

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

THIRD 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

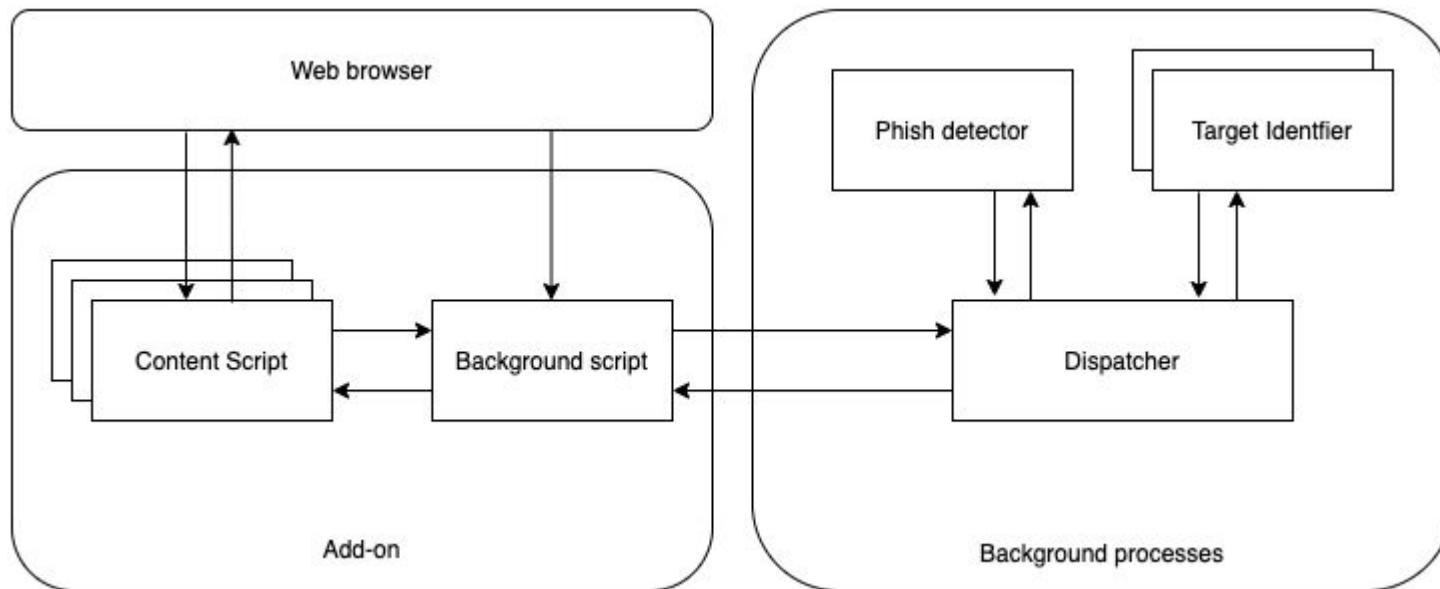
- Mahdieh Zabihimayvan and Derek Doran
- IEEE International Conference on Fuzzy Systems, June 2019
- Fuzzy Rough Set (FRS) theory
- Feature selection algorithm
- Random Forest classification
- No third party features

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.

