

An Efficient and Usable Client-Side Cross Platform Compatible Phishing Prevention Application

SECOND REVIEW

Guide

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OUTLINE

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INTRODUCTION

- Phishing
- Lists of such sites
- Time constraints
- Computational resources
- Vulnerabilities
- Cross platform

OVERALL OBJECTIVE

- Create a phishing list
- Cross Platform application
- Web browser add-on
- Provide temporal resilience
- Remove false positives from list

LITERATURE SURVEY

- Previous work by Samuel Marchal, Giovanni Armano, Tommi Grondahl, Kalle Saari, Nidhi Singh, and N. Asokan
- IEEE Trans. Comput., vol. 66, no. 10, pp. 1717-1733, Oct. 2017
- Implemented a client-side phishing prevention application.
- Had background tasks communicate with a browser add-on.
- Not platform independent.

AUTOMATIC PHISHING CLASSIFICATION

- Colin Whittaker, Brian Ryner and Marria Nazif for Google
- Proc. Netw. Distrib. Syst. Security Symp., 2010
- Features used
 - 1. The URL of the page
 - 2. The HTML page contents
 - 3. The host server details
- Needs blacklist updating.

CANTINA

- Guang Xiang, Jason Hong, Carolyn P. Rose and Lorrie Cranor
- ACM Trans. Inf. Syst. Secur., 2011
- Page similarity
- SHA 1 algorithm
- Easy to break
- Performance gains

AUTO UPDATED WHITELIST

- Ankit Kumar Jain and B. B. Gupta
- EURASIP J. Inf. Secur., vol. 2016, no. 1, Dec. 2016
- Whitelist
 - a. the domain name
 - b. the IP address
- Reverts to old system if not in whitelist

FUZZY ROUGH SET FEATURE SELECTION TO ENHANCE PHISHING ATTACK DETECTION

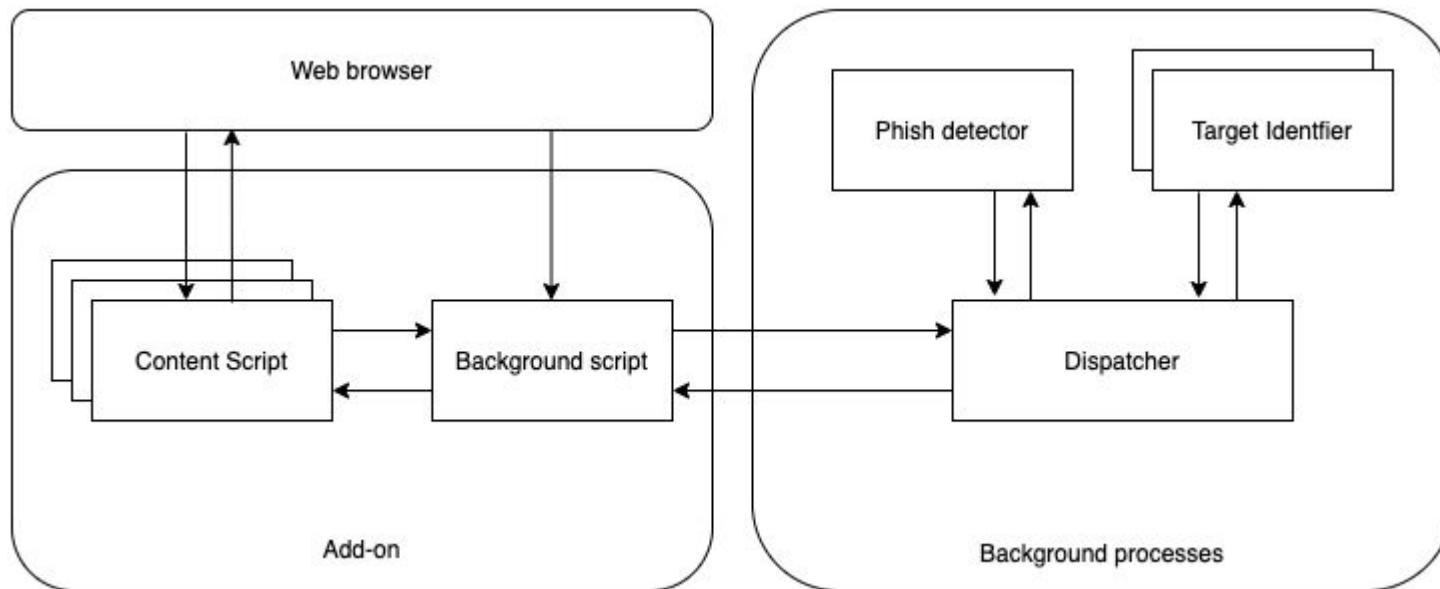
- Mahdieh Zabihimayvan and Derek Doran
- IEEE International Conference on Fuzzy Systems, June 2019
- Fuzzy Rough Set (FRS) theory
- Feature selection algorithm
- Random Forest classification
- No third party features

Paper	Journal/Conf. , Year	Contributions	Limitations
Large-Scale Automatic Classification of Phishing Pages	Proc. Netw. Distrib. Syst. Security Symp., 2010	Machine learning model can be used with reliable accuracy.	Needs blacklist for updating.
CANTINA: A feature-rich machine learning framework for detecting phishing Web sites	ACM Trans. Inf. Syst. Secur., 2011	SHA1 based similarity check for similar looking sites.	SHA1 could be manipulated.
A novel approach to protect against phishing attacks at client side using auto-updated white-list	EURASIP J. Inf. Secur., vol. 2016, no. 1, Dec. 2016	Auto-updated whitelist for faster detection of sites on average.	Not temporally resilient.
Fuzzy Rough Set Feature Selection to Enhance Phishing Attack Detection	IEEE International Conference on Fuzzy Systems, June 2019	Feature selection.	Not a user oriented application.

