From WHOIS to WHOWAS:

# A Large-Scale Measurement Study of Domain Registration Privacy Under the GDPR

**Chaoyi Lu**, Baojun Liu, Yiming Zhang, Zhou Li, Fenglu Zhang, Haixin Duan,
Ying Liu, Joann Qiongna Chen, Jinjin Liang, Zaifeng Zhang, Shuang Hao and Min Yang

TSINGHUA UNIVERSITY 1911

UCI University of California, Irvine

奇安信 QI-ANXIN

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

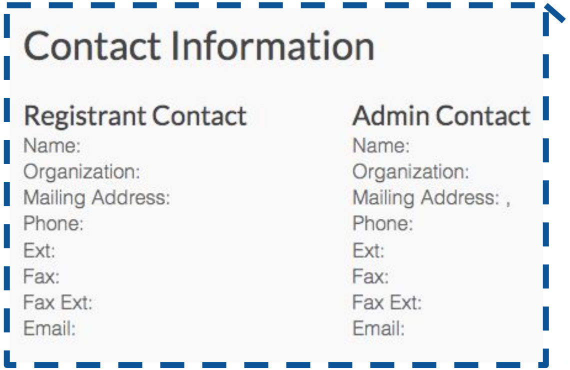
## Profound impact on Internet applications

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

# Domain Registration (WHOIS) Data

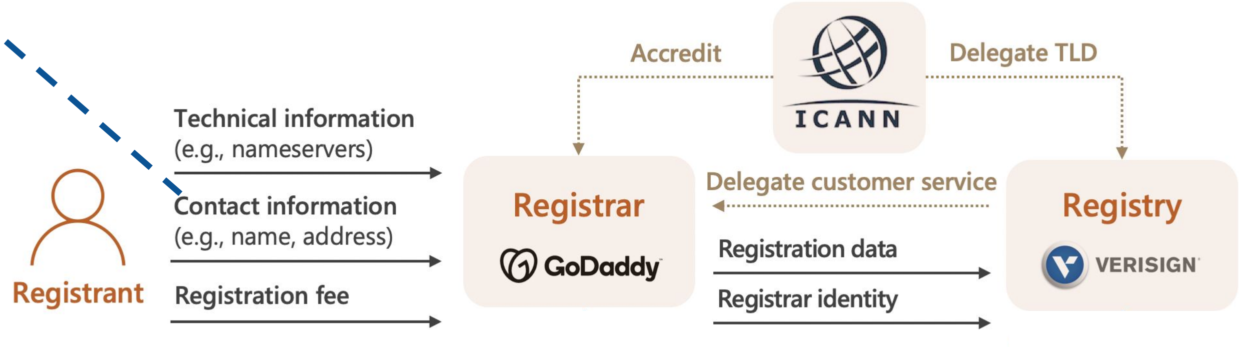
## Personal data of domain holders are *collected*

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



Contact Information

| Registrant Contact | Admin Contact |
|---|---|
| Name: | Name: |
| Organization: | Organization: |
| Mailing Address: | Mailing Address: , |
| Phone: | Phone: |
| Ext: | Ext: |
| Fax: | Fax: |
| Fax Ext: | Fax Ext: |
| Email: | Email: |



Registrant

Technical information (e.g., nameservers)

Contact information (e.g., name, address)

