From WHOIS to WHOWAS: A Large-Scale Measurement Study of Domain Registration Privacy Under the GDPR

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TSINGHUA UNIVERSITY 1911

UCI University of California, Irvine

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Netlab 360.com

UT DALLAS The University of Texas at Dallas

FUDAN UNIVERSITY 1905

General Data Protection Regulation

A high-level framework about protecting personal data

Personal data: information of identifying/identifiable natural person

Protects personal data *processing* (storage, disclosure, ...)

Expanded territorial scope

Applies to processing of personal data of subjects in the EU

Regardless of where the processing takes place

Profound impact on Internet applications

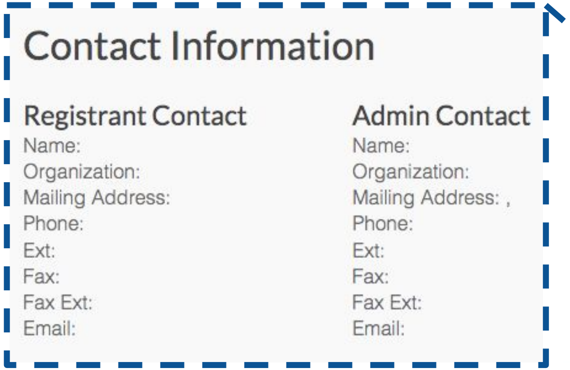
Website cookies, online ads, privacy notices, ...

Domain Registration (WHOIS) Data

Personal data of domain holders are *collected*

Names, addresses, phone numbers and emails

Stored by registrars and registries (WHOIS *providers*)



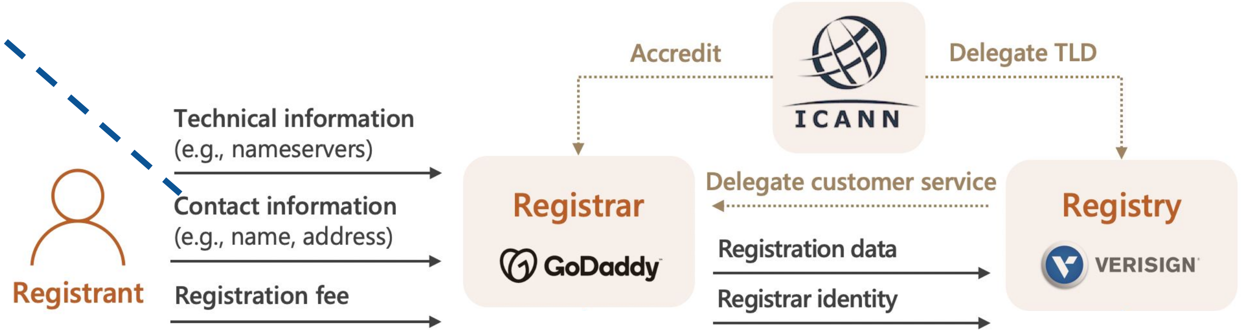
Contact Information

Registrant Contact

Name:
Organization:
Mailing Address:
Phone:
Ext:
Fax:
Fax Ext:
Email:

Admin Contact

Name:
Organization:
Mailing Address: ,
Phone:
Ext:
Fax:
Fax Ext:
Email:



Domain Registration (WHOIS) Data

Personal data of domain holders are *collected*

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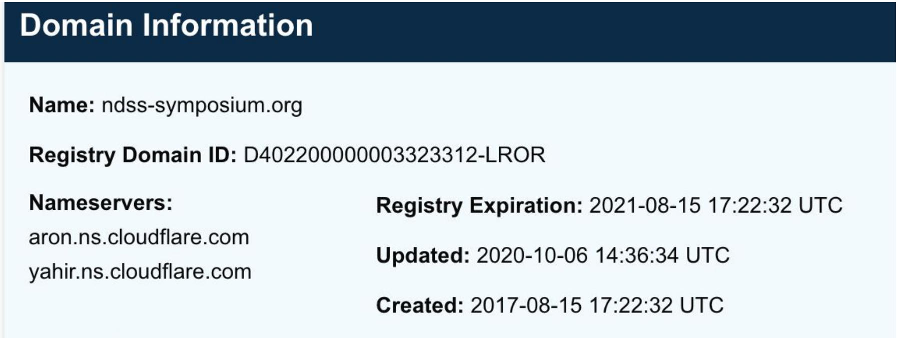
- Stored by registrars and registries (WHOIS *providers*)

Personal data of domain holders are *published*

- Free query-based access via *WHOIS protocol*



Domain Information

Name: ndss-symposium.org

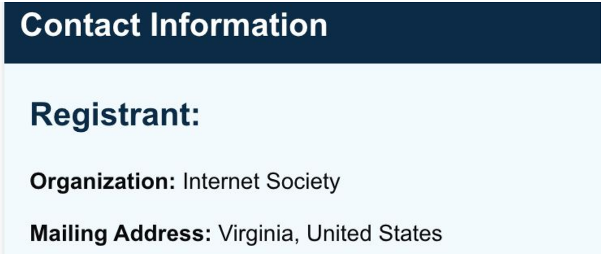
Registry Domain ID: D402200000003323312-LROR

