Stanislav Dashevskyi, Daniel Ricardo Dos Santos, Fabio Massacci, Antonino Sabbat

TestREx: A Testbed for Repeatable Exploits

UNIVERSITY OF TRENTO - Italy

FONDAZIONE BRUNO KESSLER

Agenda

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The motivation

- Our current research is focused on JavaScript code analysis
- We need the all-purpose framework that will enable us to quickly deploy all kinds of web applications
  - *Observe dynamic behavior of the code*
  - *Get better understanding on how security vulnerabilities are mapped to the code*
  - *Find a better way to assess the amount of false positives and false negatives in our code analysis tool*

Empirical security research and software development

- Systematic collection of exploits into a knowledge base
  - *Study explicit/implicit causes of vulnerabilities, their connections*
  - *Collect evidence on risks that vulnerabilities might pose*
  - *Get insight for software analysis tools and testing approaches*
  - *Lower the probability of making the same mistakes*
- But... having yet another corpus of exploits doesn't scale
  - *Software is evolving → certain exploits work for certain versions*
  - *Sofware configuration does matter → applications often support multiple platforms → one can't execute SQL injection on MongoDB*

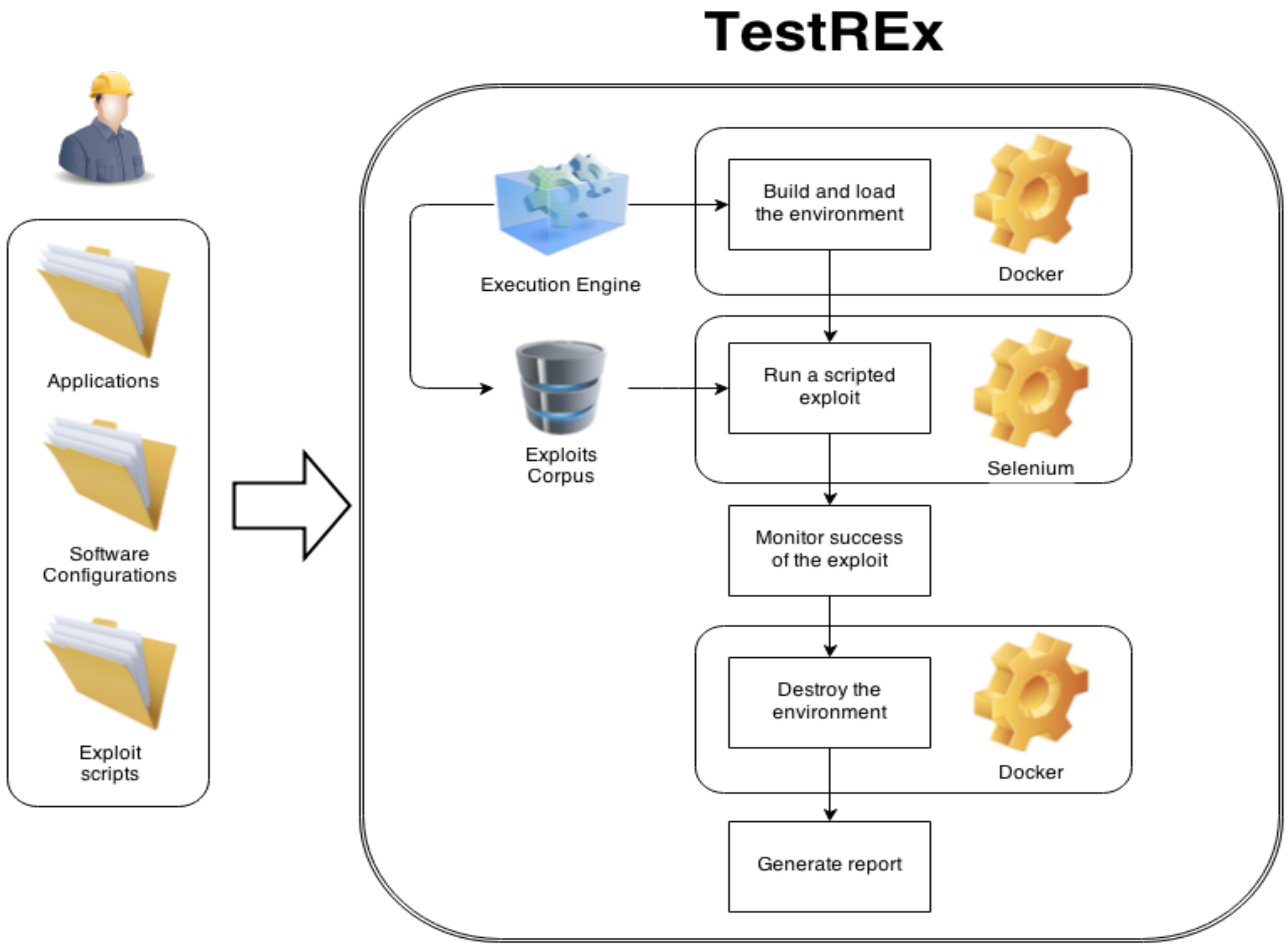
Getting more information out of the corpus