Registration fee

Registrar

GoDaddy

ICANN

Accredit

Delegate TLD

Delegate customer service

Registration data

Registrar identity

Registry

VERISIGN

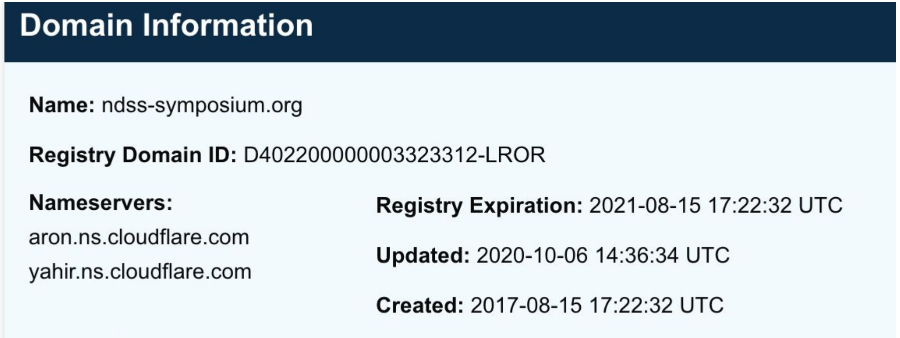
# Domain Registration (WHOIS) Data

## 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*



**Domain Information**

**Name:** ndss-symposium.org

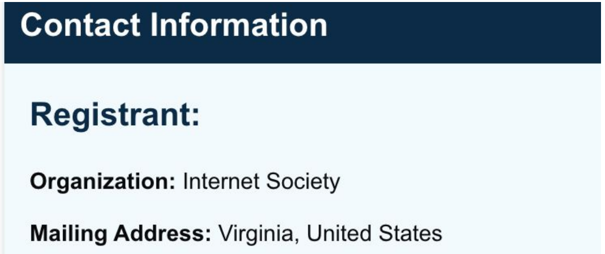
**Registry Domain ID:** D402200000003323312-LROR

**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<br>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

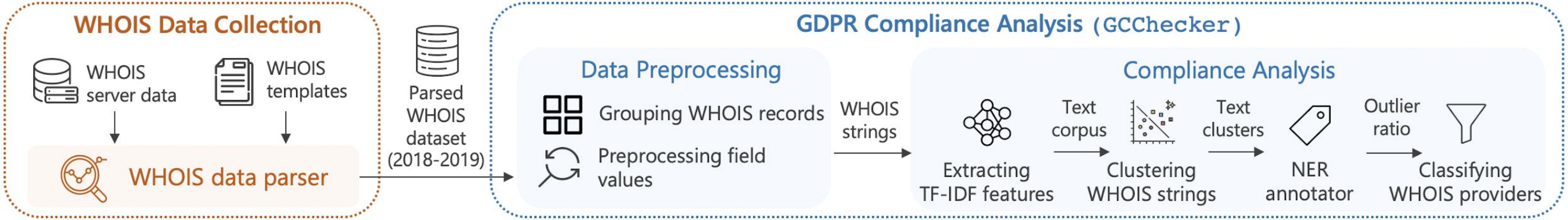
*Longitudinal view*: covering dates before/after GDPR went effective

### 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

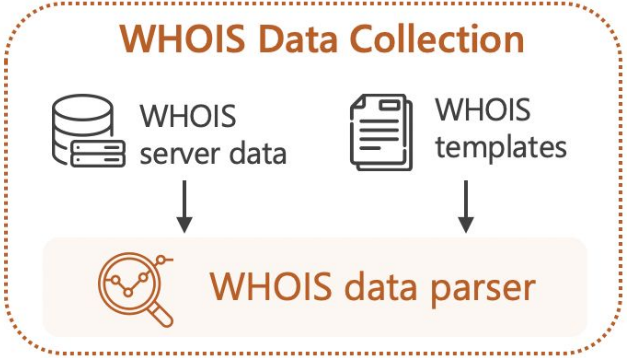
Hundreds of providers maintain WHOIS servers