Nameservers:
aron.ns.cloudflare.com
yahir.ns.cloudflare.com

Registry Expiration: 2021-08-15 17:22:32 UTC

Updated: 2020-10-06 14:36:34 UTC

Created: 2017-08-15 17:22:32 UTC



Contact Information

Registrant:

Organization: Internet Society

Mailing Address: Virginia, United States

(Domain registration data of **ndss-symposium.org** acquired from lookup.icann.org on Jan 31, 2021)

Domain Registration (WHOIS) Data

Personal data of domain holders are *collected*

- Names, addresses, phone numbers and emails
- Stored by registrars and registries (WHOIS *providers*)

Personal data of domain holders are *published*

- Free query-based access via *WHOIS protocol*

Heavily relied on by security applications

- Domain reputation, spam detection, vulnerability notification...

When WHOIS Meets GDPR

“*WHOIS*” becomes “*WHOWAS*”

Releasing personal data in WHOIS shall be consented

When WHOIS Meets GDPR

“WHOIS” becomes *“WHOWAS”*

Releasing personal data in WHOIS shall be consented

Guidelines published by ICANN on May 17, 2018

“Temporary Specification for gTLD Registration Data”* (TempSpec)

Applies to all gTLD registries and registrars

* https://www.icann.org/en/system/files/files/gtld-registration-data-temp-spec-17may18-en.pdf

When WHOIS Meets GDPR

“*WHOIS*” becomes “*WHOWAS*”

Releasing personal data in WHOIS shall be consented

Guidelines published by ICANN on May 17, 2018

“*Temporary Specification for gTLD Registration Data**” (TempSpec)

Applies to all gTLD registries and registrars

Collection of registration data

Is maintained.

Personal data is still collected at domain registration.

Access to registration data

Is restricted.

Tiered/layered access under legitimate purposes.

* https://www.icann.org/en/system/files/files/gtld-registration-data-temp-spec-17may18-en.pdf

When WHOIS Meets GDPR

WHOIS publishing requirements of ICANN TempSpec

Replacing personal data with *redacted/anonymized* values

Providers decide the scope of data to be protected.

Registration Data Fields	Data Subjects	Data Publishing Requirements
Name, Street, City, Postal Code, Phone, Fax	Registrant, Admin, Tech	1) Provide a **redacted value** (“*substantially similar*” to “redacted for privacy”), or 2) Provide an **empty value**, or do not provide the fields
Organization, State/Province, Country	Admin, Tech	
Email Address	Registrant, Admin, Tech	Provide an **anonymized email address** or **web form** enabling communication with data subject

* https://www.icann.org/en/system/files/files/gtld-registration-data-temp-spec-17may18-en.pdf

Research Questions

Data Publishing Changes of WHOIS Providers

Are providers compliant to the TempSpec?

How do they redact WHOIS data?

Are there any compliance flaws?

What is the scope of protected domains?

Security Impact of WHOIS Data Loss

How many security works rely on WHOIS?

Do they use redacted WHOIS data?

What are the security systems used for?

How to remediate the loss of WHOIS?

Part I-A:

Data Publishing Changes of WHOIS Providers (Methodology)

Methodology: Overview

Data-driven measurement study

Latitudinal view: covering a wide range of WHOIS providers

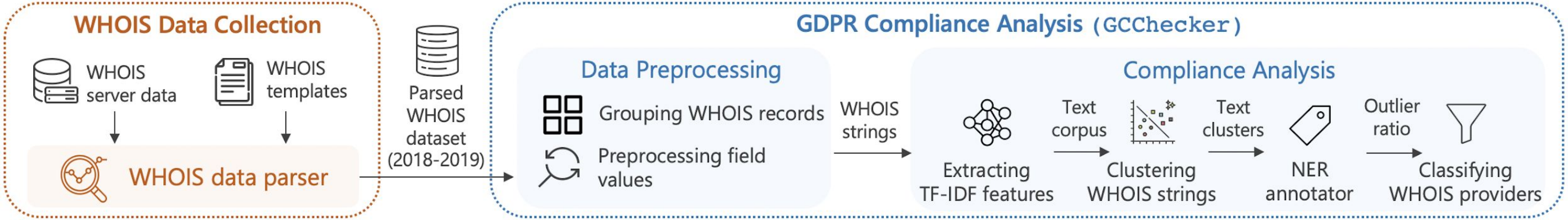
Longitudinal view: covering dates before/after GDPR went effective