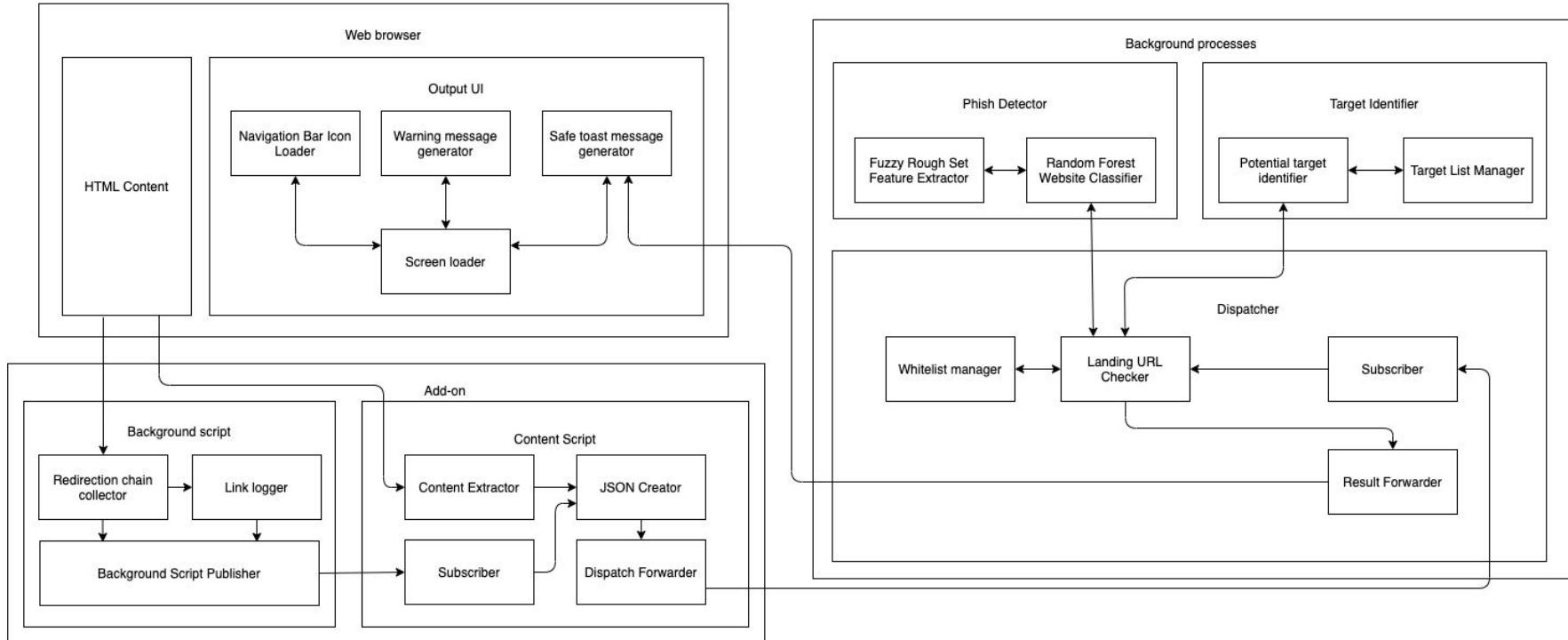
PROPOSED SYSTEM

- Platform independent
- Browser add-on
- Reduce false warnings
- Context independent detection
- Static observations