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”*

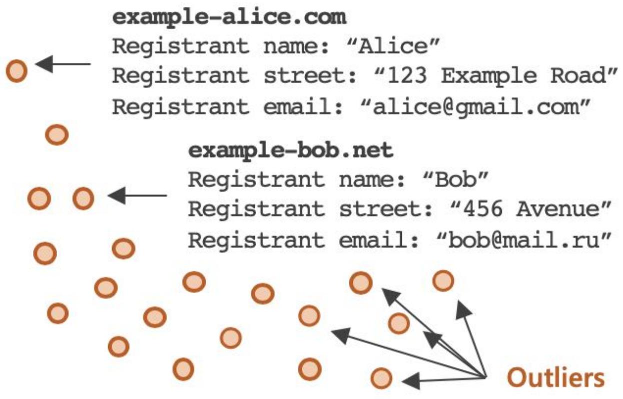
# Methodology: Compliance Analysis

## Challenge: different wording/language for redaction

TempSpec do not enforce the use of *"redacted for privacy"*

## Solution: unsupervised clustering of WHOIS record groups

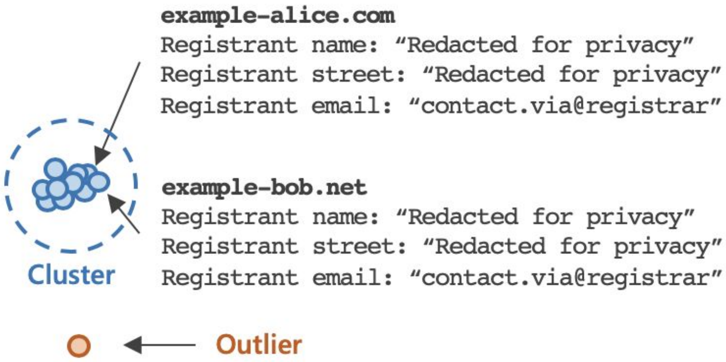
Replace records at scale → High textual similarity → Clusters → Few *Outliers*



```
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"
```

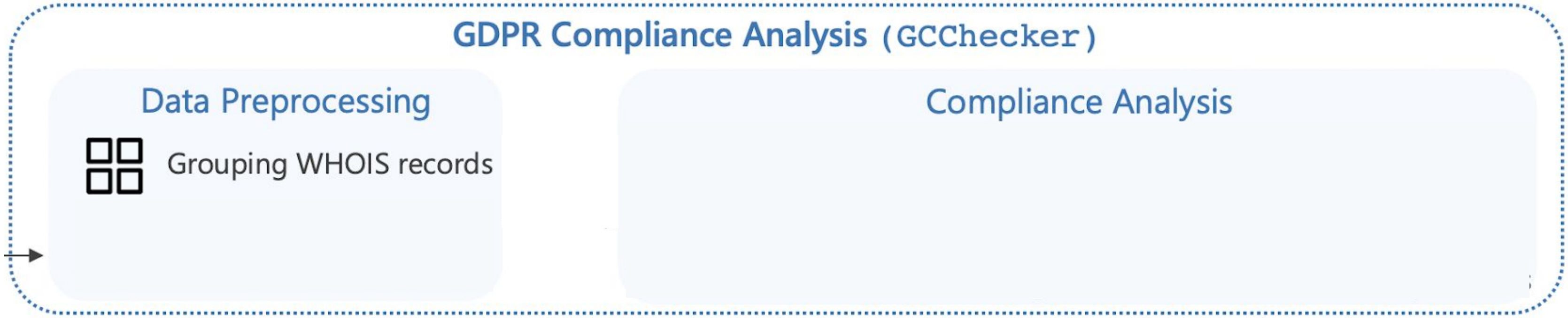
```
example-bob.net
Registrant name: "Redacted for privacy"
Registrant street: "Redacted for privacy"
Registrant email: "contact.via@registrar"
```

Compliant, %outlier is low

# Methodology: Compliance Analysis

## Design of *GCChecker*

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



GDPR Compliance Analysis (GCChecker)