A. WHOIS data collection

2-year parsed WHOIS data

B. Compliance Analysis (*GCChecker*)

Identify protected/redacted records and give compliance rankings



Methodology: WHOIS Data Collection

Challenge: WHOIS ecosystem is fragmented

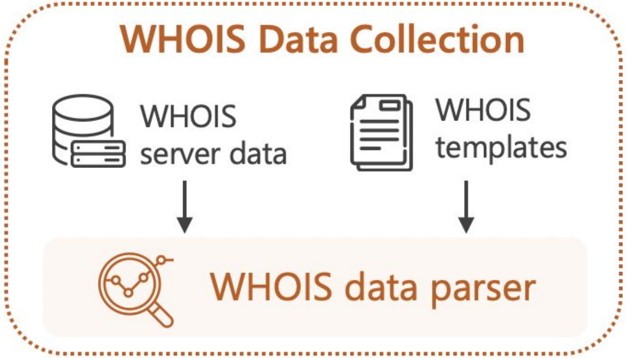
Hundreds of providers maintain WHOIS servers

Format of WHOIS data is *inconsistent*

Solution: parsed historical WHOIS dataset from industrial partner

Collects WHOIS of domains observed in its passive DNS

Parsed by *manually-generated templates*



Methodology: WHOIS Data Collection

Overview of WHOIS dataset (Jan 2018 ~ Dec 2019)

12% EEA domains; 13% domains older than 10 years

Collected from port 43 of WHOIS servers (not from web WHOIS tools)

Year	Count of				Creation Date		Registrant Region	
	Record	Domain	Region	TLD	~ ’09	’10 ~ ’19	EEA	Non-EEA
2018	659M	211M	218	758	15.7%	84.3%	12.9%	87.1%
2019	583M	215M	218	754	14.5%	85.5%	12.4%	87.6%
All	**1.24B**	**267M**	**219**	**783**	**13.4%**	**86.6%**	**12.2%**	**87.8%**

Methodology: Compliance Analysis

Challenge: different wording/language for redaction

TempSpec do not enforce the use of *“redacted for privacy”*

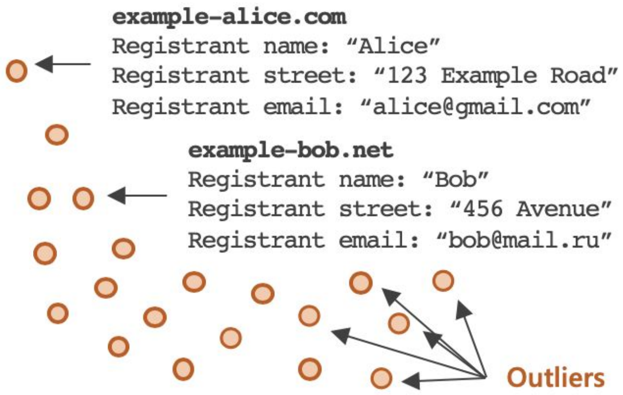
Methodology: Compliance Analysis

Challenge: different wording/language for redaction

TempSpec do not enforce the use of *“redacted for privacy”*

Solution: unsupervised clustering of WHOIS record groups

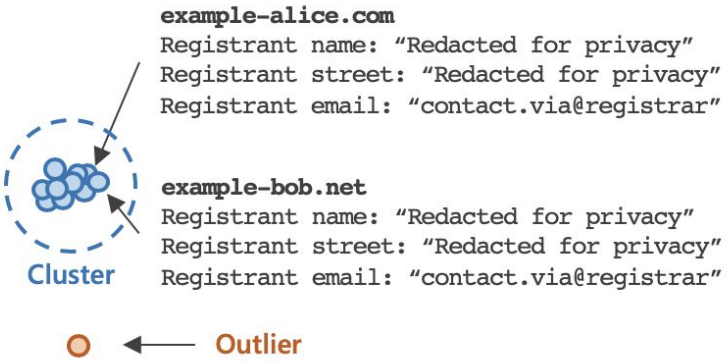
Replace records at scale → High textual similarity → Clusters → Few *Outliers*



```
example-alice.com
Registrant name: “Alice”
Registrant street: “123 Example Road”
Registrant email: “alice@gmail.com”
```

```
example-bob.net
Registrant name: “Bob”
Registrant street: “456 Avenue”
Registrant email: “bob@mail.ru”
```

Not compliant, %outlier is high



```
example-alice.com
Registrant name: “Redacted for privacy”
Registrant street: “Redacted for privacy”
Registrant email: “contact.via@registrar”
```