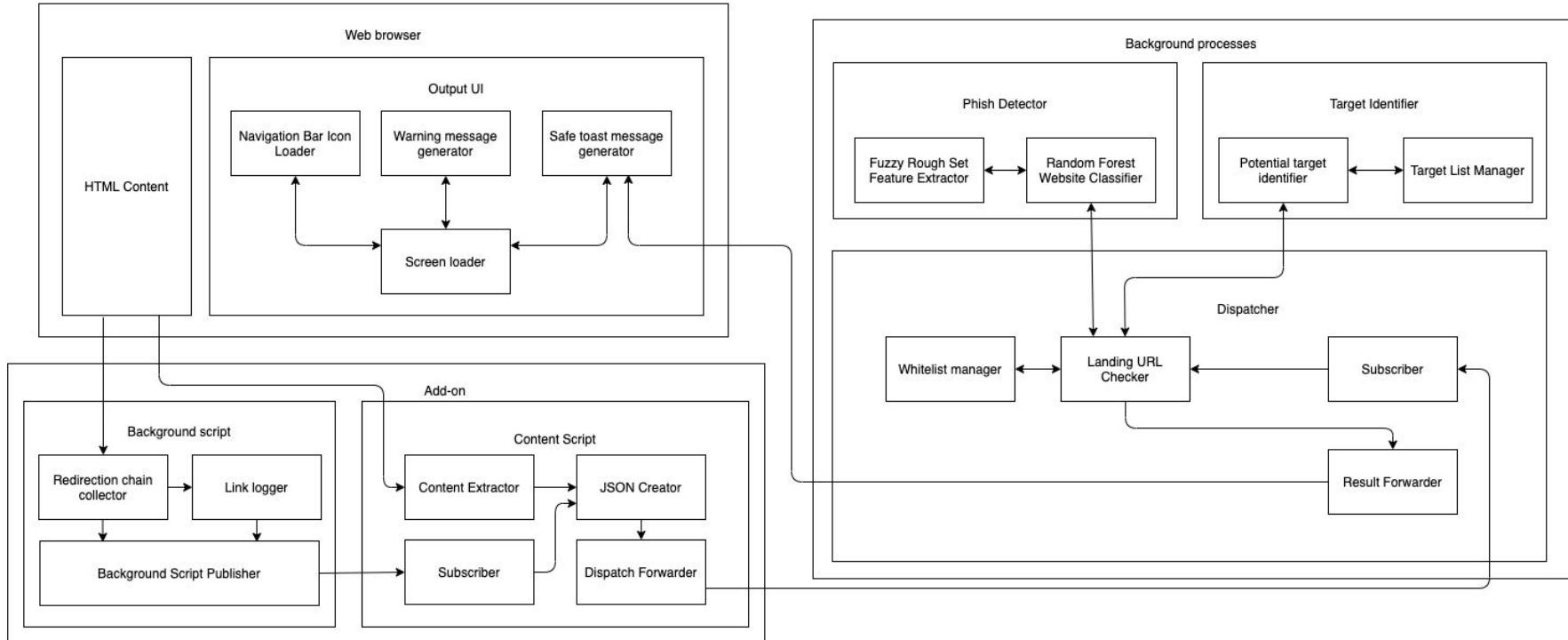
PROPOSED SYSTEM

- Off-the-hook-plus
- Platform independent
- Browser add-on
- Reduce false warnings
- Context independent detection
- Static observations