Data Preprocessing

Grouping WHOIS records

Compliance Analysis

# Methodology: Compliance Analysis

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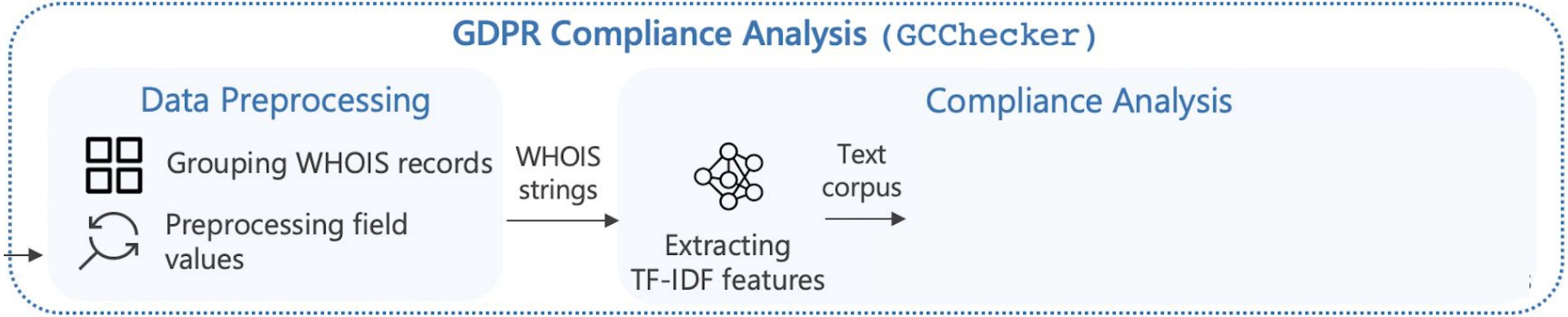
**Preprocessing**: normalize values, extract *TF-IDF features*


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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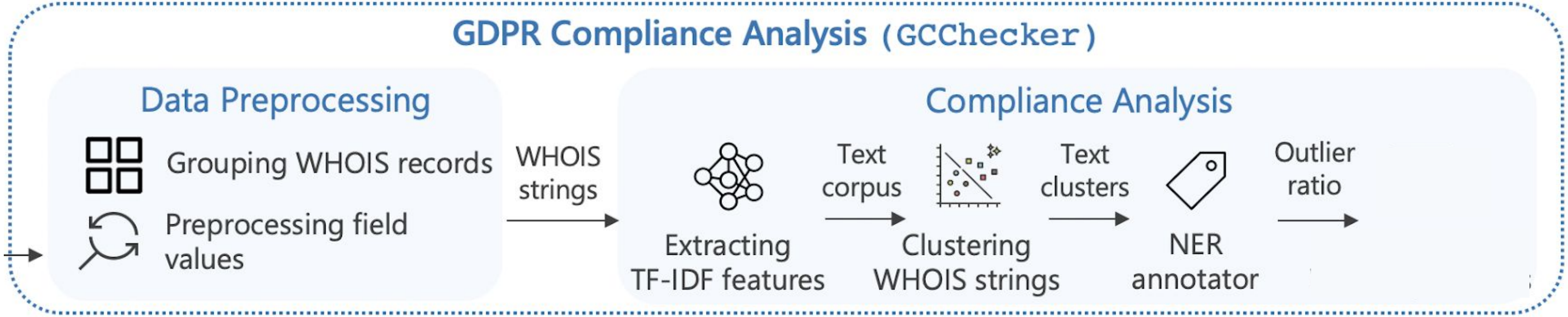
**Clustering**: DBSCAN finds *outliers*, NER refines clusters