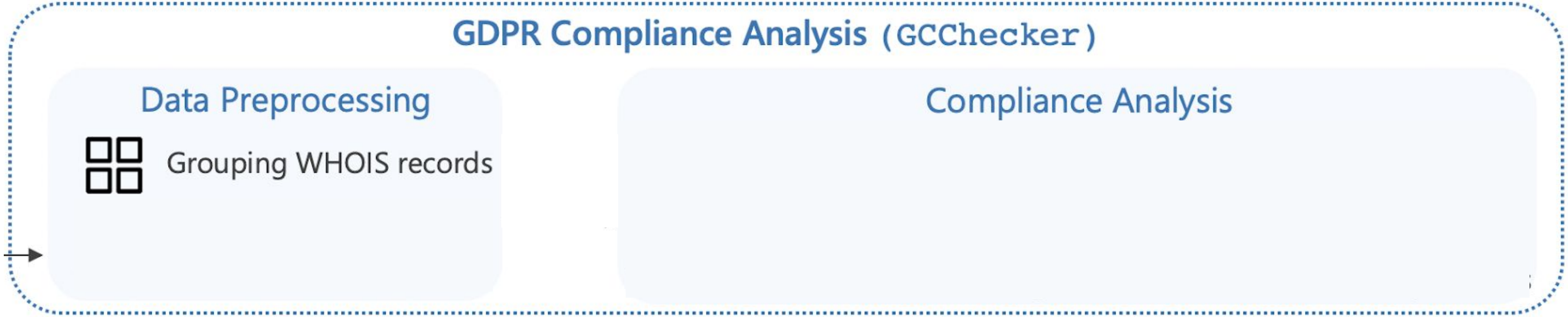
```
example-bob.net
Registrant name: “Redacted for privacy”
Registrant street: “Redacted for privacy”
Registrant email: “contact.via@registrar”
```

Compliant, %outlier is low

Methodology: Compliance Analysis

Design of *GCChecker*

Grouping WHOIS records: *(provider, registrant_region, data_subject, week)*



Methodology: Compliance Analysis

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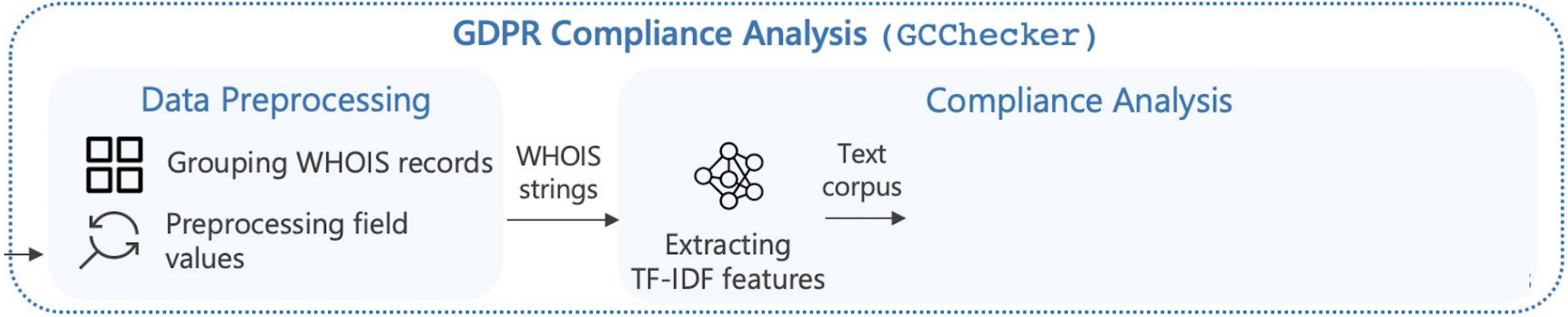
Preprocessing: normalize values, extract *TF-IDF features*


GDPR Compliance Analysis (GCChecker)
Data Preprocessing
Grouping WHOIS records
Preprocessing field values
WHOIS strings
Compliance Analysis
Extracting TF-IDF features
Text corpus

Methodology: Compliance Analysis

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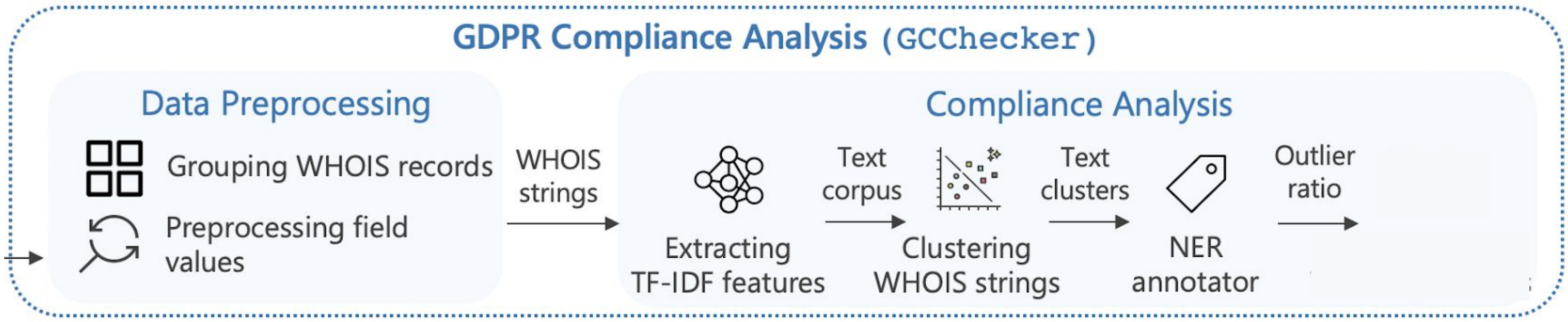
Clustering: DBSCAN finds *outliers*, NER refines clusters