- Apart from "documenting" an exploit, what other information can be inferred?
- Given an environment E, and an exploit X that successfully subverts an application A that is running on E
  - *Will X be successful on the application A running on a new environment E'?*
  - *Will X be successful on a new version of A, A', running on E?*
  - *Will X be successful on a new version of A, A', running on E'?*
- Deploying and matching all possible software configurations and application versions might be very hard and tedious

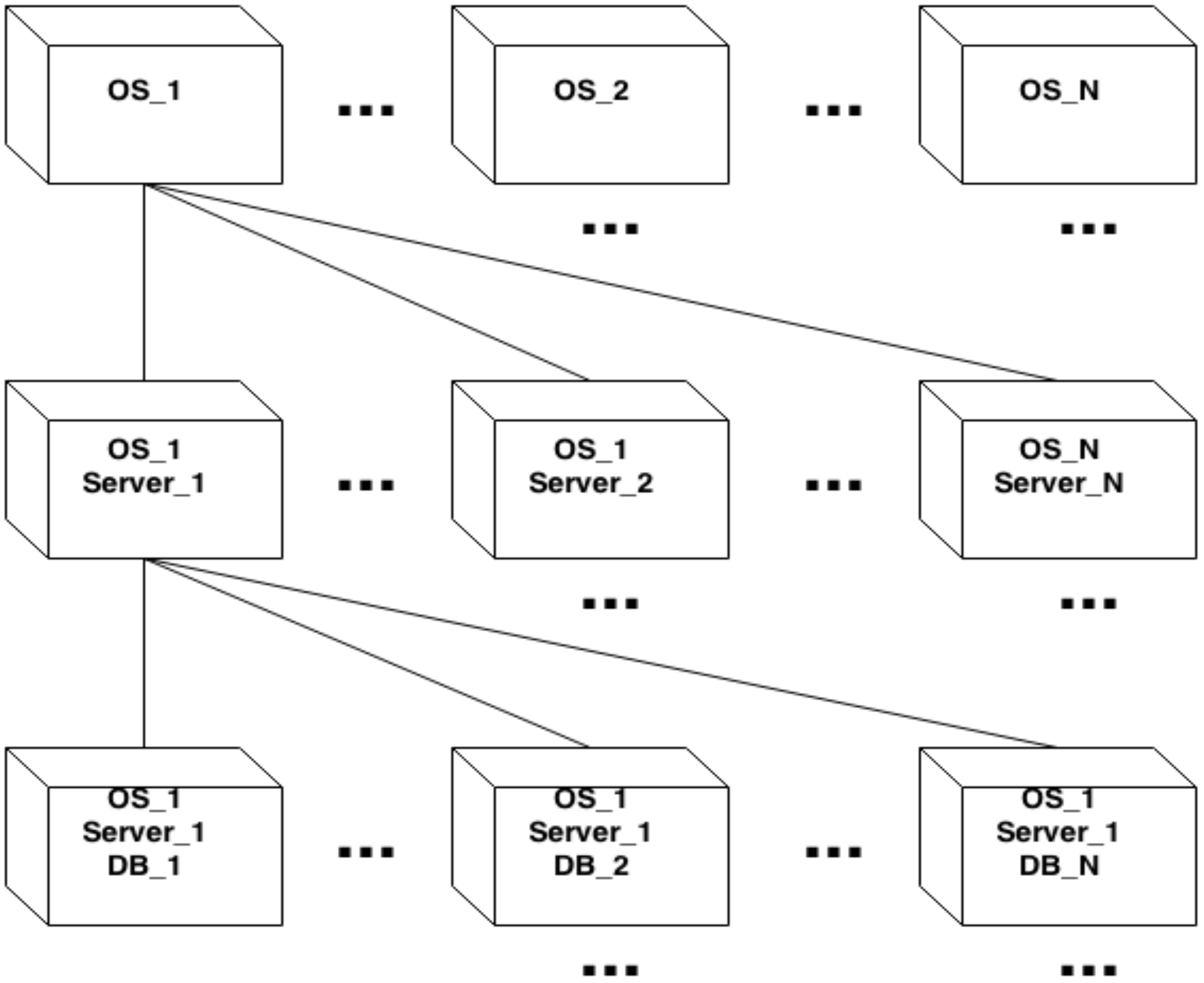
What is TestREx?

