Design of Professional Laboratory Exercises for Effective Stateof-the-Art OSINT Investigation Tools - Part 2: Censys

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Abstract

Open-source technologies (OSINT) are becoming increasingly popular with investigative and government agencies, intelligence services, media companies, and corporations.

These OSINT technologies use sophisticated techniques and special tools to analyze the continually growing sources of information efficiently.

There is a great need for professional training and further education in this field worldwide.

After having already presented the overall structure of a professional training concept in this field in a previous paper [25], this series of articles offers individual further training modules for the worldwide standard state-of-the-art OSINT tools.

The modules presented here are suitable for a professional training program and an OSINT course in a bachelor's or master's computer science or cybersecurity study at a university.

In part 1 of a series of 4 articles, the OSINT tool RiskIQ PassivTotal [26] is introduced, and its application possibilities are explained using concrete examples. In this part 2 the OSINT tool Censys is explained [27]. Part 3 deals with Maltego [28] and Part 4 compares the 3 different tools of Part 1-3 [29].

Introduction and Motivation

CENSYS is often referred to as the most dangerous search engine in the world alongside SHODAN. CENSYS was developed by a group of researchers at the University of Michigan to make the Internet safer. Regular Internet-wide port scans across the entire public IPv4 address space can be used to identify vulnerable devices and networks and generate statistics on usage patterns of specific protocols or certificates. The results can be retrieved with an advanced full-text search or via an API [14].

Censys – Accompanying theory

While similar search services of this kind focus on host discovery, CENSYS takes the path of performing complete protocol handshakes and analyzing the recorded data. This achieves a significantly higher hit rate without sacrificing accuracy.

The backend of CENSYS consists of the highly parallel application scanner ZGrab (part of the open-source project ZMap), which currently detects and analyzes numerous other application handshakes in addition to StartTLS, Heartbleed, and SSLv3 and makes them available as JSON objects. ZMap identifies the interesting hosts, and ZGrab initiates the handshakes and provides the corresponding structured data [13]. Using simple searches like

443.https.heartbleed.vulnerable: true

can be found, for example, by heartbleed vulnerable hosts. Filters can also be used to search for Poodle vulnerable hosts or outdated SHA-1 SSL Certificates [15].

With this new approach and the project's open-source nature, there is a transparent platform to uncover and detect global and local grievances [16]. All scanned data is available at **https://scans.io/**. The source code of ZMap and ZGrab is available on GitHub at **https://github.com/zmap**.

First steps

CENSYS provides a complex web interface and detailed filtering options. The central part of the site consists of a search field (fig. 1) that divides the search into three separate areas:

- IPv4 host,
- Websites,
- Certificate.

The search is based on classic Boolean search queries. The following section explains the keyword system and the differences between the three search areas [10].

After entering the search line results, the results that were found based on this search appear. At the top right, one will find various options for viewing the results.

The first way to view it is the **Results** tab (Fig. 2), which outputs the search results as a list. (Here, for example, the category **IPv4 Hosts** was searched for **protocols:''80/http''**) (Fig. 3).

Next to it one will find the tab page **Map** (Fig. 4). By clicking on it, the output results are displayed on a map, as shown here:

Ç censys		HOW WE HELP +	PRICING ABOUT	LOGIN
	Security starts		у	
	it servers and devices are exposed 19 network?	(F		
Ent	ter an IP address or CIDR block (141.211.)	0.0/16)	٩	

Figure 1. CENSYS search

IPv4 Hosts

≣	Results	0	Мар	i	Metadata	Lill Report	Docs
Figur	re 2. Resu	lts t	ab				

Page: 1/2,099,291 Results: 52,482,263 Time: 686ms
23.240.39.84 (cpe-23-240-39-84.socal.res.rr.com) TWC-20001-PACWEST - Charter Communications Inc (20001)
45.195.15.171
ANCHGLOBAL-AS-AP Anchnet Asia Limited (137443) Windows No. 80/http IIS7
Q protocols: 80/http
195.93.224.143 (media001-b.pictura-hosting.nl) PICTURA-NET (49820)
□ 3.88.76.174 (ec2-3-88-76-174.compute-1.amazonaws.com)
 AMAZON-AES - Amazon.com, Inc. (14618) Ashburn, Virginia, United States 80/http Savings Made Real protocols: 80/http
58.225.36.94
SKB-AS SK Broadband Co Ltd (9318) Siheung-si, Gyeonggi-do, South Korea Mindows Si B0/http protocols: 80/http

Figure 3. Search result for 80/http

Switching to the **Metadata** tab page (Fig. 5), one gets an overview of the result set.