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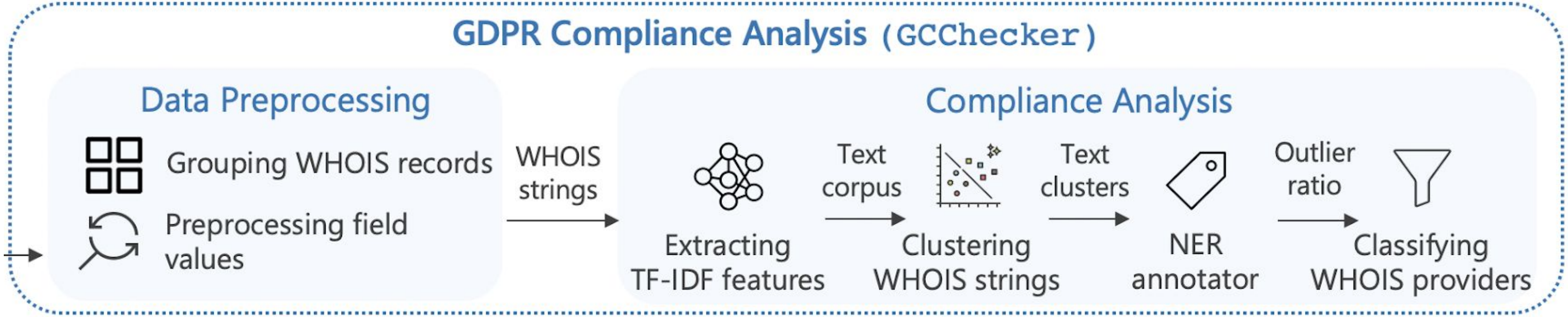
Provider classification: rank from on weekly outlier ratios



Part I-B:

Data Publishing Changes of WHOIS Providers (Results of 143 large providers)

Scale of WHOIS Data Redaction

Over 85% large WHOIS providers are fully-compliant

Large: as of *EEA WHOIS records* collected

Registrars: 73 / 89 (total domain share > 54%)

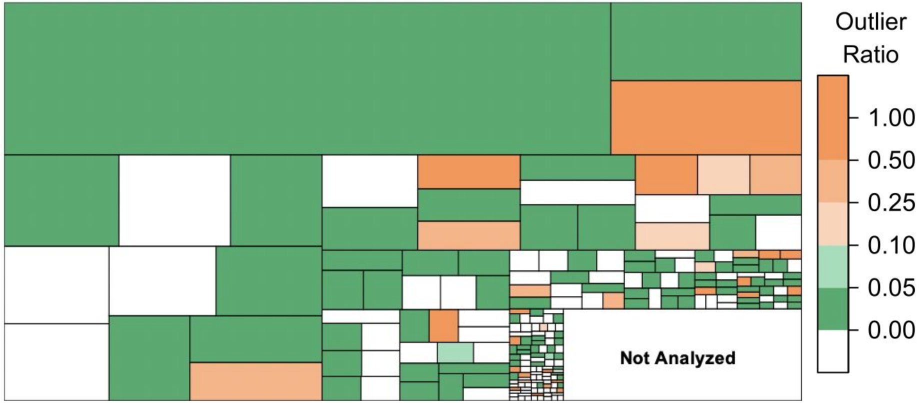
Registries: 51 / 54

Flawed implementations

Missing protection of addresses

Only protecting email addresses

Others...



WHOIS compliance of EEA records from registrars (corresponding with their domain share)

Timeline of WHOIS Data Redaction

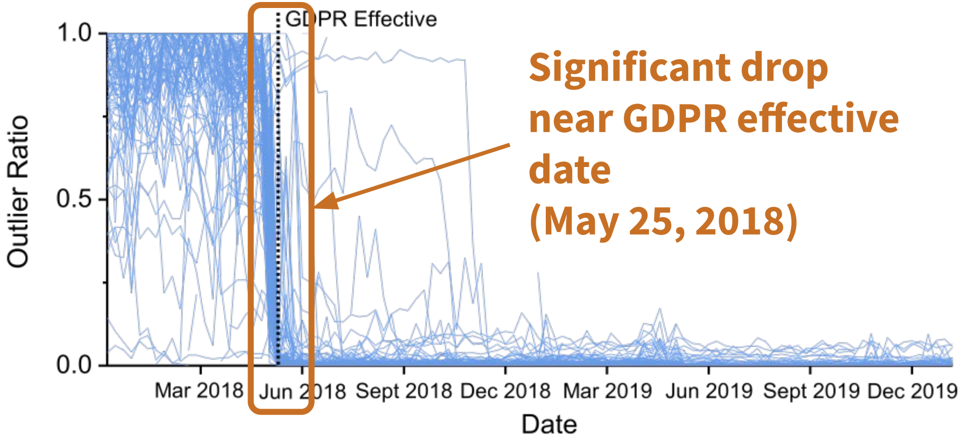
Over 80% fully-compliant providers completed in time