# Methodology: Compliance Analysis

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

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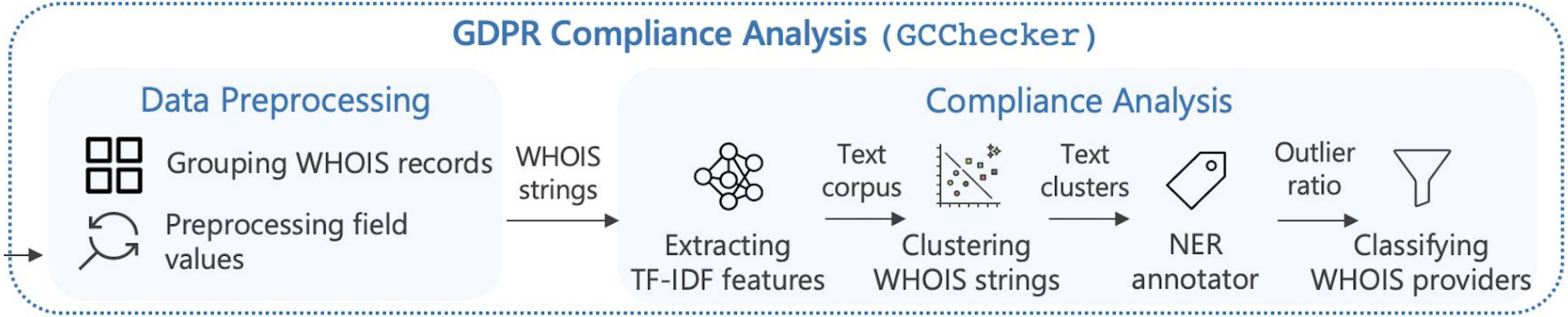
**Provider classification**: rank from on weekly outlier ratios



# 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%)

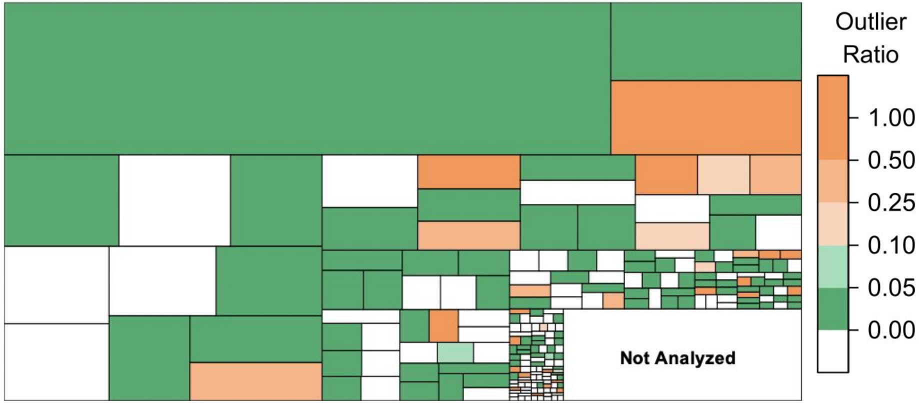
**Registries: 51 / 54**

## 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

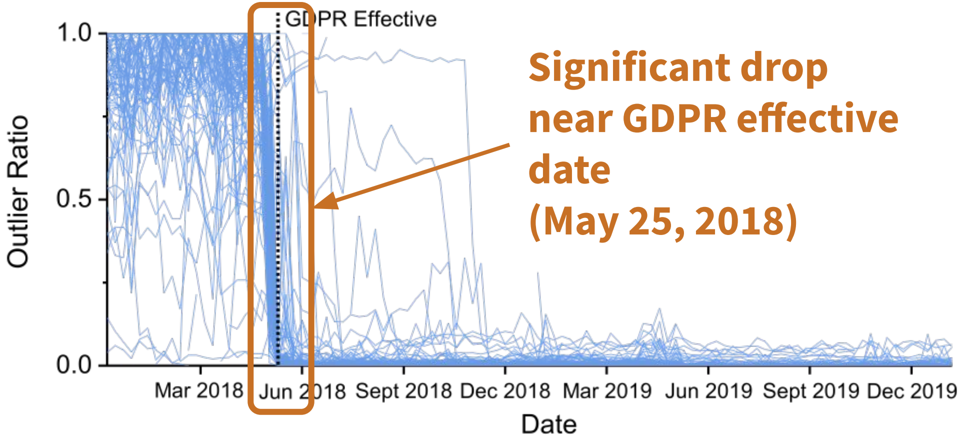
## Over 80% fully-compliant providers completed in time