- A management system for software environments
  - *We are able to provide an isolated sandbox per every application version and its corresponding software environment*
- A testbed for performing web application vulnerability experimentations
  - *Automatically, via scripted exploits*
  - *Manually, by giving testers the access to the requested application from within its sandbox*
  - *An application can be started in either "clean" or "spoiled" state*
- A test suite for managing and running scripted exploits against corresponding applications

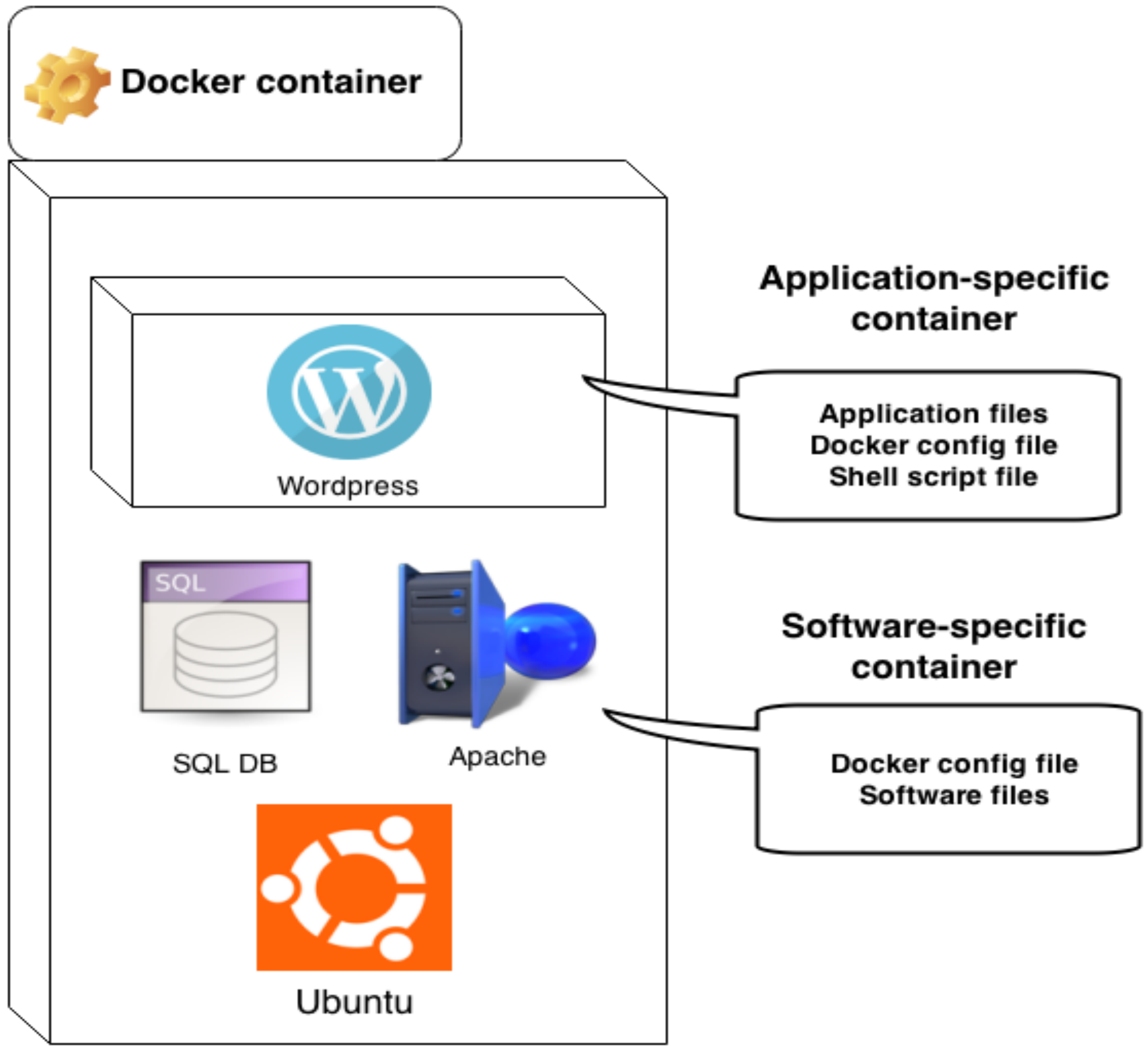
TestREx: The workflow



TestREx: Software Containers hierarchy