SYSTEM ARCHITECTURE



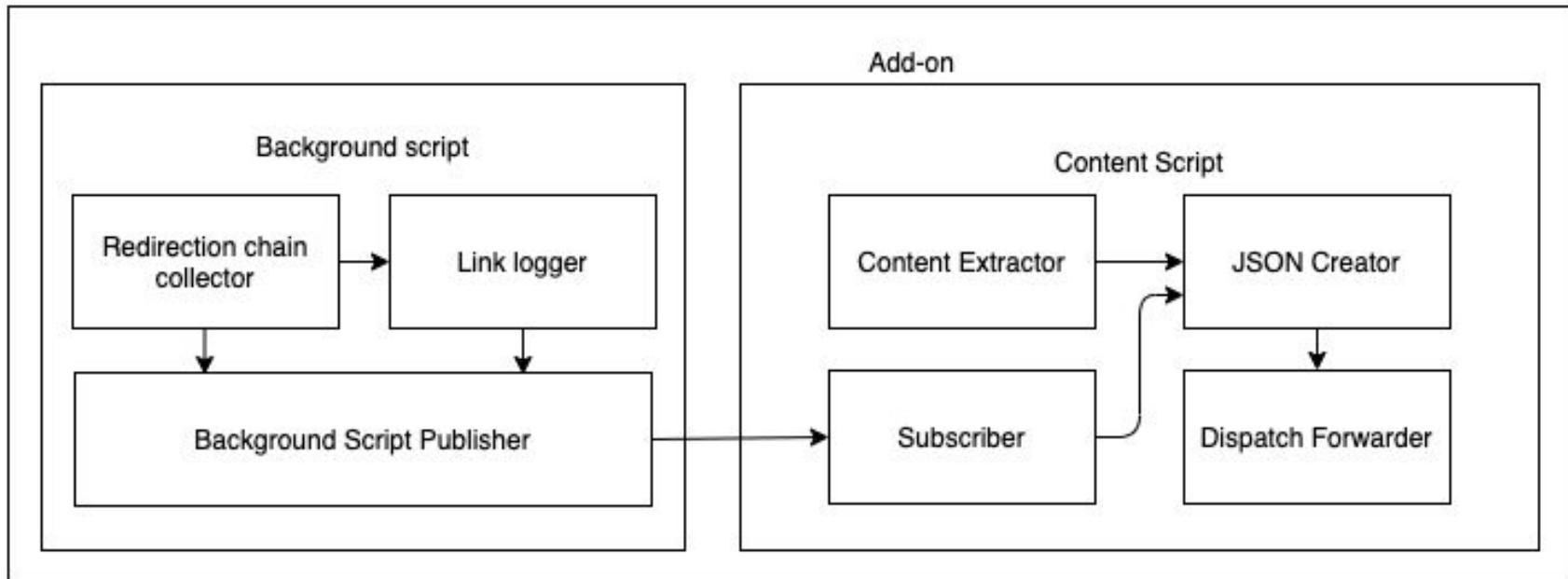
HIGH LEVEL BLOCK DIAGRAM



MODULE LIST

- Add on
 - a. Background script
 - b. Content script
- Background process
 - a. Dispatcher
 - b. Phish Detector
 - c. Target Identifier
- Web Browser
 - a. HTML content
 - b. Output UI

ADD-ON



BACKGROUND SCRIPT

Begin

For each page load redirect

Add listener to that event

Get the list of redirects from listener

If page is fully loaded

Send the list of redirects to content script

Done

End

CONTENT SCRIPT

Begin

For each page load redirect

If page is fully loaded

Get the URL from the tab

Get the HTML content from innerHTML tag

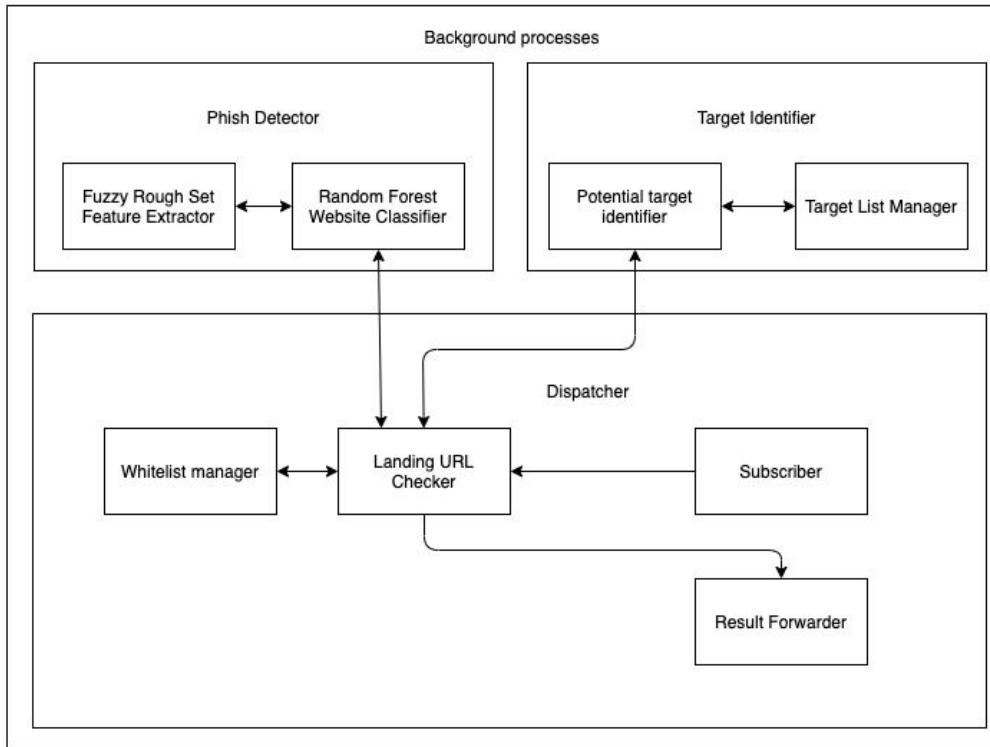
Get redirection list from background script

Send them to the background process

Done

End

BACKGROUND PROCESS



DISPATCHER

Begin

If page address is in whitelist

Send the GREEN signal

Else

Send content to phish detector

Get results from phish detector

If phish is FALSE

Send the GREEN signal

Else

Send the RED signal

Send content to target identifier

If target is found

Publish target

Else

No target matched

End

PHISH DETECTOR

Begin

For each page URL

Get the fuzzy set feature values for the URL

Load the saved random forest model

Publish the result

Done

End

FUZZY ROUGH SET

Begin

Compute indiscernibility matrix $M(A)$

Reduce M using absorption laws

d - number of non-empty fields

Initialise all fields

For all fields

Compute fields using formulas $R=SUT$

Done

End

RANDOM FOREST MODEL

Begin

For each record in dataset

Get the fuzzy set feature values

Create an arff file to save results

Done

Train the dataset with at least 7 splits as random forest

Save the model as pkl file

End

TARGET IDENTIFIER

Begin

Remove all href tags in page

Get the hash value for page content

Compare with values in hash list

If match

Display target

Else

No target found

End

SHA

Begin

Input is an array 8 items long where each item is 32 bits.

Calculate all the function boxes and store those values.

Store input, right shifted by 32 bits, into output.

Store the function boxes.

