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Classifying Web Exploits with Topic Modeling

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TIR 2017, Lyon

Outline

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2. Motivation
3. Data
4. Examples
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Terminology

- Software **vulnerabilities** are security-related bugs
- **Exploits** are implementations targeting such bugs
  - To compromise a system, to cause a denial-of-service, etc.
- Yet, **proof-of-concept** (PoC) exploits are slightly different
  - Neither written nor used for actual attacking
  - Typically used during vulnerability **disclosure**
  - Though, also for money and fame & glory
  - This said, ethical issues are still present also with PoCs

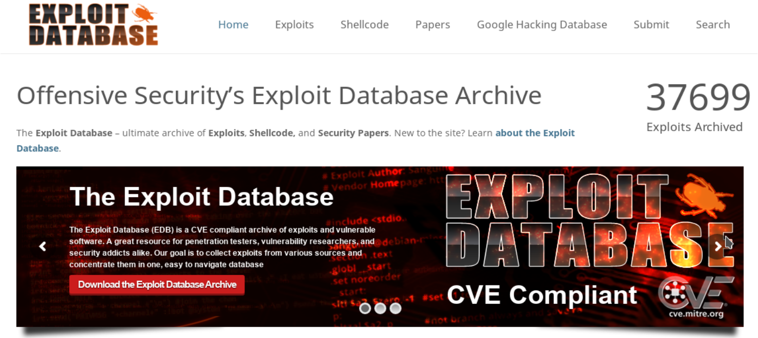
Motivation

- The **demand** for exploits has increased in recent years
  - Penetration testing and offensive security in general, etc.
- **Archiving** of vulnerabilities and exploits requires a lot of work
  - Recent delays in **CVE assignment** via MITRE Corporation
  - **OSVDB** was shutdown due to maintenance problems
- Thus, a basic question is how to **automate** the archiving?
  - Basically, assign a case to a predefined meta-data category
  - Related work in software engineering ("**bug triaging**")

Data

- 36184 raw exploits archived in **Exploit Database** (EDB)
- The exploits archived are in **unstructured text** format
  - PoC code, disclosure events, attribution credits, etc.
  - Gathered from mailing lists, bug trackers, blogs, etc.
- A number of **meta-data categories** are present
  - Based on manual classification done by EDB maintainers
  - In this work, web and PHP categories are used for brevity

Examples (1/3)



Offensive Security's Exploit Database Archive

37699
Exploits Archived

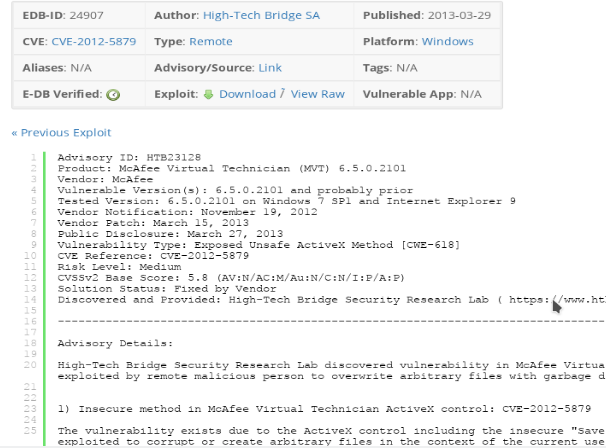
The **Exploit Database** – ultimate archive of **Exploits**, **Shellcode**, and **Security Papers**. New to the site? Learn **about the Exploit Database**.