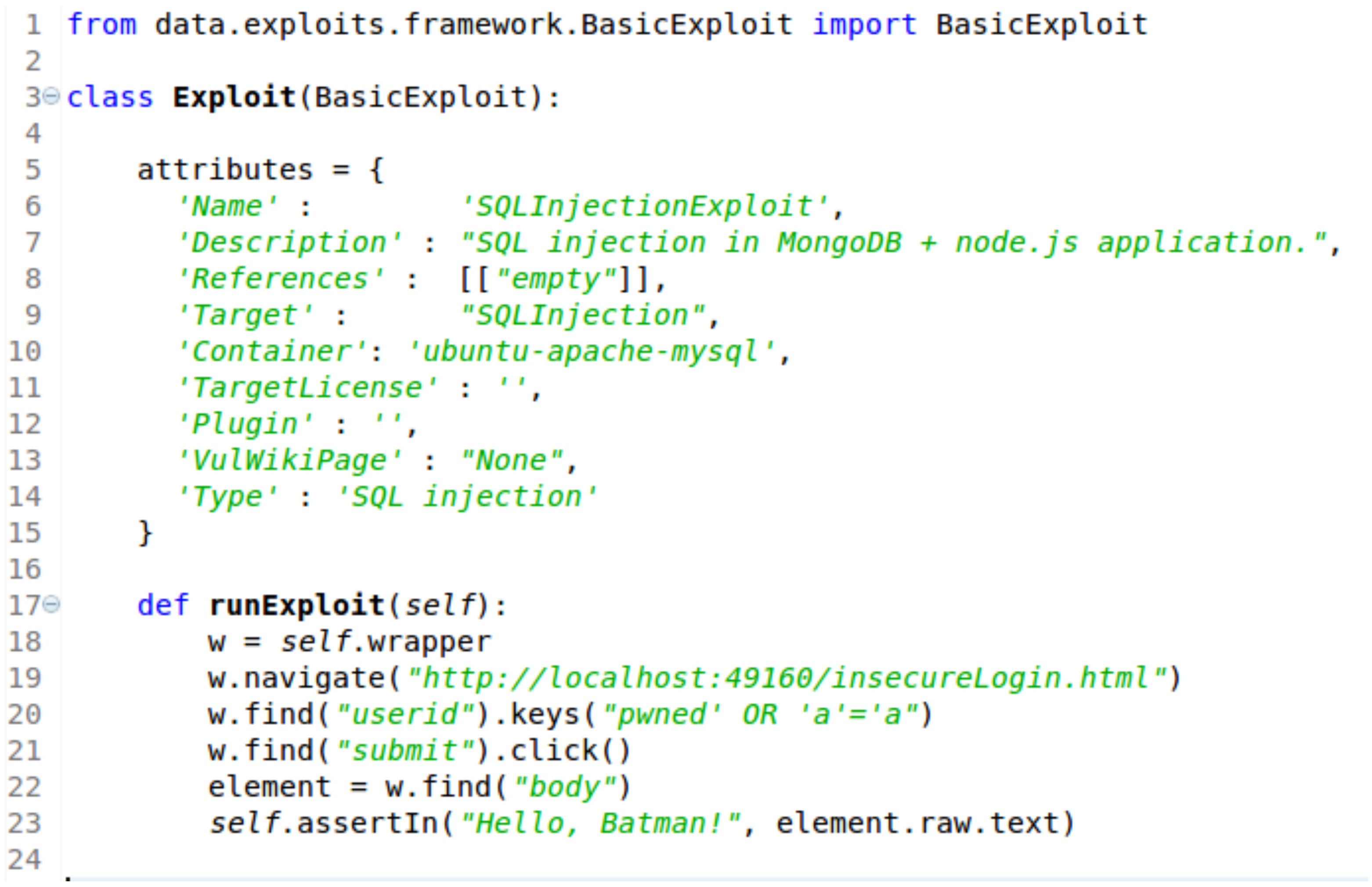
TestREx: Application Container example



The Exploits

- **By exploits we mean sets of [automated] actions required to subvert a vulnerability in an application and verify the success**
- **What is an exploit technically**
  - ***A self-contained unit test that has description metadata***
  - ***A Python script that uses Selenium driver to automate the browser***
  - ***The script passes the results of its run to the Execution Engine***
- **Why Selenium?**
  - ***So far we are dealing only with browser-based attacks***
  - ***We are able to simulate attacker's behavior with a browser***
  - ***Native JavaScript support***

