

Automated Software Vulnerability Management and Monitoring

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Ehab Qadah
Supervisor: Luis Alberto Benthin
Sanguino

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Abstract. One of the main concerning areas for most organizations is software vulnerability analysis. In this paper, we discuss techniques and systems to automatically monitor software vulnerabilities using open standards and public vulnerability data repositories or alternative sources such as social media and developer blogs.

1 Introduction

One of the main concerning areas for most organizations is software vulnerability analysis to ensure certain level of security, and this area is important due the continuous discovery of software vulnerabilities that open the doors for cyber-attacks. All organization must be aware of the known software vulnerabilities to perform the needed actions including installing the corresponding patches if available. Information about known software vulnerabilities can be retrieved from online repositories like the National Vulnerability Database (NVD).

1.1 Software Vulnerability Management

Vulnerability is defect or weakness in system result security incident or violation such as inappropriate access to system component or data breaches defined by G. Stonebumer et al. in [1].

The Software Vulnerability Management concept can be defined as the process of identifying related vulnerabilities in software that is installed inside an organization. The process first requires managing the inventory of the organization's IT assets and the periodic search for the related vulnerabilities. In case of the discovery of a vulnerability, a certain action should be performed such as alerting the system administrators or trying to install the corresponding patches to avoid possible threats based on those known vulnerabilities.

2 Automated Vulnerability Management and Monitoring System

This section presents the proposed technique and system by Takahashi et al. in [3] to automatically monitor vulnerabilities of computing assets inside the IT infrastructure of an organization. Their main contribution is to automate the process of vulnerability management using open standards and tools, and to make available in a wide range of organizations.

The proposed system first collects a list of IT assets, the system uses the collected and stored information about the organization's IT assets to find the corresponding standards identifiers (CPE-IDs) ¹, then the system utilizes those identifiers to check the existence of related vulnerabilities by querying the vulnerability repositories. Finally an alert about the identified security defects will be sent to the system administrator by the proposed system.

¹ Common Platform Enumeration (CPE) IDs explained in section 3

2.1 System Components

The system proposed in [3] is composed by 4 elements, which are described in the following:

1. **Terminals:** This element includes all electronic devices used by the organization's employees to perform their job activities. In most cases, an agent is installed on a terminal to collect information about the installed IT assets on it. The collected information is then sent to the asset management server.
2. **Asset Management Server:** this component is responsible to communicate with the installed agents on the terminals to collect information about the computing assets of the organization, and to collect information about the terminals without installed agent the asset management server monitors and analysis the organization's network traffic. The asset management server determines the IT assets standards identifiers using the collected information. Afterward this element checks for the vulnerabilities by querying the vulnerability knowledge base.
3. **Vulnerability Knowledge base:** is the local system's database for the vulnerability information to compose data from different vulnerability repositories like NVD.
4. **Administrator terminal:** is the console used by the system administrator which receives the notification alert about the found security vulnerabilities from the asset management server.

2.2 System Workflow

In this section the workflow of the proposed system is described.

1. **Compile IT assets information:** the system starts with the process of collecting the information on the organization's IT assets. This is achieved by sending requests to the agents installed on the terminals, or by monitoring the network. The agents gather the information of the installed software, and then, an XML document is generated. This document contains, for instance, the software name, version, publisher, and installation date, as shown in Figure 1.²
2. **Resolving of IT assets identifiers:** the system determines the CPE-IDs for the IT assets using the collected information from the first stage, the CPE dictionary⁴ obtained from NVD repository is used as reference CPE-IDs for the proposed system. The basic algorithm to extract the corresponding CPE-IDs for the IT-assets builds a query from the collect information like name, version and owner and calculate the matching rate (percentage of the

² based on figure 4 in [3]

³ The information in Figure 1 also include cpe and cve which generated by the system in later stages

⁴ <https://nvd.nist.gov/cpe.cfm>

```

<?xml version="1.0" encoding="UTF-8"
standalone="yes"?>
<assetInfo version="1">
  <!-- SNIP -->
  <installedSoftwareInfo version="1">
    <softwareInfo>
      <name>Adobe Flash Player 23.0.0.205</name>
      <version>23.0.0.205</version>
      <publisher> Adobe Systems Software </publisher>
      <size>0x24e23</size>
      <installationDate>20161122</installationDate>
      <cpe id="cpe:/a:adobe:flash-player:23.0.0.205"
matchingRate="7.654244" />
      <cve id="CVE-2016-4273" />
      <cve id="CVE-2016-6982" />
    </softwareInfo>
  <!-- SNIP -->
</installedSoftwareInfo>
<networkInfo version="1">
  <hostName>ehab-qadah-pc</hostName>
  <openPorts>
    <port>444</port>
    <!-- SNIP -->
  </openPorts>
  <nicInfoList>
    <gateWay>131.220.207.254</gateWay>
    <ipAddress>131.220.198.146</ipAddress>
    <macAddress>255.255.240.0</macAddress>
    <subnetMask>255.255.252.0</subnetMask>
    <nicName>Intel(R) 82578DM Gigabit Network Connection</nicName>
  </nicInfoList>
  <!-- SNIP -->
</networkInfo>
</assetInfo>

```

Fig. 1. An example of the collected information by the proposed system for a terminal.

similar characters) for each CPE-ID record in the CPE dictionary and select the CP-IDs with the highest matching rate and these CPE-IDs added to assets stored information as seen in Figure 1.

