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PhishReplicant: A Language Model-based Approach to Detect Generated Squatting Domain Names

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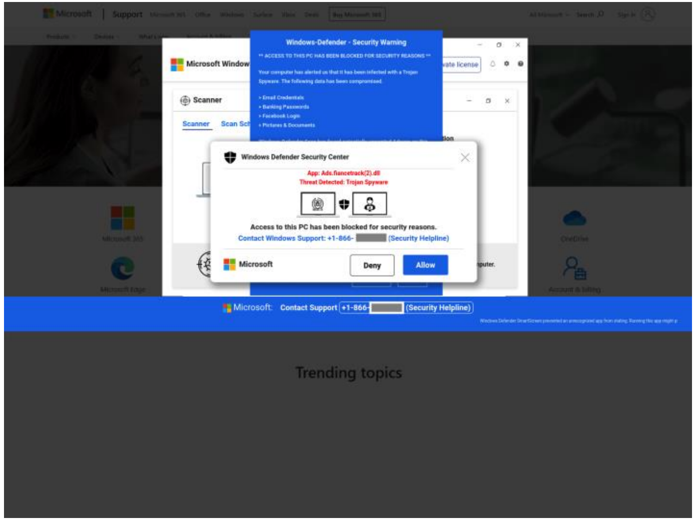
Artifacts Evaluated acm Functional V1.1

Phishing Sites

- Employ social engineering techniques
- Impersonate brands
- **Disguise legitimate domain names**



Windows-Defender - Security Warning

** ACCESS TO THIS PC HAS BEEN BLOCKED FOR SECURITY REASONS **

Your computer has alerted us that it has been infected with a Trojan Spyware. The following data has been compromised.

> Email Credentials
> Banking Passwords
> Facebook Login
> Pictures & Documents

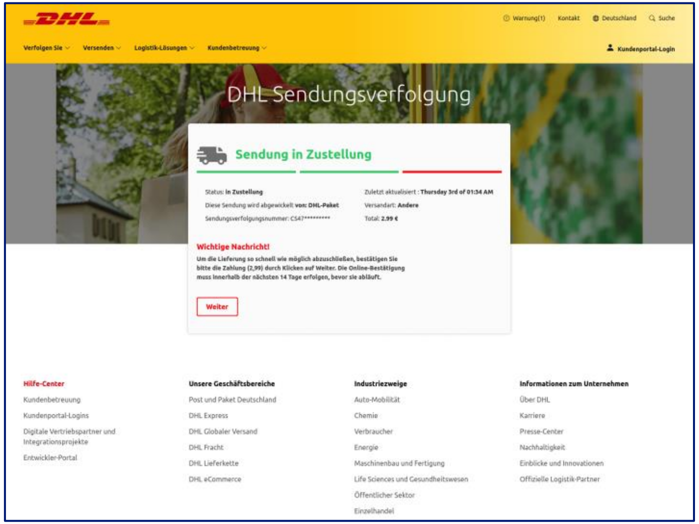
Windows Defender Security Center

App: Ads.fiancetrack(2).dll
Threat Detected: Trojan Spyware

Access to this PC has been blocked for security reasons.

Contact Windows Support: +1-866- [redacted] (Security Helpline)

Microsoft: Contact Support +1-866-[redacted] (Security Helpline)



DHL Sendungsverfolgung

Sendung in Zustellung

Status: **In Zustellung**
Diese Sendung wird abgewickelt **von: DHL-Paket**
Sendungsverfolgungsnummer: CS47**********
Zuletzt aktualisiert : **Thursday 3rd of 01:34 AM**
Versandart: **Andere**
Total: **2.99 €**

Wichtige Nachricht!

Um die Lieferung so schnell wie möglich abzuschließen, bestätigen Sie bitte die Zahlung (2,99) durch Klicken auf Weiter. Die Online-Bestätigung muss innerhalb der nächsten 14 Tage erfolgen, bevor sie abläuft.