The tab to the right of it has the name **Report**. This tool can generate a report on the breakdown of value present on the hosts returned by request.

The last and far-right tabs **Docs** contain important information about the syntax of CENSYS, examples of queries and data definitions, such as:

• timestamp (updated_at),

• tags (tags),



Figure 4. Output of the search on the map

			III Results 9 Map	i Metadata Lal Repo	t 🖉 Doci
Query Me	etadata				
Your query (protocols :	"80/http") found 5	i2,482,263 IF	v4 hosts.		
Country Break	down		Network Breakdown		
Country	Hosts H	Frequency	Autonomous System (AS)	Hosts	Frequen
United States	23,763,084	45.28%	AKAMAI-AS - Akamai Technologies, Inc.	4,854,241	9.25
China	3,538,857	6.74%	AMAZON-02 - Amazon.com, Inc.	2,990,052	5.7
Netherlands	2,211,663	4.21%	CNNIC-ALIBABA-CN-NET-AP Hangzhou Alibaba Advertising Co.,Ltd.	1,524,350	2.9
Germany	2,047,751	3.9%	AKAMAI-ASN1	1,480,545	2.82
Japan	1,609,784	3.07%	AMAZON-AES - Amazon.com, Inc.	1,218,117	2.32
France	1,254,331	2.39%	OVH	852,189	1.62
United Kingdom	1,239,187	2.36%	EGIHOSTING - EGIHosting	799,768	1.52
Hong Kong	1,166,463	2.22%	DIGITALOCEAN-ASN - DigitalOcean, LLC	785,224	1.5
South Korea	1,037,850	1.98%	CLOUDFLARENET - Cloudflare, Inc.	730,764	1.39
Russia	990.492	1.89%	COMCAST-7922 - Comcast Cable Communications, LLC	554.153	1.06

Figure 5. Result set

• location data (location) and *autonomous system data (autonomous_system)*.

In the left column there is a hint to **Quick Filters** and below that the number of **Protocols** and the so-called **Tags** (Fig. 6). **Tags**

Tags are specific values that can be appended to some hosts. CENSYS includes heuristics that attempt to identify interesting hosts based on their banner responses and other factors [12]. Tags are then used to bundle hosts based on a specific factor. Tags include, for example:

- ''camera'' Public cameras,
- "nas" Network Attached Storage,
- "raspberry pi".

To view the complete list of tags, the URL https://censys. io/ipv4/report must be opened in the browser (Fig. 7). There the command tags.raw must be entered into the search field. The complete list should then be opened (Fig. 8). IPv4 hosts

The primary purpose of CENSYS is to scan the IPv4 space, find open services, and collect the banners.

The Fig. 9 shows an example of an IPv4 results page. The host has two open services: **80/HTTP** and **443/HTTPS.** CENSYS





Report Builder					
This tool allows you to generate a report on the breakdown of a value pre HTTPS servers in the United States, you could query for location.count 443.https.tls.cipher_suite.name. A list of reportable fields is available	y_code: US AND protocols:443/https and then get				en by
tags.raw		50	~	BUILD REPO	RT
Host Report					
Host Report				Hosts	1
				Hosts 71,282,721	29.399
tags.raw http					
tags.naw http https				71,282,721	29.399
tags.raw				71,282,721 38,825,106	29.399

Figure 8. Complete list of tags

allows filtering by protocol specific fields. For example, you can filter for the HTTP response status code for **80/http** and for a public key for **22/ssh** at the same time.