Exploit example

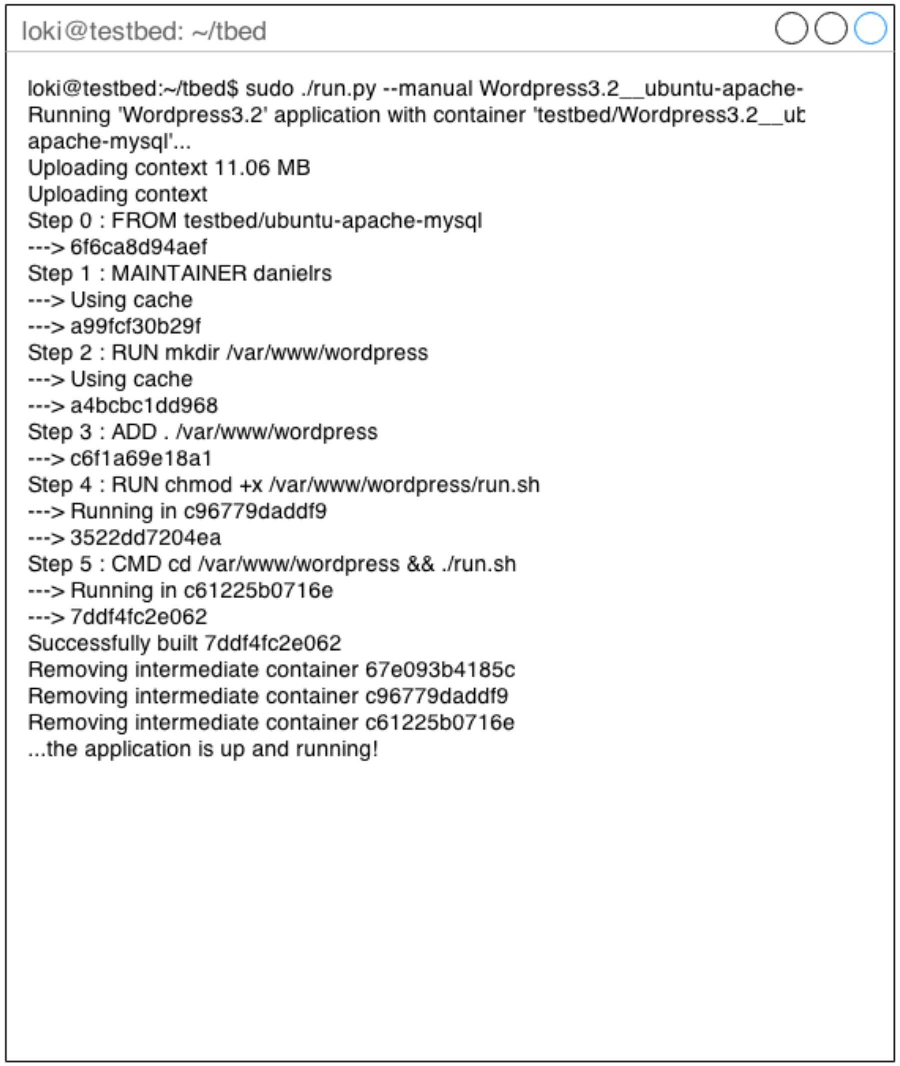


```python
from data.exploits.framework.BasicExploit import BasicExploit

class Exploit(BasicExploit):

    attributes = {
       'Name' :          'SQLInjectionExploit',
       'Description' : "SQL injection in MongoDB + node.js application.",
       'References' :  [["empty"]],
       'Target' :       "SQLInjection",
       'Container': 'ubuntu-apache-mysql',
       'TargetLicense' : '',
       'Plugin' : '',
       'VulWikiPage' : "None",
       'Type' : 'SQL injection'
    }

    def runExploit(self):
        w = self.wrapper
        w.navigate("http://localhost:49160/insecureLogin.html")
        w.find("userid").keys("pwned' OR 'a'='a")
        w.find("submit").click()
        element = w.find("body")
        self.assertIn("Hello, Batman!", element.raw.text)
```

Experimentation capabilities

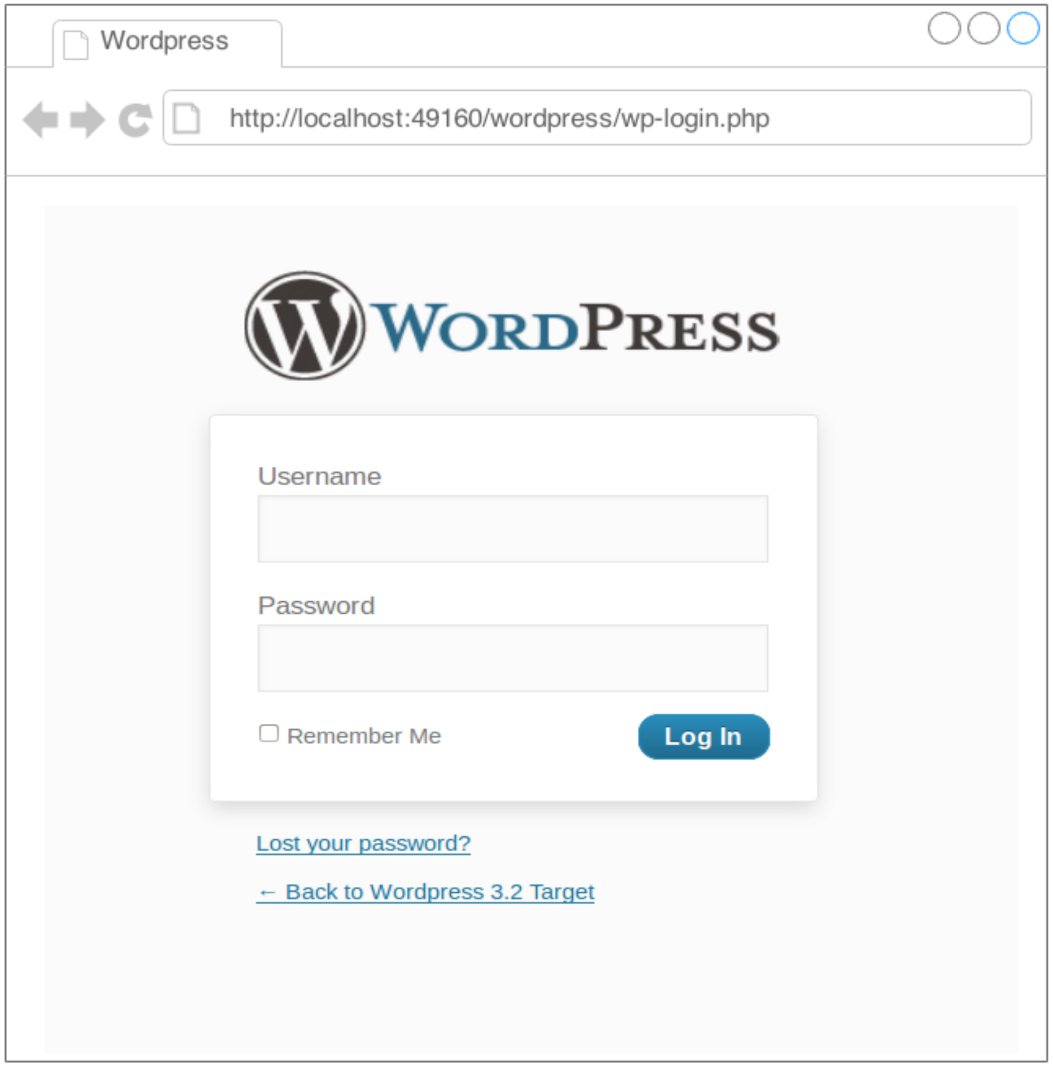
- Flexible way to run exploits and applications
  - *Manual, single and batch runs*
  - *All exploits are independent scripts that can be supplied at any time by anyone*
- Report generation
  - *A .csv file with exploit run results and exploit metadata*
- Regression testing and configuration testing
  - *Deploy multiple versions of an application and understand what was fixed though the whole version history*
  - *Deploy an application on different platforms and see the corellation between third-party software and vulnerabilities*