The Exploit Database

The Exploit Database (EDB) is a CVE compliant archive of exploits and vulnerable software. A great resource for penetration testers, vulnerability researchers, and security addicts alike. Our goal is to collect exploits from various sources and concentrate them in one, easy to navigate database

Figure: Source: EDB (`https://www.exploit-db.com/`), August 2017

Examples (2/3)



EDB-ID: 24907	Author: High-Tech Bridge SA	Published: 2013-03-29
CVE: CVE-2012-5879	Type: Remote	Platform: Windows
Aliases: N/A	Advisory/Source: Link	Tags: N/A
E-DB Verified: ✓	Exploit: Download / View Raw	Vulnerable App: N/A

« Previous Exploit

```
Advisory ID: HTB23128
Product: McAfee Virtual Technician (MVT) 6.5.0.2101
Vendor: McAfee
Vulnerable Version(s): 6.5.0.2101 and probably prior
Tested Version: 6.5.0.2101 on Windows 7 SP1 and Internet Explorer 9
Vendor Notification: November 19, 2012
Vendor Patch: March 15, 2013
Public Disclosure: March 27, 2013
Vulnerability Type: Exposed Unsafe ActiveX Method [CWE-618]
CVE Reference: CVE-2012-5879
Risk Level: Medium
CVSSv2 Base Score: 5.8 (AV:N/AC:M/Au:N/C:N/I:P/A:P)
Solution Status: Fixed by Vendor
Discovered and Provided: High-Tech Bridge Security Research Lab ( https://www.ht

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Advisory Details:

High-Tech Bridge Security Research Lab discovered vulnerability in McAfee Virtua
exploited by remote malicious person to overwrite arbitrary files with garbage d


1) Insecure method in McAfee Virtual Technician ActiveX control: CVE-2012-5879

The vulnerability exists due to the ActiveX control including the insecure "Save
exploited to corrupt or create arbitrary files in the context of the current use
```
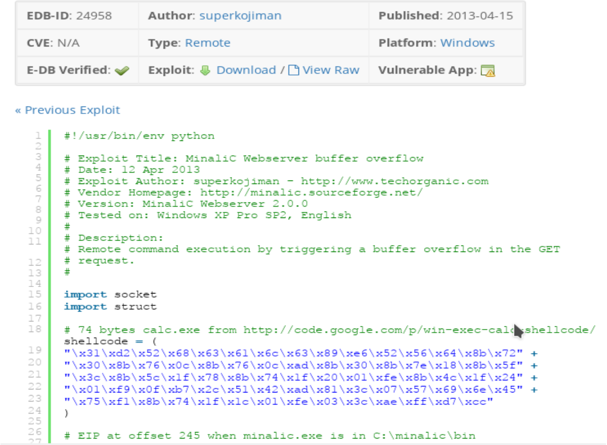

Figure: Source: EDB (https://www.exploit-db.com/), August 2017

Examples (3/3)



EDB-ID: 24958	**Author**: superkojiman	**Published**: 2013-04-15
CVE: N/A	**Type**: Remote	**Platform**: Windows
E-DB Verified: ✓	**Exploit**: Download / View Raw	**Vulnerable App**:

« Previous Exploit

```
#!/usr/bin/env python

# Exploit Title: MinaliC Webserver buffer overflow
# Date: 12 Apr 2013
# Exploit Author: superkojiman - http://www.techorganic.com
# Vendor Homepage: http://minalic.sourceforge.net/
# Version: MinaliC Webserver 2.0.0
# Tested on: Windows XP Pro SP2, English
#
# Description:
# Remote command execution by triggering a buffer overflow in the GET
# request.
#

import socket
import struct

# 74 bytes calc.exe from http://code.google.com/p/win-exec-calc-shellcode/
shellcode = (
"\x31\xd2\x52\x68\x63\x61\x6c\x63\x89\xe6\x52\x56\x64\x8b\x72" +
"\x30\x8b\x76\x0c\x8b\x76\x0c\xad\x8b\x30\x8b\x7e\x18\x8b\x5f" +
"\x3c\x8b\x5c\x1f\x78\x8b\x74\x1f\x20\x01\xfe\x8b\x4c\x1f\x24" +
"\x01\xf9\x0f\xb7\x2c\x51\x42\xad\x81\x3c\x07\x57\x69\x6e\x45" +
"\x75\xf1\x8b\x74\x1f\x1c\x01\xfe\x03\x3c\xae\xff\xd7\xcc"
)

# EIP at offset 245 when minalic.exe is in C:\minalic\bin
```

Figure: Source: EDB (https://www.exploit-db.com/), August 2017

Processing

- A **pre-processing** routine with six steps
  - Including tokenization, lemmatization, stop words, etc.
- Separation of English **words** and non-English **terms**
- Word and term frequency matrices are used for LDA
  - That is, the **Latent Dirichlet Allocation** (LDA) method
  - Each exploit is assigned to the **most dominant** (text or word) topic according to the highest membership rate
- **Number of topics** (k) restricted to $k = 5, 10, 20, 30, 40, 50$
  - Default settings and parameters used otherwise (R impl.)

