 70–85, 2016.

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