Weiter

Hilfe-Center	Unsere Geschäftsbereiche	Industriezweige	Informationen zum Unternehmen
Kundenbetreuung	Post und Paket Deutschland	Auto-Mobilität	Über DHL
Kundenportal-Logins	DHL Express	Chemie	Karriere
Digitale Vertriebspartner und Integrationsprojekte	DHL Globaler Versand	Verbraucher	Presse-Center
Entwickler-Portal	DHL Fracht	Energie	Nachhaltigkeit
	DHL Lieferkette	Maschinenbau und Fertigung	Einblicke und Innovationen
	DHL eCommerce	Life Sciences und Gesundheitswesen	Offizielle Logistik-Partner
		Öffentlicher Sektor	
		Einzelhandel	

Domain Squatting

Typosquatting: Typing errors

e.g., examp**k**e[.]com

Combo-squatting: Including brand names

e.g., example**-login**[.]com

Deceptive subdomain: Using the legitimate domain name in a subdomain

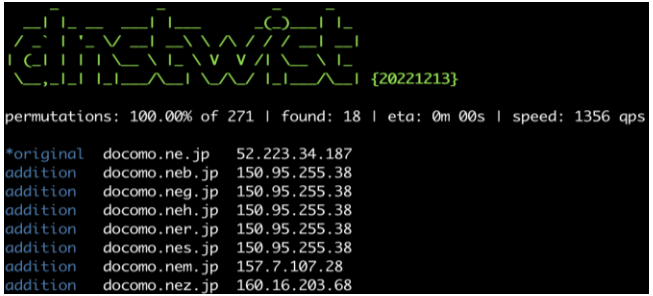
e.g., example.com.**malicious[.]example**

Homograph attack: Replacing characters with similar ones

e.g., exampl**é**[.]com

Mitigating Domain Squatting

1. Generating domain squatting candidates
   - Rule-based systems (e.g. dnstwist)
   - Machine learning-based systems



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     _           _            _     _
  __| |_ __  ___| |___      _(_)___| |_
 / _` | '_ \/ __| __\ \ /\ / / / __| __|
| (_| | | | \__ \ |_ \ V  V /| \__ \ |_
 \__,_|_| |_|___/\__| \_/\_/ |_|___/\__| {20221213}