*Store (Input H + Ch + ((Wt+Kt) AND 2^31)) AND 2^31 As
mod1*

Store (sum1 + mod1) AND 2^31 as mod2

Store (d + mod2) AND 2^31 into output E

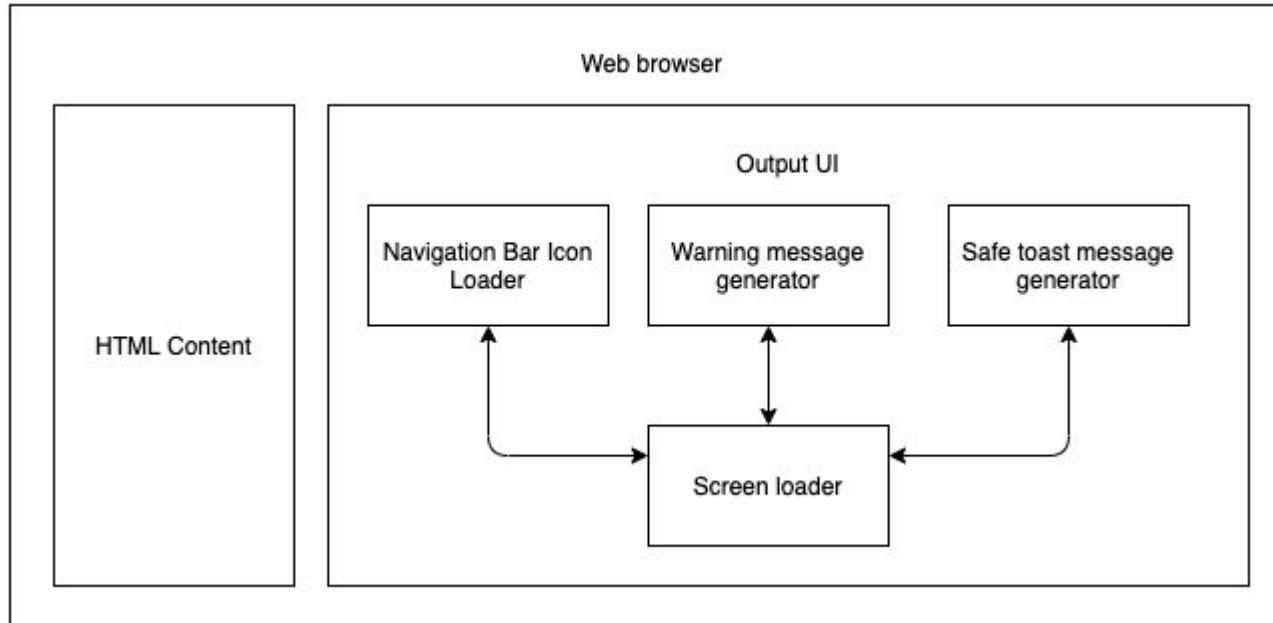
Store (MA + mod2) AND 2^31 as mod3

Store (sum0 + mod3) AND 2^31 into output A

Output is an array 8 items long where each item is 32 bits.