For example, to display a tag and a specific protocol:

```
((195.37.1.142) AND tags.raw:"ssh") AND proto-
```

Figure 10. Structure of a search query

The above query (Fig. 10) represents hosts that return status code 404 for **GET "/**". Several key-value pairs can be combined with "**AND**" or "**OR**", e.g.:

Hosts who opened SSH and Telnet: ports:22 AND ports:23

Hosts in Slovakia that are marked as camera: location.country_code: SK AND tags.raw: "camera"

OpenSSH servers running on Debian all over Europe: 22.ssh.v2.metadata.product: "OpenSSH"AND metadata.os: "Debian"AND location.continent: "Europe"

It is also possible to open the JSON output for a host that displays all key names. CENSYS also provides the ability to specify ranges.

Example: Hosts that have been updated since May and returned 5xx HTTP code.

updated_at:[2018-05-01	то	*]	AND
80.http.get.status_code:[500 TO	600]		

Regular expressions and placeholders are also possible. Example: "name.first": "s.*y"

Websites

Websites offer mainly the same view as IPv4 hosts. CENSYS currently scans all domains from Alexa's top 1 million visited websites. Information about certificates and DNS (e.g., AXFR checks) is added to the usual host scan.



Figure 11. Search result for google.com

Search results for the website **google.com** were found here (Fig. 11).

One can choose between Results and Report as options for displaying the results.

Certificates



Figure 12. Result of a certificate search

In CENSYS you can also search directly for certificates (Fig. 12). The only 20% of the certificates in CENSYS come from SSL scans in the IPv4 address space. The rest comes directly from the Certificate Transparency (CT) protocols.

The Certificate Transparency Project was created to get an overview of the CAs issue certificates. The process looks like this (Fig. 13):



Figure 13. Certificate Transparency Project

This means that in CENSYS the certificates are made available immediately after issue (almost in real-time) [11]. CENSYS does not have to rely on IPv4 scans to find certificates.

Especially when searching for certificates CENSYS offers one of the best services currently available.

CENSYS offers several new keys for the certificate search, such as

- Certificate Fields (parsed),
- Certificate Metadata (metadata),
- Trust Chain (validation),
- Certificate Transparency (ct.)

To view the complete list of certificates, the URL https:// censys.io/certificates must be opened in the browser. A list of certificates should appear (Fig. 14). Examples:

Certificates for www.example.com: parsed.names:"www.example.com"

Certificates that are valid from Apple, but not from Mozilla NSS:

validation.apple.valid:true AND validation.nss.valid:false

Certificates issued by Symantec that were seen during the SSL search:

parsed.issuer.organization.raw:"Symantec Corporation"AND

metadata.seen_in_scan:true

Certificates issued by Let's Encrypt in 2018:



Figure 14. List of certificates

parsed.issuer.organization.raw:"Let's Encrypt"AND parsed.validity.start:[2018-01-01 TO *]

CENSYS also offers interesting pivot/discovery techniques. Thus, several common factors can be searched for. To open it, click on the **Explore** tab in the upper right corner (Fig. 15).

Censys API

Exercise 1 (Obtaining the CENSYS API key)

CENSYS also offers an API interface. This can be set up as follows.

- 1. Please visit the following page first: https://censys.io/ account (Fig. 16).
- 2. Now select the item API (Fig. 17):
- 3. Make a note of your API ID and the corresponding secret. The API is a simple REST API. This means that calls can be made using fixed addresses. A simple client is even possible with the Linux console. A simple Python client looks like this (Fig. 18):

Exercise 2 (Setup of CENSYS API client)

Of course, CENSYS also offers a ready-made client for your own use and further development. It is a Python client. The developer page of the Python client is available at the following URL:

https://github.com/censys/censys-python

However, it is constrained and can instead be regarded as a starting point for its own development. In this exercise, you will, therefore, use a third-party implementation of the client. This is available at the following address:

https://github.com/gelim/censys

🗁 Raw Data 🗸 🔍 Explore 🗸
Related Certificates
Certificates with the same identity (key + subject)
♣ Certificates with the same public key
Certificates with the same serial number
 Certificates with the same names
Certificate Transparency
Associated Pre-Certificates
CA Hierarchy
What's using this certificate?
Popular Websites
📮 IPv4 Hosts
External Services
⊘ AWS Certlint
🖈 crt.sh
G Pilot 2018-05-02 17:59 259,419,991
G Rocketeer 2018-05-03 08:45 266,803,968