permutations: 100.00% of 271 | found: 18 | eta: 0m 00s | speed: 1356 qps

*original  docomo.ne.jp   52.223.34.187
addition   docomo.neb.jp  150.95.255.38
addition   docomo.neg.jp  150.95.255.38
addition   docomo.neh.jp  150.95.255.38
addition   docomo.ner.jp  150.95.255.38
addition   docomo.nes.jp  150.95.255.38
addition   docomo.nem.jp  157.7.107.28
addition   docomo.nez.jp  160.16.203.68
```

2. Detecting domain names
   - Matching domain names with the feed of created candidates
     - › Certificate Transparency (CT) Logs
     - › Passive DNS traffic
     - › Other domain name feeds (e.g., TLD zone files)

Generated Squatting Domains (GSDs)

- Combining multiple squatting techniques to create domain names
- Registering thousands of domain names simultaneously
- Vague similarities can be seen when GSDs are listed

appleid.apple[.]com:
www.appleid-signinmy.gsmserver-pro[.]com
www.applesign-in.gsmserver-pro[.]com
www.applesign-us.gsmserver-pro[.]com
www.support-appleid.gsmserver-pro[.]com

login.microsoftonline[.]com:
login-micro-online-doc-file-share-view.web[.]app
micro-login-drive-file-share-view-doc.web[.]app
micro-login-drive-file-share-view.web[.]app
micro-login-file-share-drive-view-doc.web[.]app

www.amazon.co[.]jp:
www.amaczon-co-jp.amazccn.bwyver[.]top
www.amaeozn-co-jp.amazecn.ibsmoa[.]top
www.amazcon-co-jp.amacszan.cwheoj[.]top
www.amazeon-co-jp.amazom.cvcvjj[.]top

www.coingecko[.]com:
www.coingeicko[.]click
www.coingjecko[.]click
www.coinsgeckko[.]click
www.coinsgqecko[.]click

rakuten.co[.]jp:
rakoten.co.ip.enxazgii[.]cf