Demo: Manual run



loki@testbed: ~/tbed

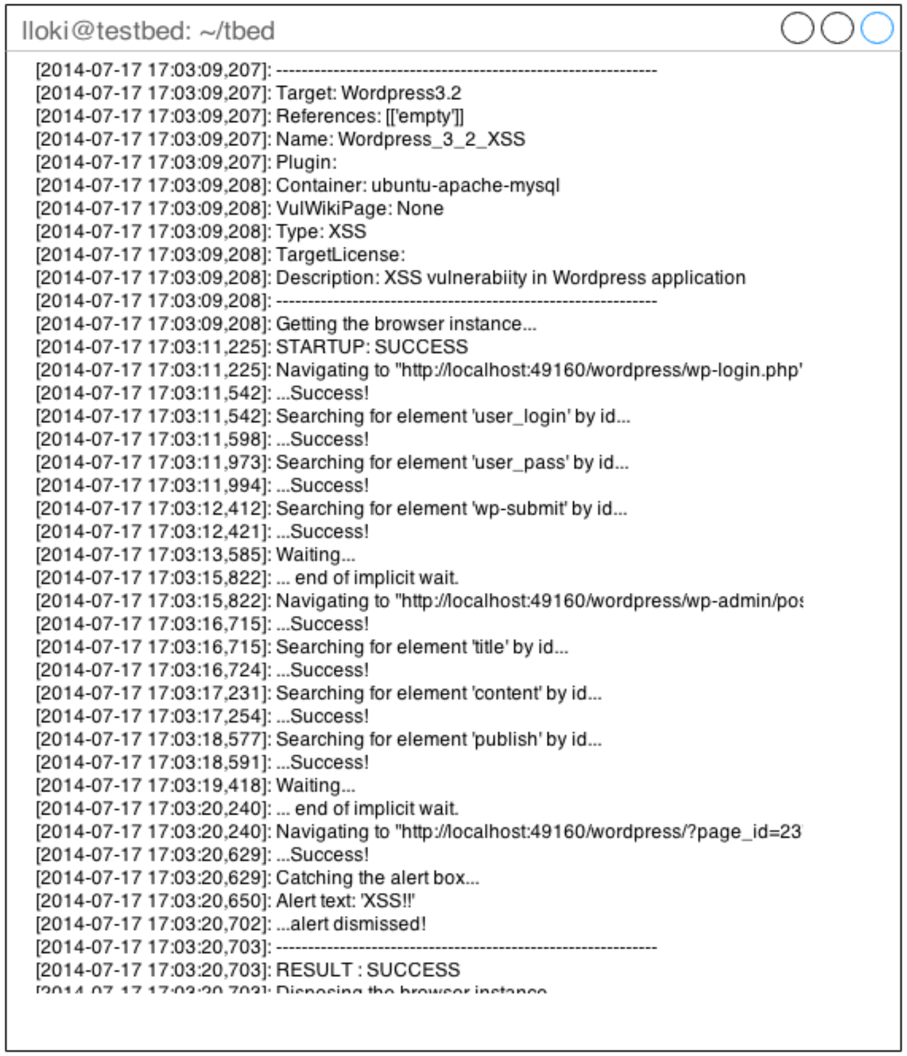
```
loki@testbed:~/tbed$ sudo ./run.py --manual Wordpress3.2__ubuntu-apache-
Running 'Wordpress3.2' application with container 'testbed/Wordpress3.2__ub
apache-mysql'...
Uploading context 11.06 MB
Uploading context
Step 0 : FROM testbed/ubuntu-apache-mysql
---> 6f6ca8d94aef
Step 1 : MAINTAINER danielrs
---> Using cache
---> a99fcf30b29f
Step 2 : RUN mkdir /var/www/wordpress
---> Using cache
---> a4bcbc1dd968
Step 3 : ADD . /var/www/wordpress
---> c6f1a69e18a1
Step 4 : RUN chmod +x /var/www/wordpress/run.sh
---> Running in c96779daddf9
---> 3522dd7204ea
Step 5 : CMD cd /var/www/wordpress && ./run.sh
---> Running in c61225b0716e
---> 7ddf4fc2e062
Successfully built 7ddf4fc2e062
Removing intermediate container 67e093b4185c
Removing intermediate container c96779daddf9
Removing intermediate container c61225b0716e
...the application is up and running!
```