3. **Finding Vulnerability Information:** The system uses the determined CPE-IDs to query the vulnerability knowledge base for related vulnerabilities and in case of discovering a vulnerability the system administrator is notified by alert containing the CPE and CVE data.

3 Standards

This section introduces the most related standards for the software vulnerability management, which is the Security Content Automation Protocol (SCAP)⁵.

3.1 SCAP

SCAP is a collection of open standards and enumerations of software flaws and configurations related to security allow the communication of that information, to support the automated vulnerability and security information management.

It is provided and maintained by the National Institute of Standards and Technology (NIST)⁶, and the repository of the SCAP content is the National Vulnerability Database (NVD)⁷ that provides a data feed for each SCAP standard which can be publicly accessed by the security community. And it is also managed by NSIT, SCAP has gained adoption by most of the information security systems.

The SCAP Standard is composed by six components. In the following we describe the components that can be utilized by vulnerability analysis systems.

- Common Vulnerabilities and Exposures (CVE)
- Common Platform Enumeration (CPE)
- Common Vulnerability Scoring System (CVSS)

The CVE is the naming list of software flaws in security context, to allow identification of cyber-security vulnerabilities to ease the exchange of information about the cyber-security issues, The CVE list is managed by The MITRE Corporation⁸. The CPE is the dictionary of all software products and applications, operating systems and hardware devices which provides identification and naming for each, the official CPE dictionary can be obtained from NVD repository⁹ and provided in XML format. The CVSS is scoring system for the software flaw vulnerabilities, and The CCE is a dictionary of systems configuration and settings issues [2].

⁵ <https://scap.nist.gov/>

⁶ <https://www.nist.gov/>

⁷ <https://nvd.nist.gov/>

⁸ <https://www.mitre.org/>

⁹ <https://nvd.nist.gov/cpe.cfm>

The CVE list is not vulnerabilities data repository ¹⁰ is just names/IDs list, and NVD is one of vulnerabilities databases based on the CVE list and it provides a data feed for SCAP content such as the XML vulnerability feed which contains the cyber security software issues and it provides CVE link and a CVSS base score and CPE mapping for each vulnerability record [?].

4 Alternatives to NVD Repository

This sections describes the an alternative vulnerability data source to the traditional vulnerability repositories as National Vulnerability Database NVD for the vulnerability monitoring task, due the usual delay of revelation of cyber security related defects in by the typical information sources the detection of zero day vulnerabilities is difficult, in order to solve this issue a technique to collect the security information from totally new data source which is the Social Media (Twitter) was proposed in [4].

The proposed system takes the advantage of getting informed about security vulnerability information earlier than the normal information sources because of the widespread usage of social media platforms and technical blogs to discuss the software bugs and issues between the software developers and experts communities, in other hand the classical information sources like NVD waits the availability of patches before publishing the vulnerability information.

The introduced system is called SMASH(Social Media Analysis for security on HANA) consist of two subsystems data collection and processing. The data collection part is responsible to gather the security information from the social media(Twitter ¹¹) by searching the Twitter stream content to related security information and store it in the local database to be utilized by the system later. The system also keeps a copy of the information form NVD to be used in recognizing the new from the known vulnerability information.

The data processing subsystem is performing the extraction of security information from the stored twitter content to detect the zero-day vulnerabilities which are not published yet, by using various data mining techniques.

The proposed system offers the functionality of monitoring certain software products, the system shows the discovered security information related to user's selected softwares.

5 Discussion

The proposed technique and system in section 2 mainly focuses on the automation of software vulnerabilities monitoring process and using the open standards and public vulnerability repositories, and the action of the system in case of

¹⁰ The list of vulnerabilities databases list can be found at https://cve.mitre.org/compatible/product_type.htmlDatabase#Vulnerability

¹¹ Twitter has been used in the prototype, but the technique is applicable for the others social media platforms

vulnerability discovery can be argued as simple and does not follow the main system focus to avoid the manual operation, it just sends an alert for the system administrator which then perform the need action, so the system should execute fast and immediate actions, such block the corresponding terminal or even the software component to ensure a certain level of security.

The main factor on the accuracy of the system's outcomes is the accuracy of the determination of CPE-IDs for all computing assets in the organization, the proposed systems find the CPE-IDs based on the numerical method of calculating the match rate, and this approach does not always give an accurate matching, and produced CPE-IDs should be validated by the system before moving to the further steps.

The proposed technique and system in section 4 is trying to detect the vulnerable Softwares as fast as possible by utilizing a different vulnerability information source social media (Twitter) by analyzing and exaggerate the security related content to be used by the detection of vulnerabilities task, which offers the opportunity to detect vulnerable softwares before event publishing the vulnerability information in the classical channels such as NVD, but this approach may utilize non validated or wrong information in the detection process that's why the proposed system consists of trust module of the extracted information from the social media data, since it the quality of data is very important to the system's output.

6 Conclusion

The importance of automatic detection and monitoring of vulnerable Softwares inside the organizations to ensure an efficient level of security and avoid cyber-attacks introduce the need software vulnerability management and monitoring systems as the two proposed system we discussed in this paper, those systems does not replace the normal security systems and policies they just complete their work. The role of vulnerability information repositories like NVD and the open standards such SCAP protocol is the main actor in building the software vulnerability management and monitoring systems.

References

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