rakoten.co.ip.enxazgii[.]ml
rakoten.co.ip.ciqrjrzk[.]ga
rakoten.co.ip.ciqrjrzk[.]tk

steamcommunity[.]com:
steamcammunnittly[.]com
steamcornmunitty[.]com
steamcoormmunity[.]ru
steamcornmunnity[.]ru

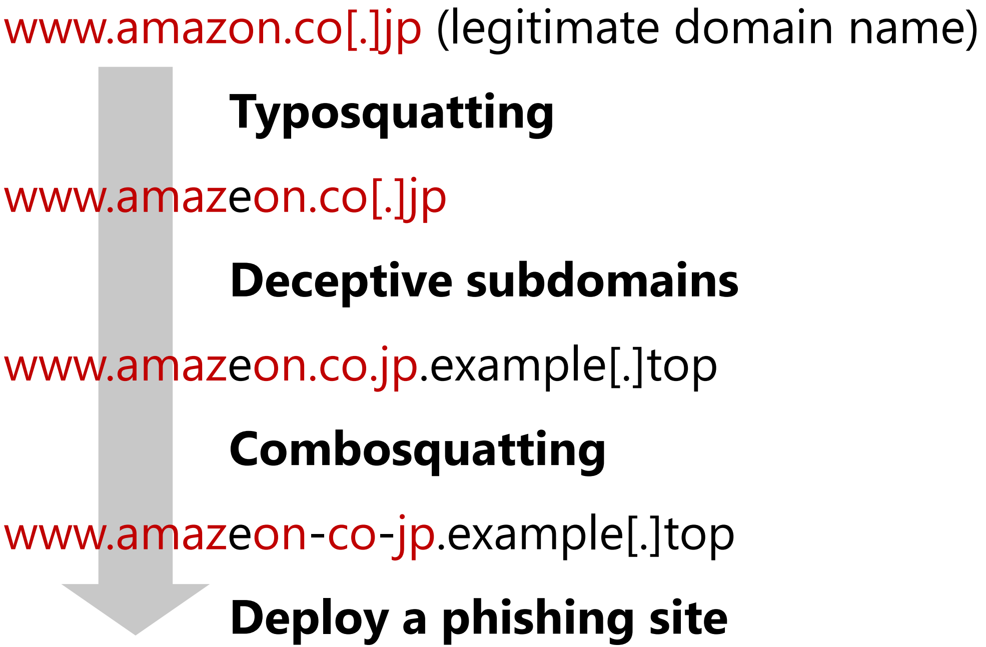
Icloud[.]com/find:
www.findmy.Icloud-online[.]in
www.findmy.phone-cloud-mx[.]info
www.findmy.phone-Icloud[.]info
www.findmy.phone-Icloud[.]top

coinbase[.]com
ccoiasbasvelog.azurewebsites[.]net
coaoiasnbaselog.azurewebsites[.]net
coiansabsabelog.azurewebsites[.]net
coinnnbaswalle.azurewebsites[.]net

kucoin[.]com
kuuucoinesslugincess.godaddysites[.]com
kuuucoinessslugincess.godaddysites[.]com
kuucoinesslugincessss.godaddysites[.]com
kuuucoinessslugincesss6.godaddysites[.]com

Generated Squatting Domains (GSDs)

Creation process of GSDs using multiple squatting techniques



www.amazon.co[.]jp (legitimate domain name)

Typosquatting

www.amazeon.co[.]jp

Deceptive subdomains

www.amazeon.co.jp.example[.]top

Combosquatting

www.amazeon-co-jp.example[.]top

Deploy a phishing site

Challenges in Detecting GSDs

- **Evasion Tactics:** GSDs evade existing squatting detection systems

- **Rapid Evolution:** The emergence of new patterns is frequent, making manual rule creation impractical

- **False Positives:** Existing ML-based systems often generate many false positives

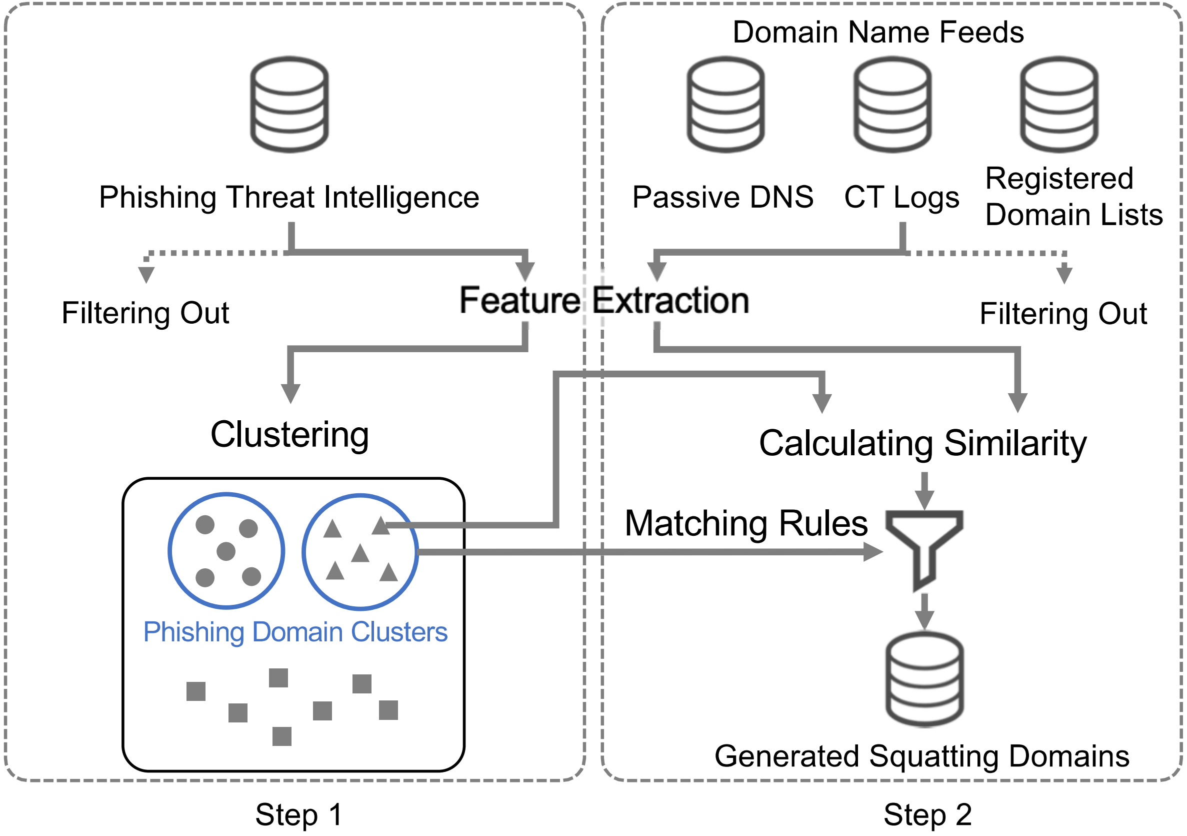
PhishReplicant: Key Ideas

- Identifying domain names that resemble known phishing domain names rather than legitimate ones

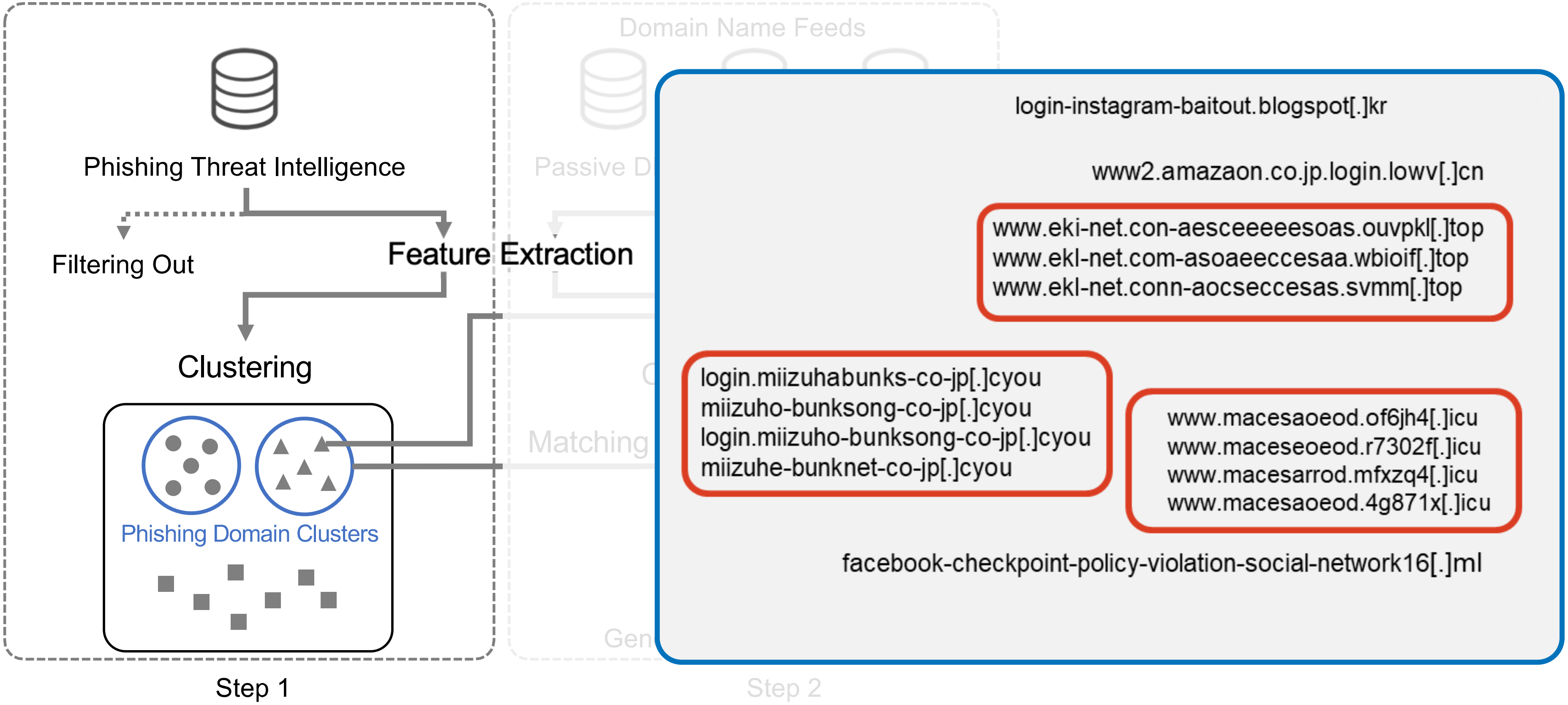