100 / 124 completed before May 25, 2018

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

Providers lack specific guidelines, thus chose to wait

Only *<u>1 week</u>* 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

# Scope of WHOIS Data Redaction

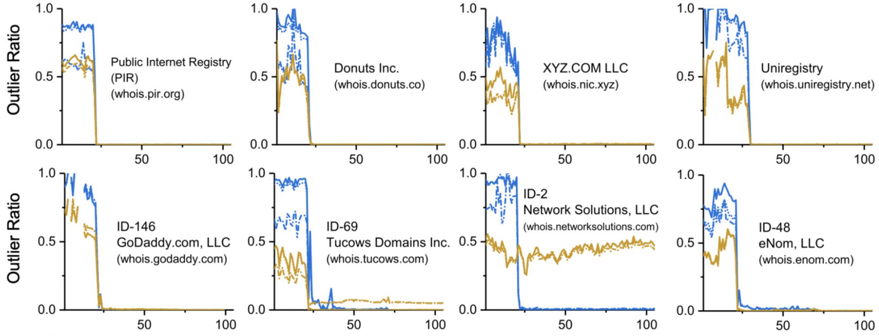
## TempSpec lets providers decide what data to protect

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 <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:

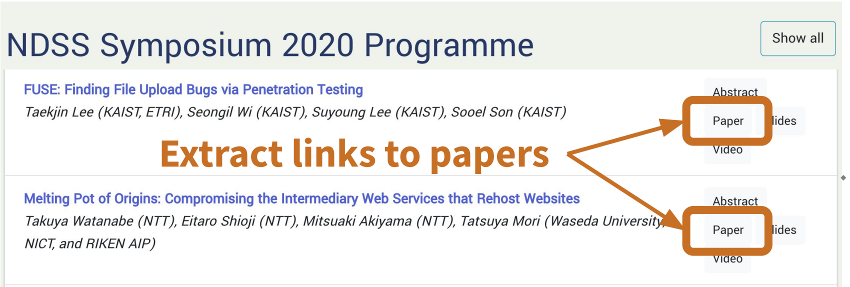
## Security Impact of WHOIS Data Loss

# 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)

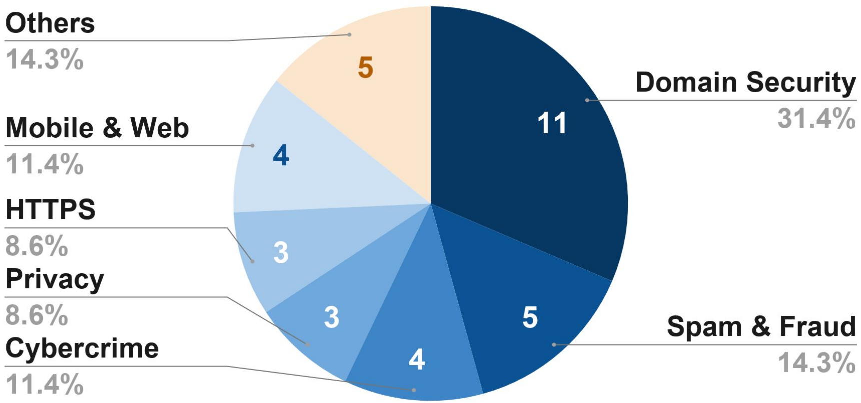
**Manual confirmation**

**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

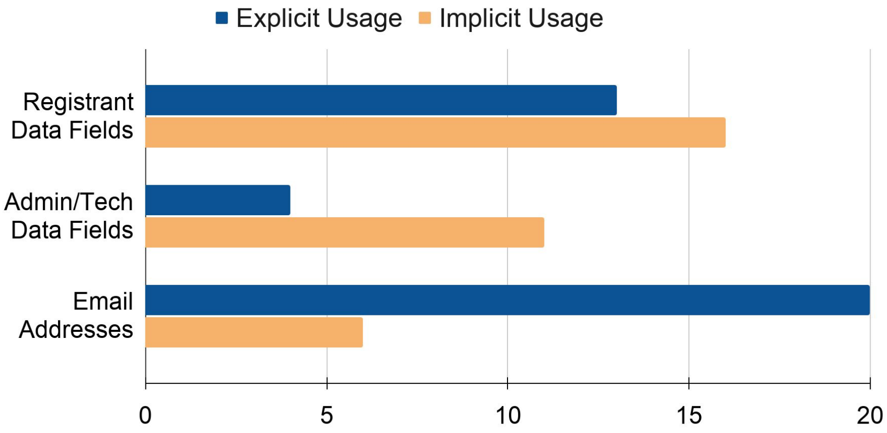
| WHOIS Usage | Paper examples |
|---|---|