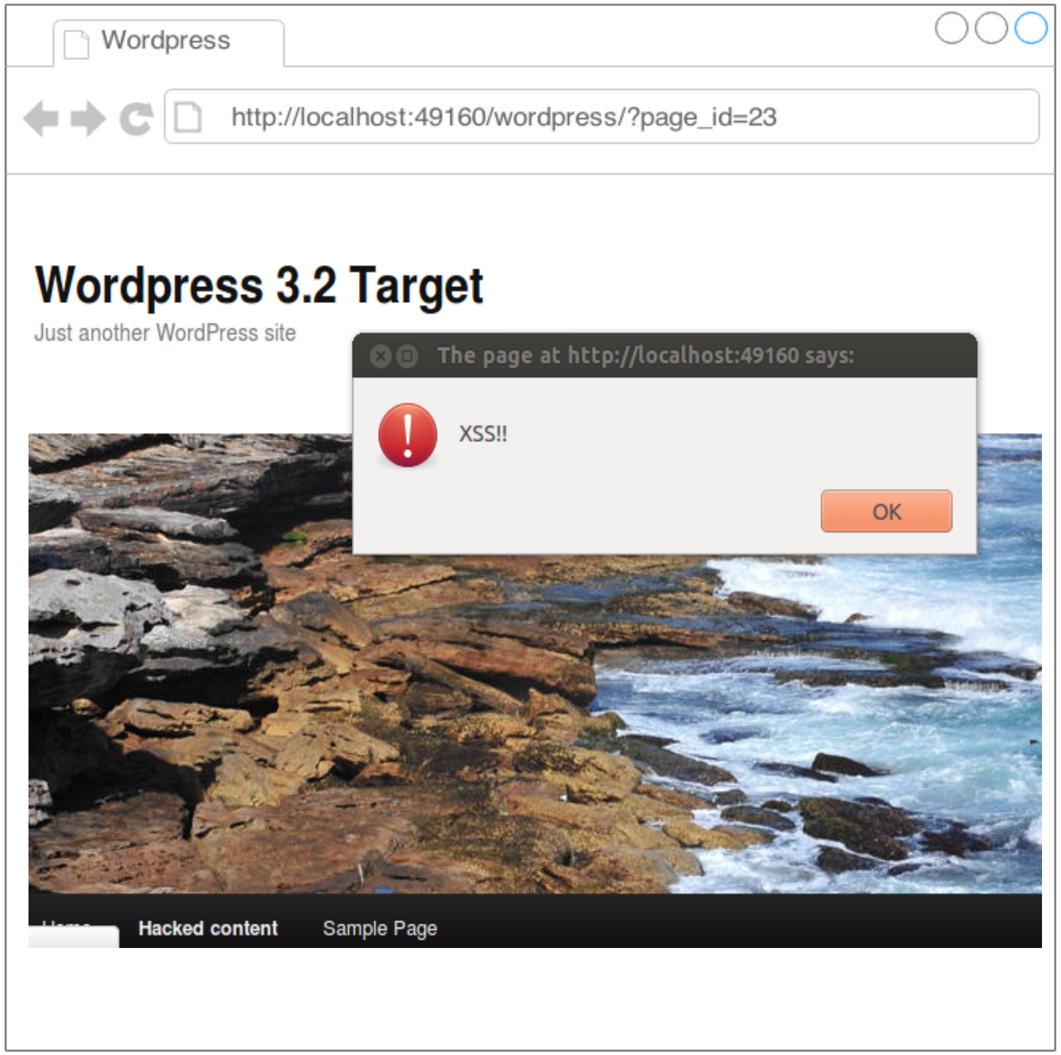
Wordpress

http://localhost:49160/wordpress/wp-login.php

Demo: Single exploit run



```
lloki@testbed: ~/tbed
[2014-07-17 17:03:09,207]: ------------------------------------------------------------
[2014-07-17 17:03:09,207]: Target: Wordpress3.2
[2014-07-17 17:03:09,207]: References: [['empty']]
[2014-07-17 17:03:09,207]: Name: Wordpress_3_2_XSS
[2014-07-17 17:03:09,207]: Plugin:
[2014-07-17 17:03:09,208]: Container: ubuntu-apache-mysql
[2014-07-17 17:03:09,208]: VulWikiPage: None
[2014-07-17 17:03:09,208]: Type: XSS
[2014-07-17 17:03:09,208]: TargetLicense:
[2014-07-17 17:03:09,208]: Description: XSS vulnerabiity in Wordpress application
[2014-07-17 17:03:09,208]: ------------------------------------------------------------
[2014-07-17 17:03:09,208]: Getting the browser instance...
[2014-07-17 17:03:11,225]: STARTUP: SUCCESS
[2014-07-17 17:03:11,225]: Navigating to "http://localhost:49160/wordpress/wp-login.php'
[2014-07-17 17:03:11,542]: ...Success!
[2014-07-17 17:03:11,542]: Searching for element 'user_login' by id...
[2014-07-17 17:03:11,598]: ...Success!
[2014-07-17 17:03:11,973]: Searching for element 'user_pass' by id...
[2014-07-17 17:03:11,994]: ...Success!
[2014-07-17 17:03:12,412]: Searching for element 'wp-submit' by id...
[2014-07-17 17:03:12,421]: ...Success!
[2014-07-17 17:03:13,585]: Waiting...
[2014-07-17 17:03:15,822]: ... end of implicit wait.
[2014-07-17 17:03:15,822]: Navigating to "http://localhost:49160/wordpress/wp-admin/pos
[2014-07-17 17:03:16,715]: ...Success!
[2014-07-17 17:03:16,715]: Searching for element 'title' by id...
[2014-07-17 17:03:16,724]: ...Success!
[2014-07-17 17:03:17,231]: Searching for element 'content' by id...
[2014-07-17 17:03:17,254]: ...Success!
[2014-07-17 17:03:18,577]: Searching for element 'publish' by id...
[2014-07-17 17:03:18,591]: ...Success!
[2014-07-17 17:03:19,418]: Waiting...
[2014-07-17 17:03:20,240]: ... end of implicit wait.
[2014-07-17 17:03:20,240]: Navigating to "http://localhost:49160/wordpress/?page_id=23
[2014-07-17 17:03:20,629]: ...Success!
[2014-07-17 17:03:20,629]: Catching the alert box...
[2014-07-17 17:03:20,650]: Alert text: 'XSS!!'
[2014-07-17 17:03:20,702]: ...alert dismissed!
[2014-07-17 17:03:20,703]: ------------------------------------------------------------
[2014-07-17 17:03:20,703]: RESULT : SUCCESS
[2014-07-17 17:03:20,703]: Disposing the browser instance
```