- Using a fine-tuned Sentence-BERT model for measuring domain name similarity

- Detecting GSDs from newly registered or observed domain names compared using the latest phishing threat intelligence

PhishReplicant: System Architecture



Step 1: Extract Similar Domain Names



login-instagram-baitout.blogspot[.]kr

www2.amazaon.co.jp.login.lowv[.]cn

www.eki-net.con-aesceeeeesoas.ouvpkl[.]top
www.ekl-net.com-asoaeeccesaa.wbioif[.]top
www.ekl-net.conn-aocseccesas.svmm[.]top

login.miizuhabunks-co-jp[.]cyou
miizuho-bunksong-co-jp[.]cyou
login.miizuho-bunksong-co-jp[.]cyou
miizuhe-bunknet-co-jp[.]cyou

www.macesaoeod.of6jh4[.]icu
www.maceseoeod.r7302f[.]icu
www.macesarrod.mfxzq4[.]icu
www.macesaoeod.4g871x[.]icu

facebook-checkpoint-policy-violation-social-network16[.]ml

Step 1: Extract Similar Domain Names

Extracting a set of similar domain names from known phishing domain names

Data Sources

- Phishing threat intelligence (TI): PhishTank, OpenPhish, CrowdCanary [ARES '23]

Feature Extraction

- Use Sentence-BERT for text embeddings of domain names

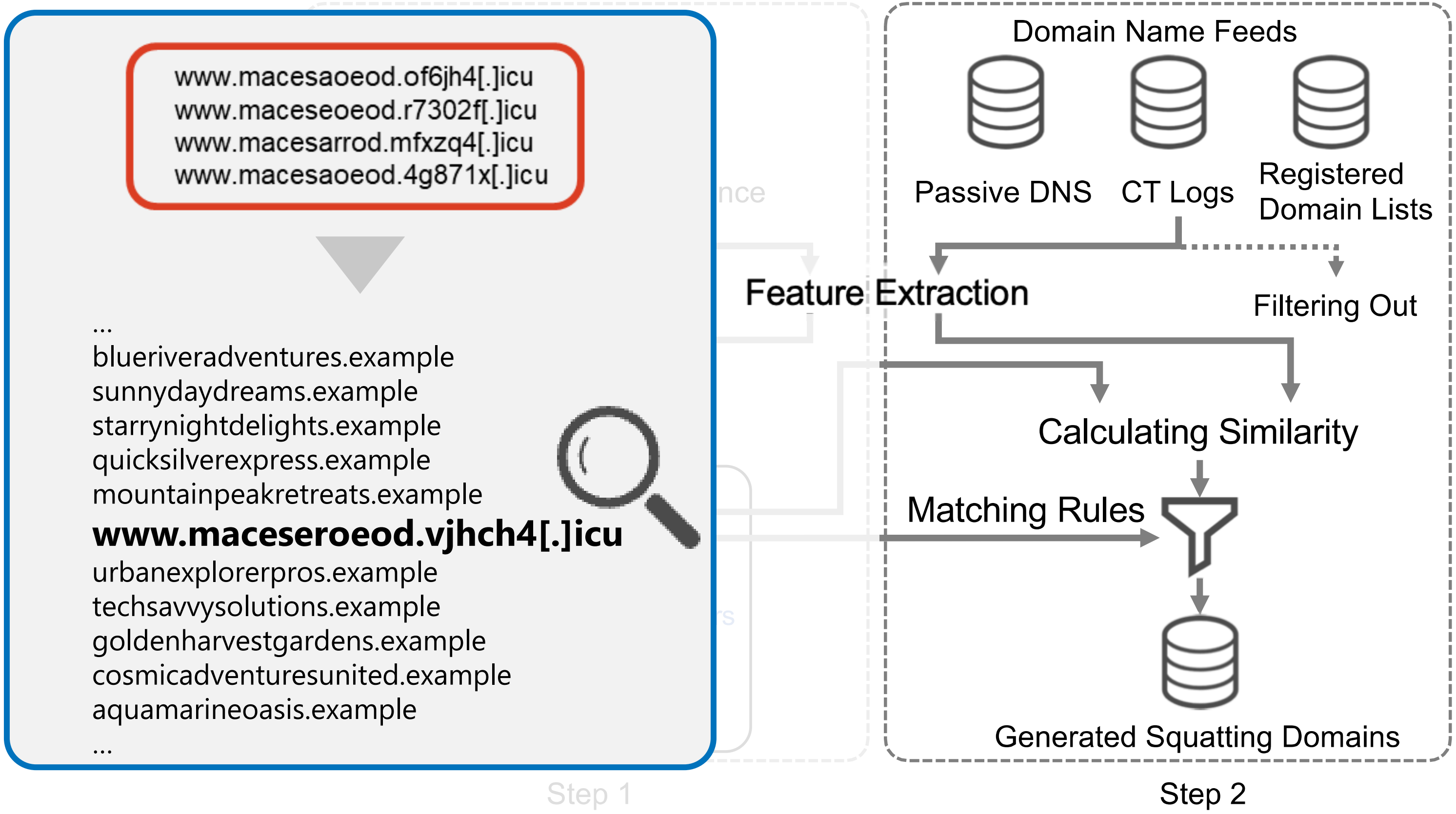
Clustering Technique

- Employ DBSCAN algorithm, utilizing cosine similarity

Matching Rule Generation

- Create rules based on TLDs, e2LDs, character count

Step 2: Detect GSDs



www.macesaoeod.of6jh4[.]icu
www.maceseoeod.r7302f[.]icu
www.macesarrod.mfxzq4[.]icu
www.macesaoeod.4g871x[.]icu

...
blueriveradventures.example
sunnydaydreams.example
starrynightdelights.example
quicksilverexpress.example
mountainpeakretreats.example
www.maceseroeod.vjhch4[.]icu