End

WEB BROWSER



OUTPUT UI

Begin

If site is phish

Change icon to red

Display warning message

If site has target

Display target link

Else

Display no target

Else

Change icon to green

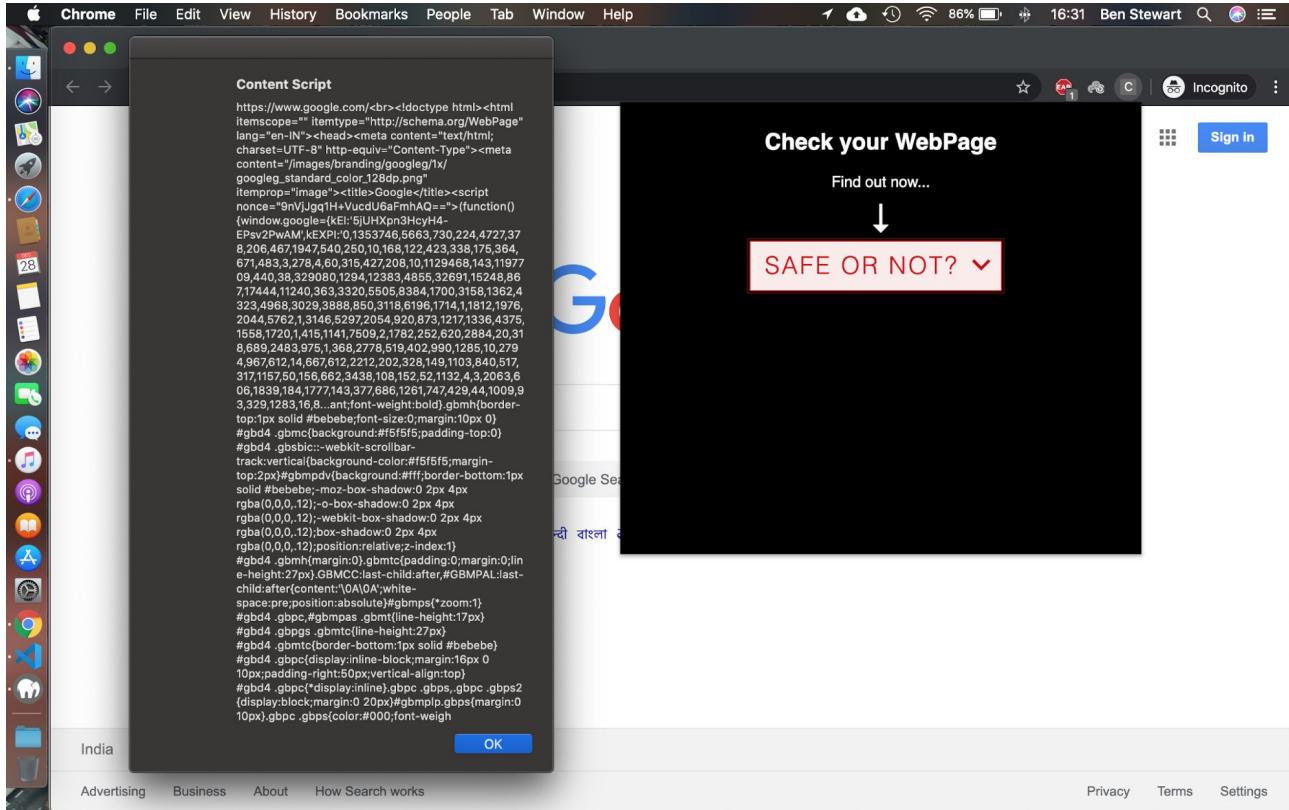
Display safe to proceed message

End

IMPLEMENTATION

- Add on
 - a. Background script
 - b. Content script
- Background process
 - a. Dispatcher
 - b. Phish Detector
 - c. Target Identifier
- Web Browser
 - a. HTML content
 - b. Output UI

CONTENT SCRIPT



CONTENT SCRIPT

```
//Retrieve URL JS  
tablink = tab.url;
```

```
//Retrieve Page content PHP  
$site=$_POST['url'];  
$html = file_get_contents($site);
```

BACKGROUND SCRIPT

The screenshot shows a Mac desktop with a Chrome browser window open to the Amazon Kindle Wireless Reading Display product page. The browser's status bar at the bottom right shows a green checkmark icon and the URL https://www.amazon.com/Kindle-Wireless-Reading-Display-Globally/dp/B003FSUDM4/ref=amb_link_353259562_2?pf_rd_m=ATVPDKIKX.... To the right of the browser window, a series of status bar notifications are displayed, each with an orange downward arrow icon and a URL:

- <http://tinyurl.com/KindleWireless>
307: Internal (browser cached) redirect to <https://tinyurl.com/KindleWireless>
- <https://tinyurl.com/KindleWireless>
301: Permanent redirect to <http://www.amazon.com/Kindle-Wireless-Re>
- <https://r.eablink.com/?key=a982cfabb5482be54a4d3a52b21>
302: Temporary redirect to <http://www.amazon.com/Kindle-Wireless-Re>
- <http://www.amazon.com/Kindle-Wireless-Reading-G>
307: Internal (browser cached) redirect to https://www.amazon.com/Kindle-Wireless-Reading-Display-Globally/dp/B003FSUDM4/ref=amb_link_353259562_2?pf_rd_m=ATVPDKIKX...
- <https://www.amazon.com/Kindle-Wireless-Reading-Display-G>
200: HTTP/1.1 200

The main content of the browser window shows the Amazon Kindle Wireless Reading Display product page, featuring a hand holding a Kindle device displaying a book cover.

BACKGROUND SCRIPT

```
//URL path item  
url: pathItem.url,  
status: pathItem.status_line,  
redirect_type: pathItem.redirect_type,  
redirect_url: pathItem.redirect_url,  
meta_timer: pathItem.meta_timer
```

DATASET

- 30 features
- 23827 records
- Scrapped from PhishTank
- Up-to-date

FEATURE SELECTION

```
benstewart@ben:~/phish_detector$ master$ python sample.py  
(11054, 1)  
(11054, 30)  
[[-1]  
 [-1]  
 [-1]  
 ...  
 [-1]  
 [-1]  
 [-1]]  
[[[-1 1 1 ... 1 1 -1]  
 [ 1 1 1 ... 1 1 1]  
 [ 1 0 1 ... 1 0 -1]  
 ...  
 [-1 1 1 ... 1 -1 1]  
 [ 1 -1 1 ... 1 0 1]  
 [-1 -1 1 ... 1 1 1]]]
```

FEATURE SELECTION

```
selector = RoughSetsSelector()  
X_selected = selector.fit(X, y).transform(X)
```

RANDOM FOREST MODEL WITHOUT FEATURE SELECTION

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.  
[Parallel(n_jobs=1)]: Done 10 out of 10 | elapsed: 0.0s finished  
precision      recall    f1-score   support  
  
      -1       0.99      0.97      0.98      460  
       1       0.98      0.99      0.98      594  
  
  micro avg       0.98      0.98      0.98     1054  
  macro avg       0.98      0.98      0.98     1054  
weighted avg       0.98      0.98      0.98     1054  
  
The accuracy is: 0.9810246679316889
```

```
[[446 14]  
 [ 6 588]]
```

```
benstewart@ben ~/phish detector
```

RANDOM FOREST MODEL WITH FEATURE SELECTION

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.  
[Parallel(n_jobs=1)]: Done 10 out of 10 | elapsed: 0.0s finished
```

	precision	recall	f1-score	support
-1	0.96	0.95	0.95	460
1	0.96	0.97	0.97	594
micro avg	0.96	0.96	0.96	1054
macro avg	0.96	0.96	0.96	1054
weighted avg	0.96	0.96	0.96	1054

```
The accuracy is: 0.961100569259962
```

```
[[435 25]  
 [ 16 578]]
```

```
benstewart@ben ~ """/phish detector > ↵ master • ?
```