0

https://oensys.io/accour	nt		
Ç C6	2NSYS Q IPv4 Hosts Search		
Ассон	unt Information	Subscription 🚥	
Name	Karla Kolumna	Plan Queries Used Allowed Queries	Free Not licensed for commercial use. Upgrade 10 (4.0%) 250
Email	akj23761@yuola.com	Queries Reset Results per search query	May 23, 2019 Up to 1,000
Login	RoteHose1324		
Affiliation	TH+Brandenburg		
Phone Number	• 03381.400912		
UPDA	TEDETAILS		
Chang	ge Password		
Current pa	ssword:		
New pass	word:		



The client offers numerous possibilities. The syntax of the

Censys Q IPv4 Hosts 🗢 Search	<pre>\$ censys_io.pyhelp usage: censys_io.py (-h) [-m MATCH] [-f FILTER] [COUNT] [-P REPORT] [-8 REPORT_BUCKET] [-a ASN] [-c COUNTRY] [-0 CERT_DRG] [-1 CERT_ISSUER] [-s CERT_MOST] [-S NTTP_SERVER] [-t HIML_TILE] [-b HIML_BUOY] [-T TASS] [-end_idA AFT_ID] [apt_secret APT_SECRET] [-d] [-V] [-1 LDITT] [-H] [tsV]</pre>
	[arguments [arguments]]
My Account	Censys query via command line
My Account	
,	gelim
	positional arguments:
	arguments Censys query
	optional arguments: -h,help show this help message and exit
Details API Billing	-m MATCH,match MATCH
	Highlight a string within an existing query result -f FILTER,filter FILTER
	Filter the JSON keys to display for each result (use value 'help' for interesting fields)
Account Information	count Print the count result and exit -r REPORT,report REPORT
/loodant information	Stats on given field (use value 'help' for listing interesting fields)
	-B REPORT_BUCKET,report_bucket REPORT_BUCKET
	Bucket len in report mode (default: 50) -a ASN,asn ASN Filter with ASN (ex: 36040 for Google Inc.)
	-c COUNTRY,country COUNTRY
	Filter with country -0 CERT_ORG,cert-org CERT_ORG
gure 17. Censys API	Cert issued to org
	-i CERT_ISSUER,cert-issuer CERT_ISSUER Cert issued by org
	-s CERT_HOST,cert-host CERT_HOST
Examples	hostname cert is issued to -S HTTP_SERVER,http-server HTTP_SERVER
REST Access (Raw Data). Below is a sample Python script that connects to the API and lists raw datasets that are available for download.	Server header -t HTML TITLE,html-title HTML TITLE
	Filter on html page title
import sys import json	-b HTML_BODY,html-body HTML_BODY Filter on html body content
import requests	-T TAGS,tags TAGS Filter on specific tags. E.g: -T tag1,tag2, (use keyword 'list' to list usual tags
API_URL = "https://censys.io/api/v1"	api_id API_ID Censys API ID (optional if no env defined api_secret API SECRET
UID = "login for API key" SECRET = "login for API secret"	Censys API SECRET (optional if no env defined)
res = requests.get(API_URL + "/data", auth=(UID, SECRET))	-d,debug Debug informations -v,verbose Print raw JSON records
<pre>if res.status_code != 200: print "error occurred: %s" % res.json()["error"]</pre>	-V,Verbose Print raw Jsow records -1 LIMIT,limit LIMIT
<pre>sys.exit(1) for name, series in res.json()["raw_series"].iteritems();</pre>	Limit to N results
<pre>print series["name"], "was last updated at", series["latest_result"]["timestamp"]</pre>	-H,html Renders html elements in a browser tsv Export result of search in TSV format
Censys Python Library. We also maintain a Python library for interacting with the APL which can be installed with P(p: pip install censys. Below is a sample script that iterates over NSS trusted certificates:	
import centys.certificates	Figure 19. Syntax Python client
UID = "login for API key" SECRET = "login for API secret"	
certificates = censys.certificates.CensysCertificates(UED, SECNET) fields = ["parsed.subject_do", "parsed.fingerprint_shal26", "parsed.fingerprint_shal1]	
<pre>for c in certificates.search("validation.nss.valid: true", fields=fields):</pre>	
<pre>print c["parsed.subject_dn"]</pre>	/censys_io_nyh

🕻 censys

Figure 18. Simple Python client

client is as follows (Fig. 19):

The client can be set up relatively easily in the previously used virtual machine.