urbanexplorerpros.example
techsavvysolutions.example
goldenharvestgardens.example
cosmicadventuresunited.example
aquamarineoasis.example
...

Domain Name Feeds

Passive DNS

CT Logs

Registered Domain Lists

Feature Extraction

Filtering Out

Calculating Similarity

Matching Rules

Generated Squatting Domains

Step 1

Step 2

Step 2: Detect GSDs

Identifying GSDs similar to known phishing domain names

Data Sources

- Passive DNS traffic, CT logs, registered domain name list (e.g., zonefiles.io)

Feature Extraction

- (In the same way as Step 1)

Calculating Similarity

- Calculate cosine similarity between each cluster (Step 1) and domain names
- Extract domain name if the similarity exceeds the 0.96 threshold

Match rules

- If the domain name follows Step 1 cluster rules, label it as a GSD

Evaluation of Real-time GSD Detection

Data Sources

- CT Logs, zonefiles.io, Passive DNS traffic: 28 days (November 2022)

Verification of detected GSDs

- **URL Inspection Services:** VirusTotal, URLScan, Google Safe Browsing
- **Phishing TI:** OpenPhish, PhishTank, CrowdCanary
- **Web Crawling:** Crawl websites + Phishpedia [USENIX '21])
- **Passive DNS:** Checking IP address sharing
- **Manual Validation**

Evaluation of Real-time GSD Detection

Results

- **92.4% Precision**: 3,498 true positives out of 3,784 detected GSDs
- **74.6% Phishing Sites**: 2,821 GSDs were used as phishing sites
- **59.0% Zero-day Phishing**: 2,233 GSDs were exclusive discoveries not identified by other services

GSDs Detected by PhishReplicant