| **Infer domain ownership / measurement purposes** | Halvorson15, Vissers15, Chen16, Liu17 |
| **Features for detection** | Sivakorn19, Le Pochat20 |
| **Vulnerability notification** | Stock16, Stock18, Roth20 |
| **Result validation** | Paxson13, Van Ede20,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

# WHOIS in Security Literature

## 69% works that use WHOIS rely on redacted data

31 papers covering a wide range of security topics

*Registrant contact* and *email addresses* are frequently used



**Registrant contact: 29 papers (83%)**

**Admin/Tech contact: 15 papers (43%)**

**Email addresses: 26 papers (74%)**

Classified by WHOIS fields

# WHOIS in Security Literature

## Hurdles for security researchers to access WHOIS

Over 70% WHOIS requests from security researchers are rejected*

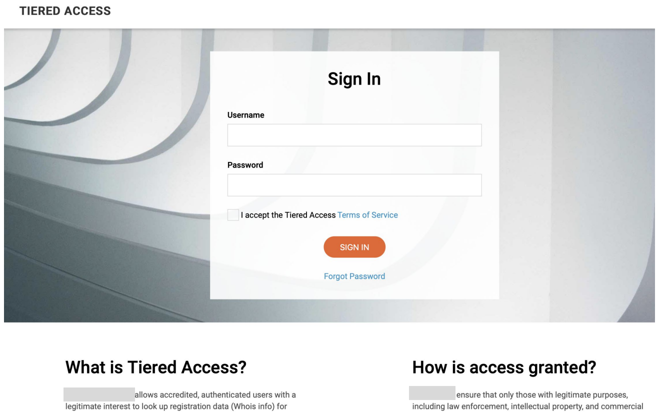
Current tiered systems lack instructions