- 1. Open a terminal window and enter the following commands, where your API data must replace xxxx and yyyy:
 - (a) git clone https://github.com/gelim/censys.git
 - (b) cd censys
 - (c) pip install -r requirements.txt
 - (d) export CENSYS_API_ID=xxxx;
 - export CENSYS_API_SECRET=yyyy (e) echo "export CENSYS_API_ID=xxxx"
 - > > ~/. zshrc; echo "export CENSYS_API_SECRET=yyyy" > > ~/. zshrc;
- 2. After entering and successfully running the commands, you should now be in the program directory. Start the program with the following command:

3. Now, you should be able to read the output as shown in the syntax image above. After the successful setup, the client can be used.

Selected console query examples Example 1

You want to count how many servers have SAP in their server header. The following request is made (Fig. 20):

./censys_io.py -S SAP -count

./censys_io.py -h



Figure 20. Counting with the CENSYS API client

Example 2

A search for hosts that have SSH and Telnet open is given by (Fig. 21):

./censys_io.py ports:22 AND ports:23

-	
Te	rminal - root@hlkali: /home/hacker/censys
File Edit View Terminal	Tabs Help
sh	1
34.227.58.245 Title:	N/A SSL:
	AS: AMAZON-AES - Amazon.com, Inc. (14618)Loc
	OS: N/A Tags: ssh
130.211.243.243 Title:	
	AS: GOOGLE - Google LLC (15169) Loc:
US / Mountain View	
54.215.190.64 Title:	
	AS: AMAZON-02 - Amazon.com, Inc. (16509)Loc:
US / San Jose	
219.131.215.81 Title:	
	AS: CHINANET-BACKBONE No.31, Jin-rong Street
(4134)Loc: CN / N/A	OS: N/A Tags: ssh
54.237.220.88 litle:	Test Page for the Apache HTTP Server [] SSL:
	AS: AMAZON-AES - Amazon.com, Inc. (14618)Loc
: US / Ashburn	OS: Amazon Tags: http, ssh
125.121.131.0 Title:	N/A SSL:

Figure 21. Output a search for special ports with the CENSYS-API Client

Example 3

Searching for OpenSSH servers running on Debian across Europe (Fig. 22):

./censys_io.py	22.ssh.v2.m	ietadata.product:"C	penSSH"
AND			
	h:	AND	lass

metadata.os:"Debian"	AND	loca-
tion.continent:"Europe"		

		Te	erminal	- root@hll	kali: /home/ha	cker/censys			• =	. • ×
File	Edit Viev	v Terminal	Tabs	Help						
<pre>proot@hlkali /home/hacker/censys (master) \$./censys_io.py 22.ssh.v2.metadata.product:"OpenSSH" AND metadata.os:"Debian" AND location.continent:"Europe" Number of results: 0 proot@hlkali /home/hacker/censys (master) \$ </pre>										

Figure 22. Output of a search for special servers with the CENSYS-API client

Rate limits

The rate limits can be viewed in the account settings. Here is an example for rate limits of a CENSYS account (Fig. 23):

Rate Limits

Below are the rate limits associated with your account.

 web
 0.2 actions/second (60.0 per 5 minute interval)

 api
 0.4 actions/second (120.0 per 5 minute interval)

Figure 23. Rate limits

Summary

In today's dynamic IT environment, many organizations struggle to find every system and application at risk before the attackers do [9]. CENSYS empowers defenders with the automated visibility they need to truly understand and to get ahead of these risks, enabling even small security teams to have an outsized impact. For this reason, it is important to have trained operators who have the necessary expertise and can use this tool effectively and profitably.

The course created in this work gives participants a comprehensive overview of the topic of Open Source Intelligence. It allows them to work independently with the newly taught tools, collect data from freely available sources, and aggregate it into investigation results. For this purpose, the tasks were designed for several laboratory exercises.

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Author Biography

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