Wordpress
http://localhost:49160/wordpress/?page_id=23
Wordpress 3.2 Target
Just another WordPress site
The page at http://localhost:49160 says:
XSS!!
OK
Home
Hacked content
Sample Page

TestREx applications

- Executable documentation for software companies
- Penetration testing support tool
- Part of a training toolkit for studying web application security
- Manual/discovery security testing
- Automated regression testing suite
- Automated security + configuration testing
- Benchmark for code analysis tools evaluation
- Aid for security-unaware developers

Future work

- Engage UNITN students
  - *Extension of the exploit/vulnerability corpus*
  - *Implement a number of attack scenarios and countermeasures for JavaScript*
  - *Use TestREx as a part of a toolchain for scanning Node.js*
- Build a hierarchy of exploits similarly to what we did with containers
- Use TestREx for JavaScript static analysis tools evaluation
- Semi-automatic generation of test cases for security vulnerabilities

Conclusions

- Created a small set of our example exploits (17) with WebGoat and server-side JavaScript
- Adapted the corpus of exploits taken from the BugBox to TestREx
- It's possible to quickly switch between execution environments and do effective version/configuration testing
- We envision the scripted exploits as the runnable documentation that can facilitate testing and bug fixing in software development

Lessons learned

- A true value of building on top of the existing approaches
  - *BugBox by Nilson et al. [1]*
  - *MalwareLab by Allodi et al. [2]*
- The importance of simple and modular architecture
- The necessity of reliable information on applications, existing exploits, software and execution environments

References

- **[1]** Nilson G.; Wills K.; Stuckman J.; Purtilo J. “***BugBox: A Vulnerability Corpus for PHP Web Applications***” Presented as part of the 6th Workshop on Cyber Security Experimentation and Test, USENIX, 2013

- **[2]** Allodi L.; Kotov V.; Massacci F. ***“Malwarelab: Experimentation with cybercrime attacks”*** Presented as part of the 6th Workshop on Cyber Security Experimentation and Test, USENIX, 2013

Questions?

- TestREx is available at [https://github.com/standash/TestREx]
- Authors:
  - Stanislav Dashevskyi: dashevskyi@fbk.eu
  - Daniel Ricardo Dos Santos: dossantos@fbk.eu
  - Fabio Massacci: fabio.massacci@unitn.it
  - Antonino Sabetta: antonino.sabetta@sap.com