## 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 |

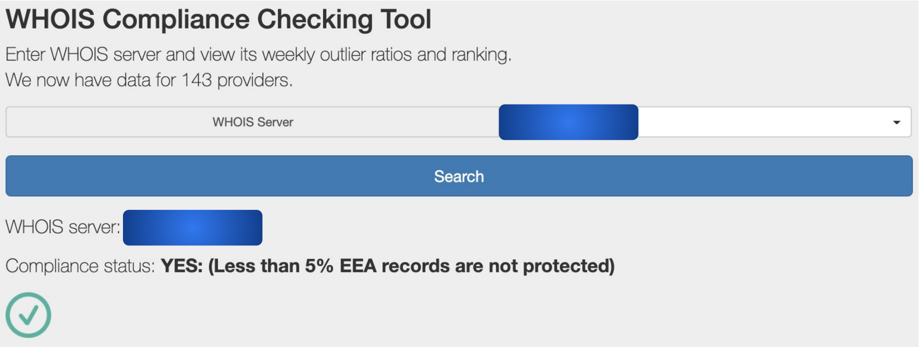
# Compliance Checking Tool

## 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

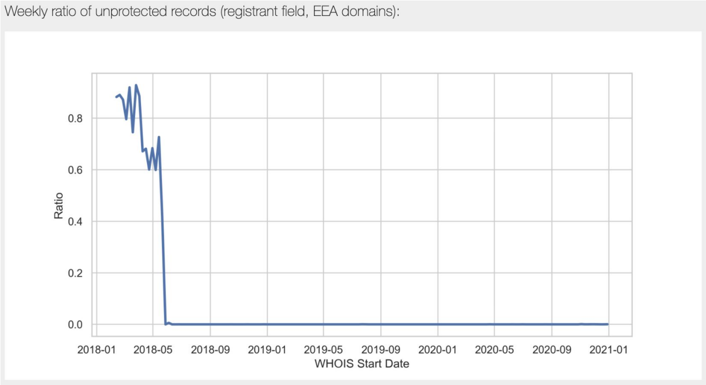
Enter WHOIS server and view its weekly outlier ratios and ranking.
We now have data for 143 providers.

WHOIS Server [redacted]

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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Netlab 360.com

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# Methodology: WHOIS Data Collection

## Challenge: WHOIS ecosystem is fragmented

Hundreds of providers maintain WHOIS servers

Format of WHOIS data is *inconsistent*

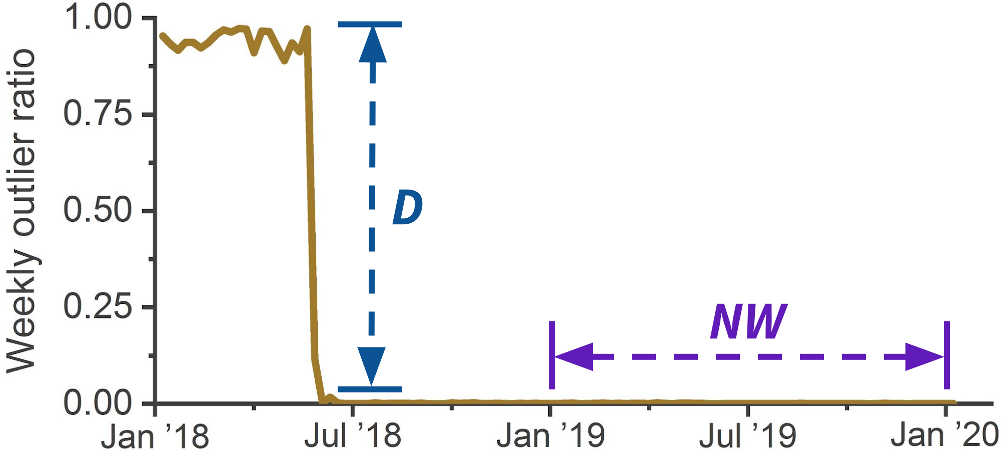
# Methodology: Compliance Analysis

## Provider classification using thresholds

Thresholds chosen from empirical study of 50 large providers

*NW*: number of weeks that outlier ratio stays low (< 0.05)

*D*: Drop of average weekly outlier ratio before/after the GDPR effective date



Weekly outlier ratio of (EEA domains, registrant info) of Network Solutions, LLC

| Category | % unprotected records |
|---|---|
| Fully compliant | < 5% |
| Partially compliant | 5% ~ 50% |
| Not compliant | > 50% |

# Measures of WHOIS Data Redaction

## Email anonymization measures

TempSpec: Use web form / anonymized email that *facilitate communication*

# WHOIS in Security Literature

## 69% works that use WHOIS rely on redacted data

31 papers covering a wide range of security topics

*Registrant contact* and *email addresses* are frequently used

## Security impact of WHOIS loss can be profound

Security systems may need adjustments

Impact *escalated* due to providers’ expanded data protection scope

Vulnerability notification is still challenging with web forms