Classification (1/4)

- Separate classifiers for **two categories**
  - Web exploits and exploits targeting PHP
  - Results almost perfectly **balanced** data
- Computation with the **random forest** algorithm
- In total, **40 features** (from which two are LDA-based)
  - Many are well-known metrics (which require manual work)
  - How much performance is gained from the LDA-metrics?

Classification (2/4)

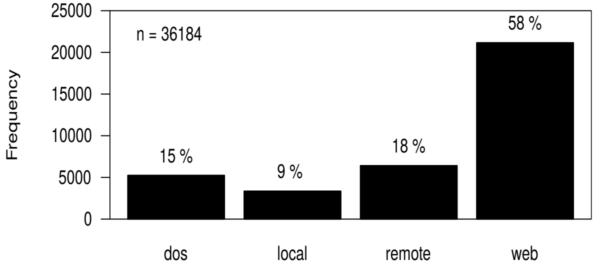


Figure: Response category #1 (“web”)

Classification (3/4)

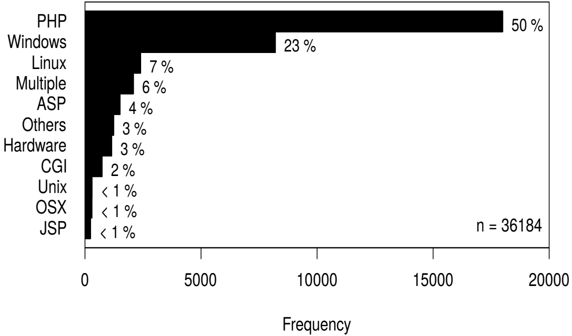


Figure: Response category #2 ("PHP")

Classification (4/4)

#	Description
1.	One for the most dominant **term-based topic** characterizing the exploit.
2.	One for the most dominant **word-based topic** characterizing the exploit.
3.	One if the EDB community has **verified** the exploit.
4.	One if the vulnerable application is available for **download**.
5.	One if a **screenshot** is provided for a demonstration or other purposes.
6.	The number of **OSVDB references** or zero for no such references.
7.	The number of **CVE references** or zero for the absence of CVE references.
8.	The mean of **CVSS base scores** for all CVE references (or zero for no refs.).
9.	The **year** at which the exploit was first published according to EDB.
10.	The **month** at which the exploit was first published according to EDB.
11. – 40.	One if the author of the exploit is among the **“top-30” developers**.

Results

k	Covariates	Accuracy	
		Web [95 % CIs]	PHP [95 % CIs]
0	38	0.788 [0.765, 0.810]	0.742 [0.717, 0.766]
5	40	0.895 [0.877, 0.911]	0.843 [0.821, 0.862]
10	40	0.910 [0.893, 0.925]	0.861 [0.841, 0.880]
20	40	**0.920** [0.904, 0.935]	**0.888** [0.869, 0.905]
30	40	0.912 [0.894, 0.927]	0.881 [0.862, 0.898]
40	40	0.914 [0.897, 0.929]	0.863 [0.843, 0.882]
50	40	0.913 [0.896, 0.928]	0.878 [0.858, 0.895]

Conclusion

- The accuracy range $[0.89, 0.92]$ is **good** in the context
  - But the statistical performance mostly comes from **conventional metrics** that require manual work
  - Should test how well **plain frequency matrices** work
  - **Multi-class** classification required in practice
- How to **separate PoC code** from other content?
  - Not as easy as separating code from code comments
  - Would have practical value in security and threat intelligence

Thank you

Questions?