RANDOM FOREST MODEL

```
//create model  
clf4=RandomForestClassifier(min_samples_split=7)  
clf4.fit(features_train, labels_train)  
//save the model  
joblib.dump(clf4, 'classifier/random_forest.pkl', compress=9)  
  
//feature weightage  
importances = clf4.feature_importances_  
//confusion matrix  
print metrics.confusion_matrix(labels_test, pred4)
```

TARGET IDENTIFIER

```
[ benstewart@ben ~ ] ➤ """/target identifier ➤ python3 score-compare-tags.py compare-tags.json
Maximum f1 0.944 at threshold=35 tp=84 fp=4 fn=6 prec=0.955 rec=0.933
benstewart@ben ~ ] ➤ """/target identifier
```

```
tags1 = get_tags(lxml.html.parse(path1))
tags2 = get_tags(lxml.html.parse(path2))
diff = difflib.SequenceMatcher()
diff.set_seq1(tags1)
diff.set_seq2(tags2)
```

```
params['url'] = url
response=requests.get(url, headers=headers, params=params)
```

AUTO UPDATED WHITELIST

Screenshot of the Network tab in the developer tools showing a single request to "clientServer.php".

Network Tab Headers:

- Elements
- Console
- Sources
- Network**
- Performance
- Memory
- >
- ⚠ 1
- ⋮

Request Details:

- Preserve log:
- Disable cache:
- Online:
- Filter: Hide data URLs
- Only show requests with SameSite issues:

All	XHR	JS	CSS	Img	Media	Font	Doc	WS	Manifest	Other	<input type="checkbox"/> Only show requests with SameSite issues
	1000 ms	2000 ms	3000 ms	4000 ms	5000 ms	6000 ms	7000 ms				

Name	Status	Type	Initiator	Size	Time	Waterfall
clientServer.php	200	xhr	popup.js:12	405 B	7.50 s	

Summary:

- 1 requests
- 405 B transferred
- 4 B resources

Screenshot of the Network tab in the developer tools showing multiple requests from a popup window.

Network Tab Headers:

- Elements
- Console
- Sources
- Network**
- Performance
- Memory
- >
- ⚠ 2
- ⋮

Request Details:

- Preserve log:
- Disable cache:
- Online:
- Filter: Hide data URLs
- Only show requests with SameSite issues:

All	XHR	JS	CSS	Img	Media	Font	Doc	WS	Manifest	Other	<input type="checkbox"/> Only show requests with SameSite issues
	1000 ms	2000 ms	3000 ms	4000 ms	5000 ms	6000 ms	7000 ms				

Name	Status	Type	Initiator	Size	Time	Waterfall
popup.html	200	document	Other	501 B	2 ms	
popup.js	200	script	popup.html	762 B	17 ms	
style.css	200	stylesheet	popup.html	1.8 KB	18 ms	
jquery.min.js	200	script	popup.html	29.6 KB	678 ms	
clientServer.php	200	xhr	popup.js:12	405 B	3.27 s	

Summary:

- 5 requests
- 33.1 KB transferred
- 87.7 KB resources
- Finish: 6.92 s
- DOMContentLoaded: 713 ms
- Load: 7

AUTO UPDATED WHITELIST

```
//insert into whitelist  
white_list_file=open('whitelist.txt', "a+")  
white_list_file.write(url)
```

```
//search whitelist  
white_list_file = open('whitelist.txt').read()  
white_list = white_list_file.split('\n')  
if url in white_list:  
    #url is safe
```

DISPATCHER

```
$decision=exec("python test.py $site 2>&1 ");
echo $decision;
```

//temporal resilience

```
$decision=exec("python scrape.py single-sites.json 1 data");
```

OUTPUT UI

Check your WebPage

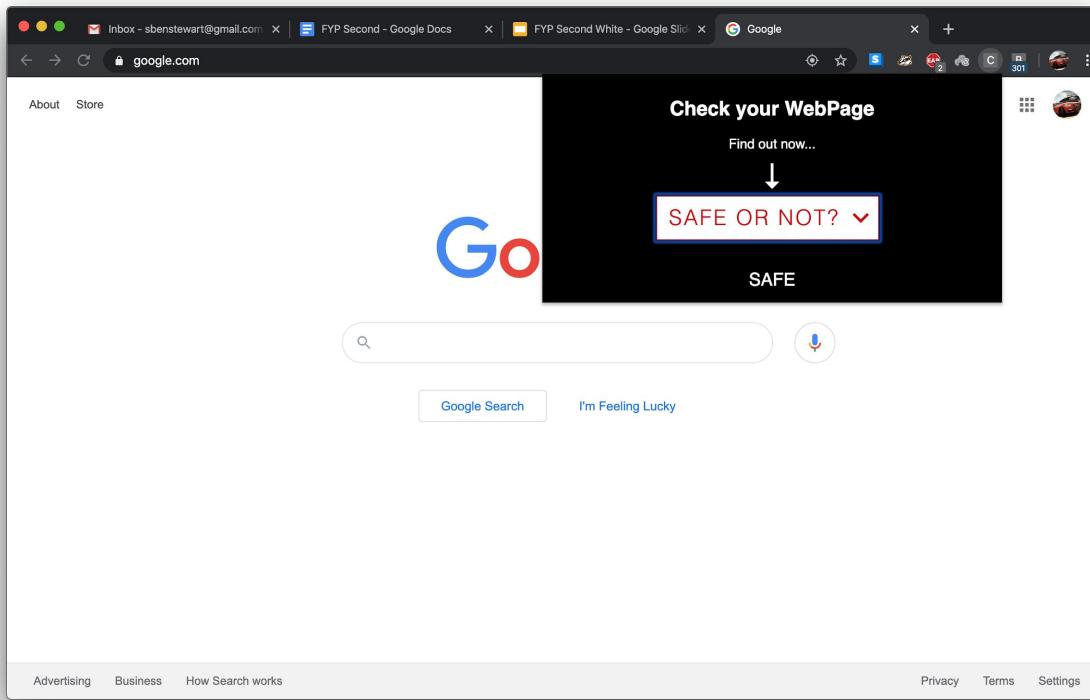
Find out now...