100 / 124 completed before May 25, 2018

Prominent efforts were taken *after* TempSpec (May 17)

Providers lack specific guidelines, thus chose to wait

Only *1 week* left for providers to take actions



Significant drop near GDPR effective date (May 25, 2018)

Measures of WHOIS Data Redaction

Contact masking measures

TempSpec: Use redacted value / empty value / privacy protection services

Category	# Provider	Example provider and values
Redacted value	**58**	ID-69 Tucows Domains Inc. (*“Redacted for privacy”*)
		ID-2 Network Solutions, LLC (*“statutory masking enabled”*)
		ID-625 Name.com, Inc. (*“non-public data”*)
		ID-1505 Gransy, s.r.o. (*“not disclosed”*)
Empty value	**63**	ID-146 GoDaddy.com, LLC; Public Internet Registry (PIR)
Privacy protection	**13**	ID-1456 NetArt Registrar Sp. z o.o. (*whoisdataprotection.com*)

Measures of WHOIS Data Redaction

Email anonymization measures

TempSpec: Use web form / anonymized email that _facilitate communication_

Over 25% fully-compliant registrars _do not_ offer such channel

Facilitates Communication	# Registrar	Interface	Example
Yes	**42 (72%)**	Web form	(_https://www.godaddy.com/whois/results.aspx_)
		Email	(_f***************7@proxyregistrant.email_)
No	**21 (28%)**	Web	(_https://tieredaccess.com_)
		Email	(_abuse@web.com_)

Scope of WHOIS Data Redaction

TempSpec lets providers decide what data to protect

Apply to EEA domains only / Apply in a global basis

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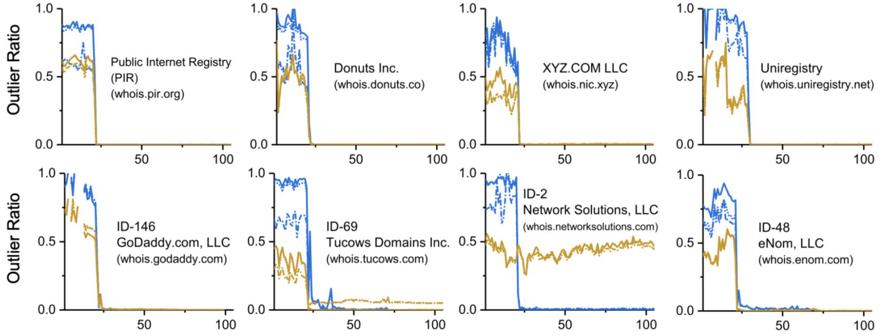
Apply to EEA domains only / Apply in a global basis

Most providers sanitize *all* WHOIS data → Bad news for researchers

At least 60% fully-compliant providers apply globally

Causing a <u>*global, escalated loss*</u> of WHOIS



Comparison of outlier ratio of EEA and non-EEA records

Scope of WHOIS Data Redaction

TempSpec lets providers decide what data to protect

Apply to EEA domains only / Apply in a global basis

Most providers sanitize *all* WHOIS data → Bad news for researchers

At least 60% fully-compliant providers apply globally

Causing a *global, escalated loss* of WHOIS

Reasons?

1 week time is short for complete plans

Hard to determine what data is under scope

Saves work to comply with future policies (e.g., CCPA)

Part II:

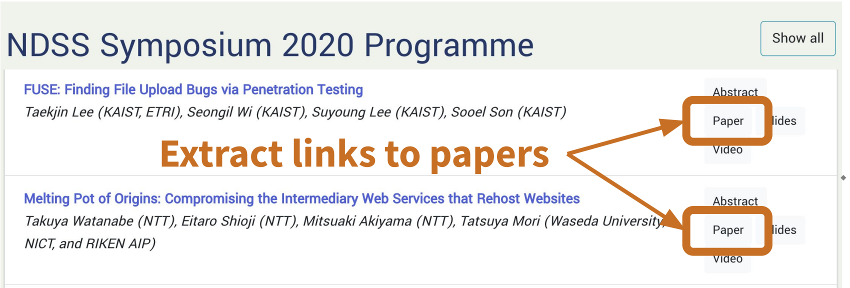
Security Impact of WHOIS Data Loss

WHOIS in Security Literature

Security papers published in 15 years of 5 conferences

NDSS, USENIX Security, IEEE S&P, ACM CCS, ACM IMC (2005 ~ 2020)