Manual Validation	VirusTotal	URLScan	GSB	Phishing TI	Crawling	Passive DNS
3,498	934	433	564	430	757	2,106

Evaluation with Baseline Systems

Data Sources

- CT Logs, zonefiles.io, Passive DNS traffic: 31 days (March 2023)

Baseline Systems

- **dnstwist**: Generates squatting domains (rule-based)
- **Phishing Catcher**: Identifies phishing domains from certificates (rule-based)
- **StreamingPhish**: Detects phishing domains (ML-based)
- **Ctl-pipeline**: Identifies phishing domains from certificates (ML-based)

Verification

- Phishing TI
- Google Safe Browsing

Evaluation with Baseline Systems

Results

- PhishReplicant outperformed baseline systems with 26.1% accuracy

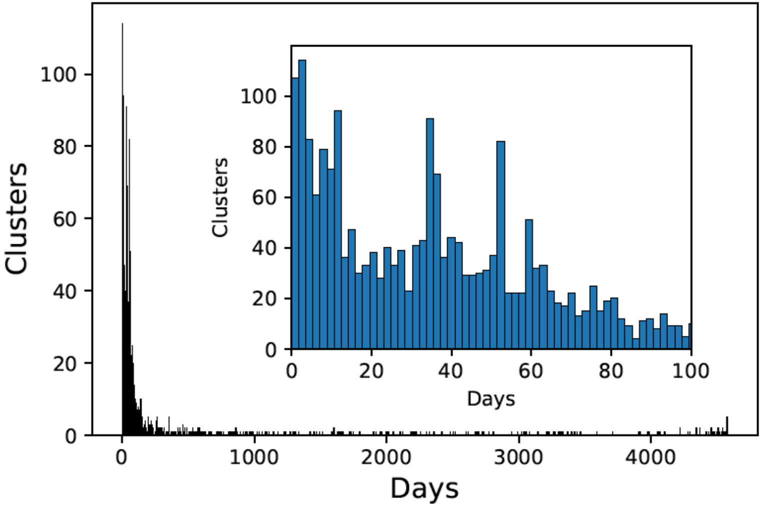
System	Detected Domains	Matched with Phishing TI or GSB	Ratio
dnstwist	352,294	3,645	1.0%
Phishing Catcher	98,326	705	0.7%
StreamingPhish	196,677	3,770	1.9%
Ctl-pipeline	50,441	201	0.4%
PhishReplicant	7,358	1,923	**26.1%**

In-depth Analysis of GSDs

Discovered 205,158 GSDs (2,842 clusters) over 150 days (since August 2022)

Active Duration of GSD Clusters:

- Median active period recorded at 41 days (between the first-seen and last-seen dates)
- Over 97% of clusters remained active for more than 24 hours



IP Address Sharing:

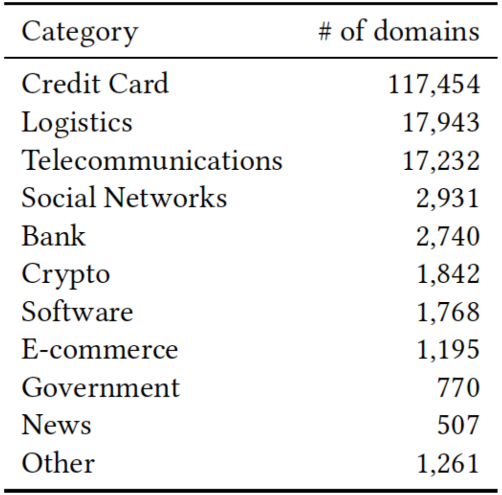
- 65% of clusters shared 1 or 2 IPs each

In-depth Analysis of GSDs

Phishing Targeted Brands:

- 265 brands in 35 countries imitated by 165,643 domain names
- Credit Card category was the most targeted (70.9% of all domain names)

Top 10 categories