SAFE OR NOT? ✓

PHISHING and the most similar site is verizon with
similarity 23.4957020057

SAFE HTML CONTENT

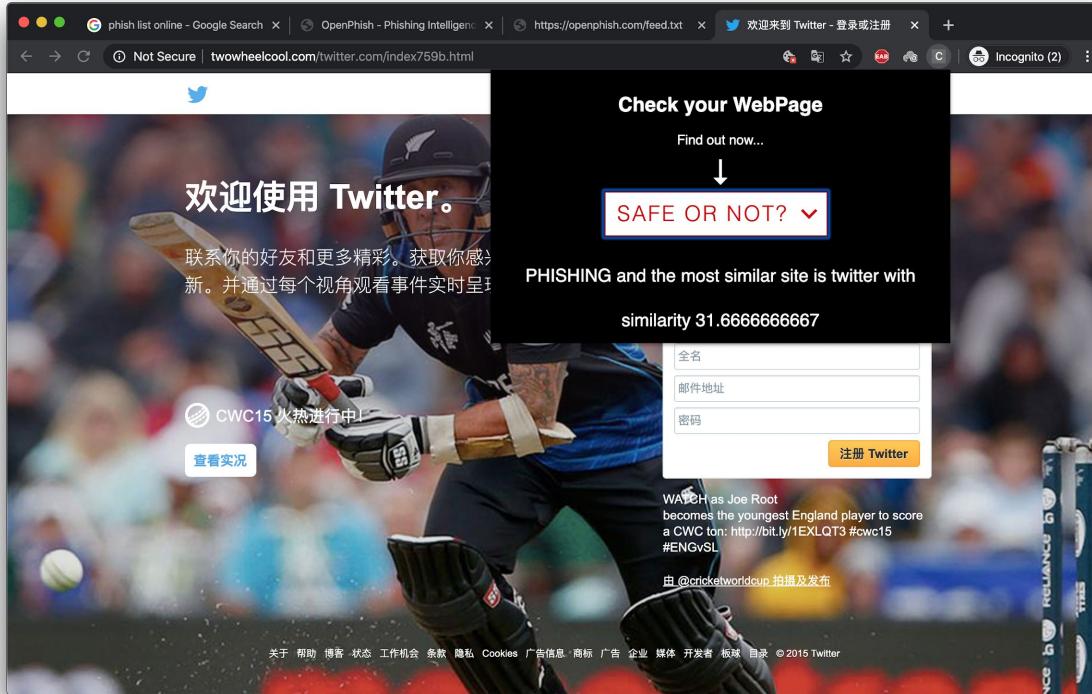


SAFE HTML CONTENT

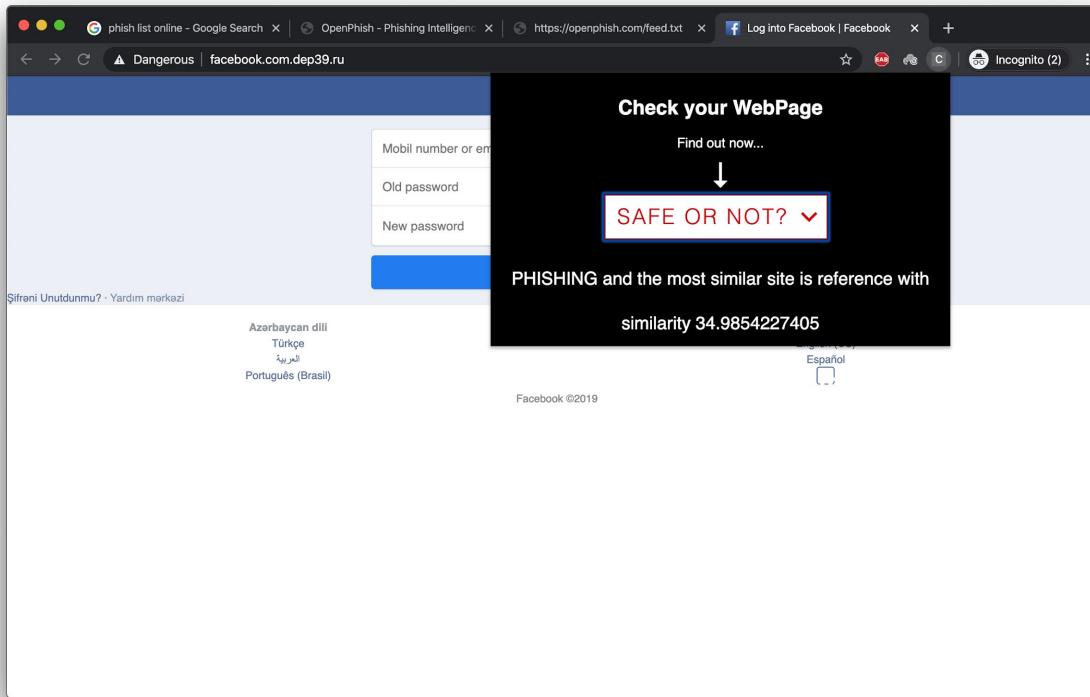
The screenshot shows a browser window with the URL annauniv.edu. The main content is the official website of Anna University, featuring sections for TANCET 2020, GRADUATION DAY 2019, and TANCA 2019. A central sidebar displays news items and links to various university services. Overlaid on the right side is a dark rectangular box containing the text "Check your WebPage" at the top, followed by "Find out now.." with a downward arrow, and a large red button labeled "SAFE OR NOT?". Below this button, the word "SAFE" is displayed in white capital letters. To the right of the "SAFE" button is a vertical list of university services, each with a blue link:

- CoE - Genuineness Verification
- Constituent Colleges
- Distance Education
- Health Centre
- International Relations
- National Apprenticeship Schemes
- NIRF
- Patents
- Harassment Cell
- Ramanujan Computing Centre
- Recruitment Cell
- Regional Offices
- RTI Mandatory Disclosure
- Services - Transcripts Online
- Students' Activities
- Tender
- University Departments
- University Library

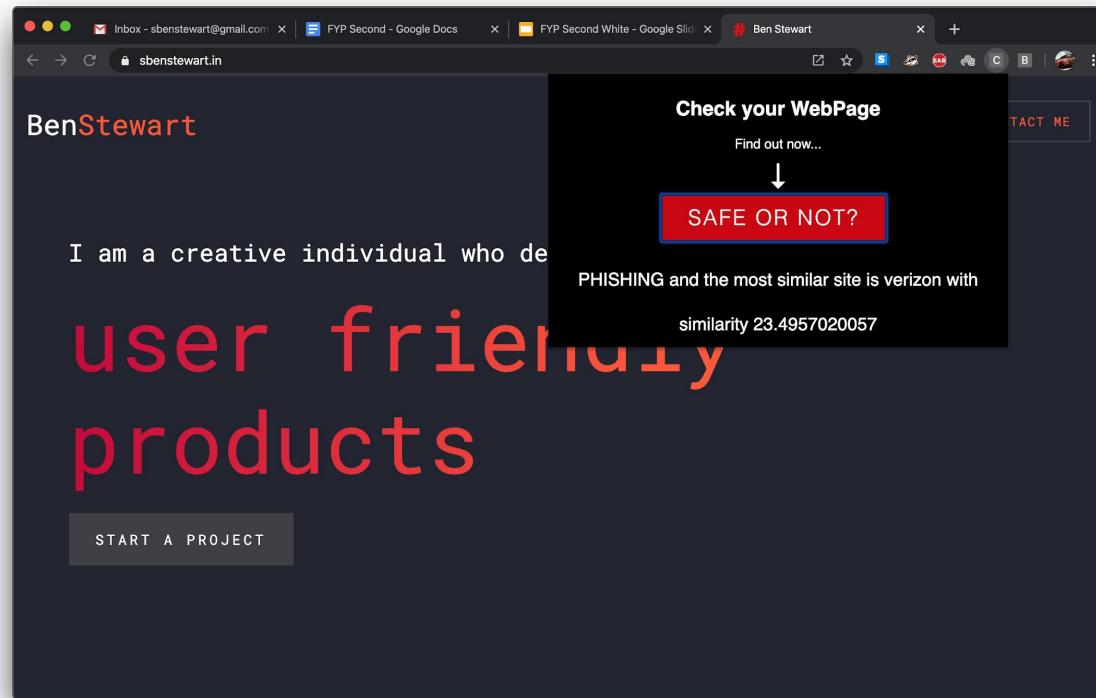
PHISHING HTML CONTENT



PHISHING HTML CONTENT



WRONG HTML CONTENT



EVALUATION METRICS

1. Phish detection accuracy

Accuracy = $(TP+TN)/(TP+TN+FP+FN)$

2. Target detection ratio

Detection Ratio = $(TP)/(TP+TN+FP+FN)$

3. Memory usage profiling

Current total memory usage = Total Memory - (Free + Buffers + Cached)

4. Addon rendering time

Rendering Time = End time - Start time

5. Temporal resilience accuracy

Accuracy = $(TP+TN)/(TP+TN+FP+FN)$

REFERENCES

1. Mahdieh Zabihimayvan and Derek Doran, "Fuzzy Rough Set Feature Selection to Enhance Phishing Attack Detection", IEEE International Conference on Fuzzy Systems, June 2019.
2. S. Marchal, G. Armano, T. Gröndahl, K. Saari, N. Singh, N. Asokan, "Off-the-hook: An efficient and usable client-side phishing prevention application", IEEE Trans. Comput., vol. 66, no. 10, pp. 1717-1733, Oct. 2017.
3. A. K. Jain, B. B. Gupta, "A novel approach to protect against phishing attacks at client side using auto-updated white-list", EURASIP J. Inf. Secur., vol. 2016, no. 1, Dec. 2016.
4. G. Xiang, J. Hong, C. P. Rosé, L. Cranor, "CANTINA: A feature-rich machine learning framework for detecting phishing Web sites", ACM Trans. Inf. Syst. Secur., vol. 14, no. 2, 2011.
5. Implementation for the Usage of Google Safe Browsing APIs (v4), 2019, [online] Available: <https://github.com/google/safebrowsing>.
6. C. Whittaker, B. Ryner, and M. Nazif, "Large-scale automatic classification of phishing pages," in Proc. Netw. Distrib. Syst. Security Symp., 2010, pp. 1–14.