Download all via custom crawler



NDSS Symposium 2020 Programme

FUSE: Finding File Upload Bugs via Penetration Testing

Taekjin Lee (KAIST, ETRI), Seongil Wi (KAIST), Suyoung Lee (KAIST), Sooel Son (KAIST)

Melting Pot of Origins: Compromising the Intermediary Web Services that Rehost Websites

Takuya Watanabe (NTT), Eitaro Shioji (NTT), Mitsuaki Akiyama (NTT), Tatsuya Mori (Waseda University, NICT, and RIKEN AIP)

Extract links to papers

https://www.ndss-symposium.org/ndss-program/2020-program/

Paper database (4,304 paper PDFs)

Search keywords

(e.g., WHOIS, Domain)

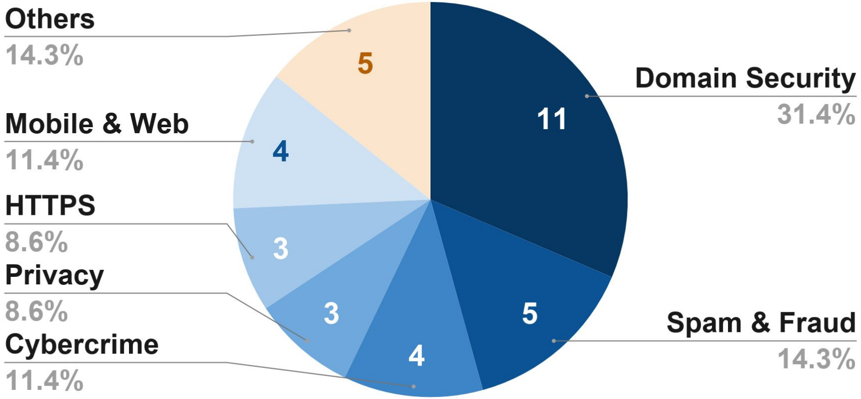
Manual confirmation

51 papers using WHOIS data

WHOIS in Security Literature

69% works that use WHOIS rely on redacted data

31 papers covering a wide range of security topics



Classified by security topics

WHOIS Usage	Paper examples
Infer domain ownership / measurement purposes	Halvorson15, Vissers15, Chen16, Liu17
Features for detection	Sivakorn19, Le Pochat20
Vulnerability notification	Stock16, Stock18, Roth20
Result validation	Paxson13, Van Ede20, Delignat-Lavaud14,

WHOIS in Security Literature

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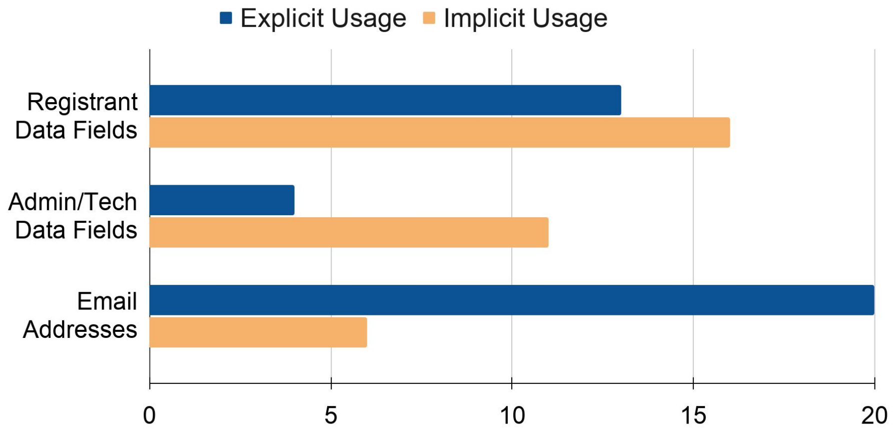
31 papers covering a wide range of security topics

Registrant contact and *email addresses* are frequently used



Classified by WHOIS fields

Registrant contact: 29 papers (83%)

Admin/Tech contact: 15 papers (43%)

Email addresses: 26 papers (74%)

WHOIS in Security Literature

Hurdles for security researchers to access WHOIS

Over 70% WHOIS requests from security researchers are rejected*

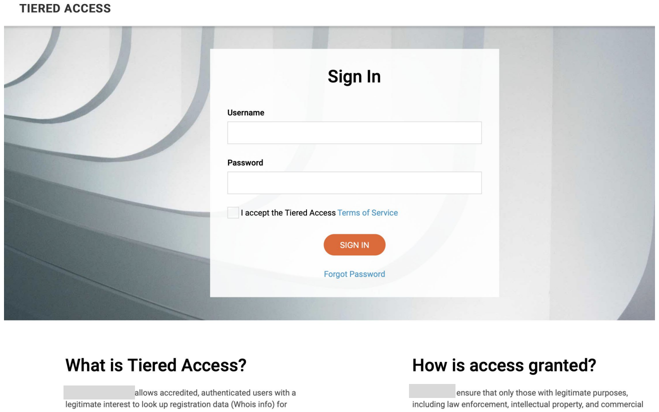
Current tiered systems lack instructions

Remediation: a better format of tiered access / data redaction

Use RDAP protocol to control access

Use Fuzzy hashing to replace fixed values

Review and adjust current security systems



TIERED ACCESS

Sign In

Username

Password

□ I accept the Tiered Access Terms of Service

SIGN IN

Forgot Password

What is Tiered Access?