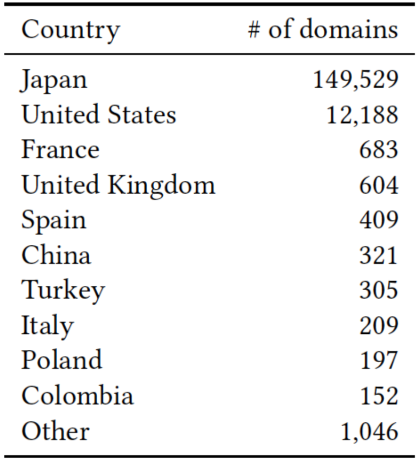
Category	# of domains
Credit Card	117,454
Logistics	17,943
Telecommunications	17,232
Social Networks	2,931
Bank	2,740
Crypto	1,842
Software	1,768
E-commerce	1,195
Government	770
News	507
Other	1,261

In-depth Analysis of GSDs

Geographical Distribution:

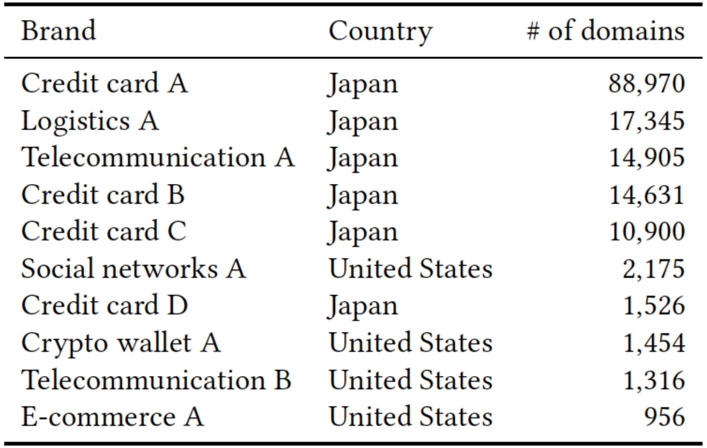
- 90.3% of domain names targeted Japanese brands.
- U.S. brands were more commonly targeted (69.7%) in global phishing trends

Top 10 countries



Country	# of domains
Japan	149,529
United States	12,188
France	683
United Kingdom	604
Spain	409
China	321
Turkey	305
Italy	209
Poland	197
Colombia	152
Other	1,046

Top 10 brands



Brand	Country	# of domains
Credit card A	Japan	88,970
Logistics A	Japan	17,345
Telecommunication A	Japan	14,905
Credit card B	Japan	14,631
Credit card C	Japan	10,900
Social networks A	United States	2,175
Credit card D	Japan	1,526
Crypto wallet A	United States	1,454
Telecommunication B	United States	1,316
E-commerce A	United States	956

Conclusion

System Proposal: Introducing a system to detect Generated Squatting Domains (GSDs)

github.com/tkoide398/PhishReplicant

System Effectiveness: PhishReplicant employs a transformer-based language model to identify domain names similar to known phishing domain names and outperformed existing systems

Real-Time Detection: Offering timely GSD detection using the latest phishing TI and new domain name feeds, enabling early countermeasures against newly emerged phishing sites

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