[redacted] allows accredited, authenticated users with a legitimate interest to look up registration data (Whois info) for

How is access granted?

[redacted] ensure that only those with legitimate purposes, including law enforcement, intellectual property, and commercial

(Tiered access system of a registrar)

* https://docs.apwg.org/reports/ICANN_GDPR_WHOIS_Users_Survey_20181018.pdf

Part III:

Discussion & Summary

Discussion

GDPR’s impact on WHOIS is substantial

Most WHOIS providers *actively* and *extensively* redact personal data

A number of security works are affected due to WHOIS loss

Discussion

GDPR’s impact on WHOIS is substantial

Most WHOIS providers *actively* and *extensively* redact personal data

A number of security works are affected due to WHOIS loss

Lessons learnt: Enforcing privacy policies is still a complex task

TempSpec leaves flexibility for providers, but not enough time

Checking tools are helpful to identify implementation flaws

The task requires more efficient collaboration across communities

Recommendations

Recommendations to multiple stakeholders

Party	Recommendation
Tech and legal authorities	Allow more lead time for more efficient discussions
Internet Supervisors (e.g. ICANN)	Develop more specific guidelines to avoid confusion
WHOIS providers	Review data protection implementations
Security researchers	Review and adjust security systems that rely on WHOIS

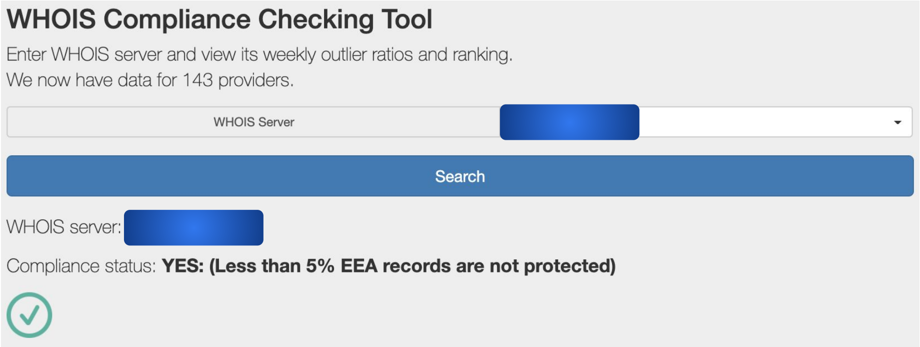
Compliance Checking Tool

Help providers check WHOIS compliance status

Location: https://whoisgdprcompliance.info/

Provide compliance rank, outlier ratios and domain samples *at request*

Data and rankings *updated to Dec 2020* for most providers



WHOIS Compliance Checking Tool

Enter WHOIS server and view its weekly outlier ratios and ranking.
We now have data for 143 providers.

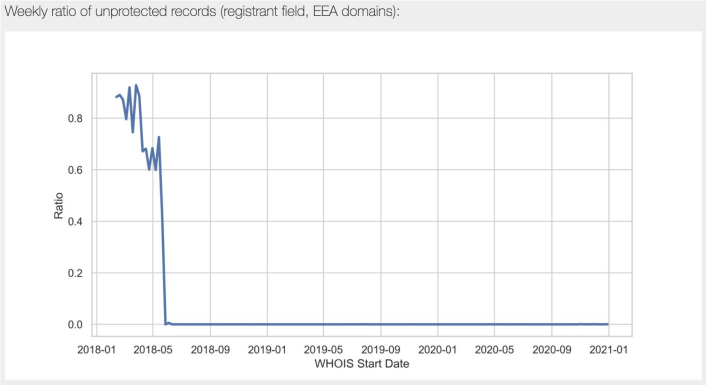
WHOIS Server [redacted]

Search

WHOIS server: [redacted]

Compliance status: **YES: (Less than 5% EEA records are not protected)**

✓



Weekly ratio of unprotected records (registrant field, EEA domains):

Summary

GDPR’s impact is profound on WHOIS

Large WHOIS providers *actively* and *extensively* redact WHOIS data

Implementation flaws need to be fixed

The *excessive data protection scope* causes global WHOIS loss

A wide range of security works need review or adjustment

Redacted WHOIS data is widely used by security literature

Lessons learnt

Multiple stakeholders need more efficient collaboration

Release compliance checking tool

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Ying Liu, Joann Qiongna Chen, Jinjin Liang, Zaifeng Zhang, Shuang Hao and Min Yang

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