SYSTEM ARCHITECTURE



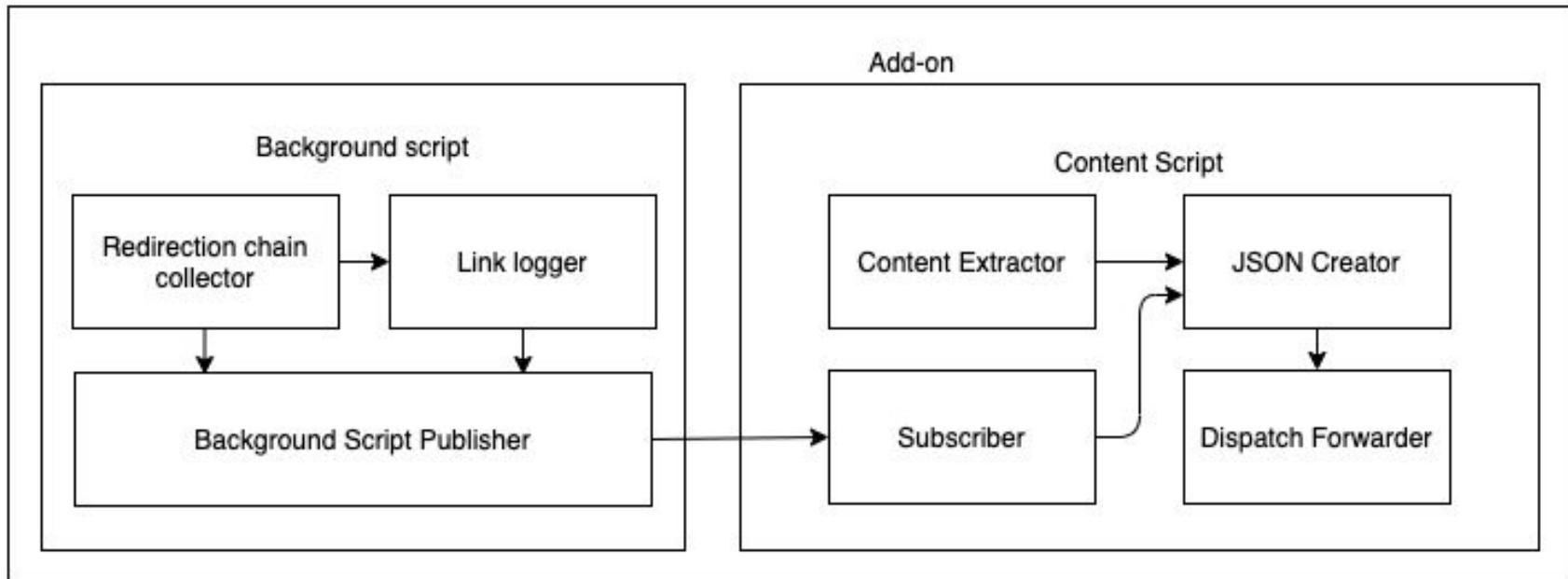
HIGH LEVEL BLOCK DIAGRAM



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

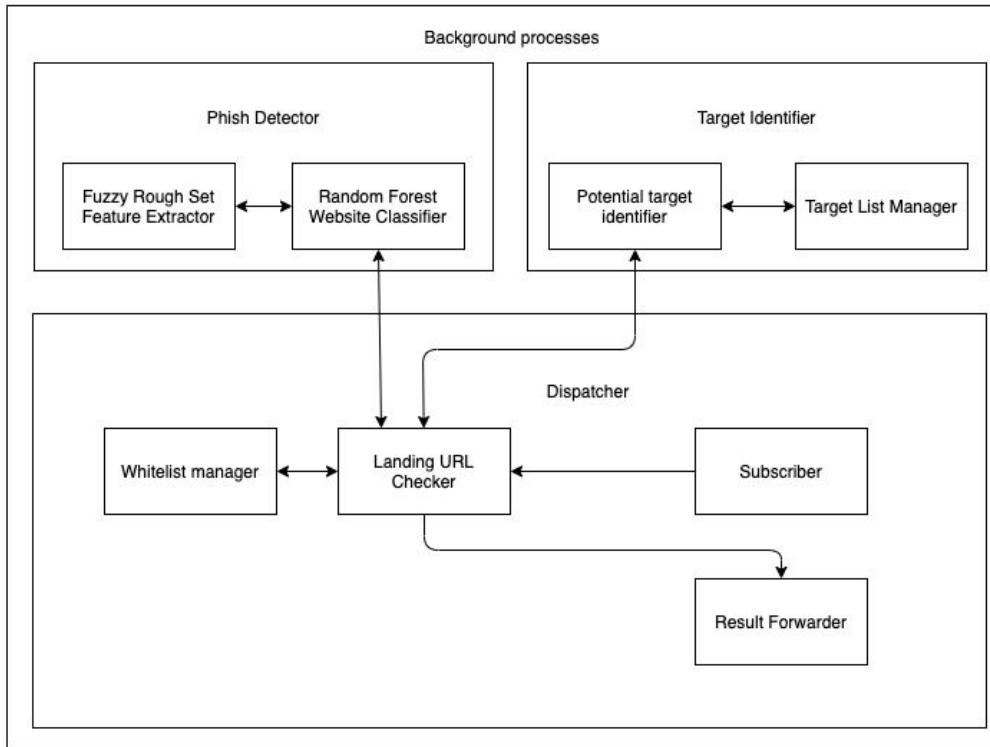
Get redirection list from background script

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

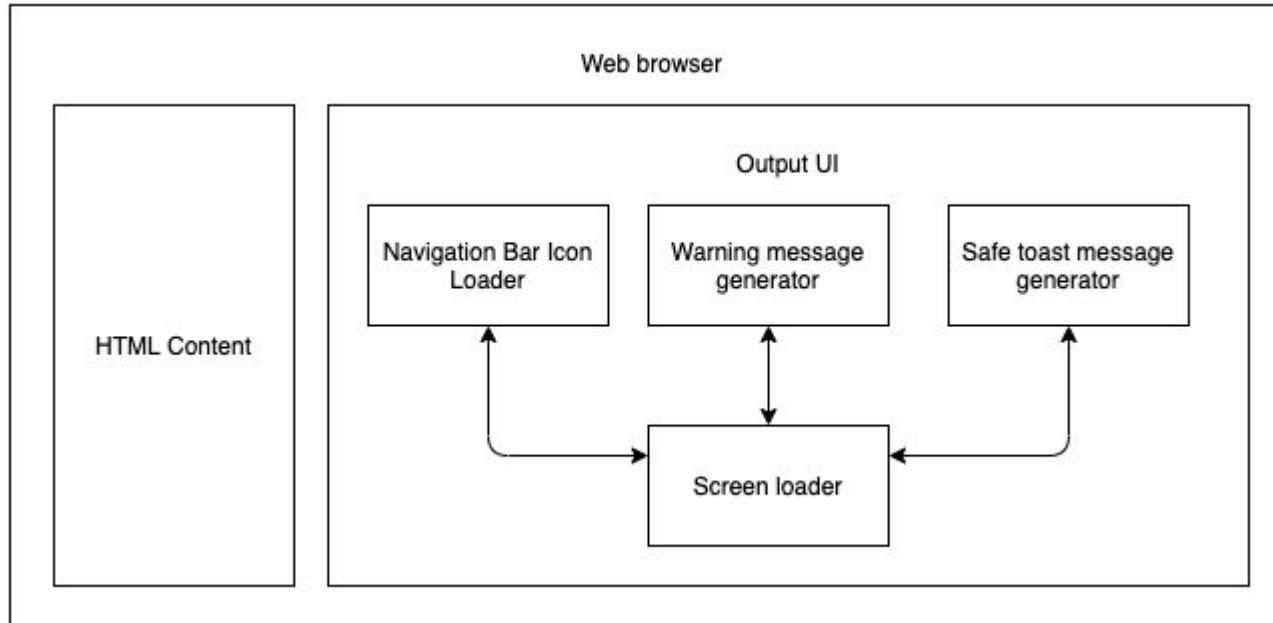
Store (MA + mod2) AND 2^31 as mod3

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

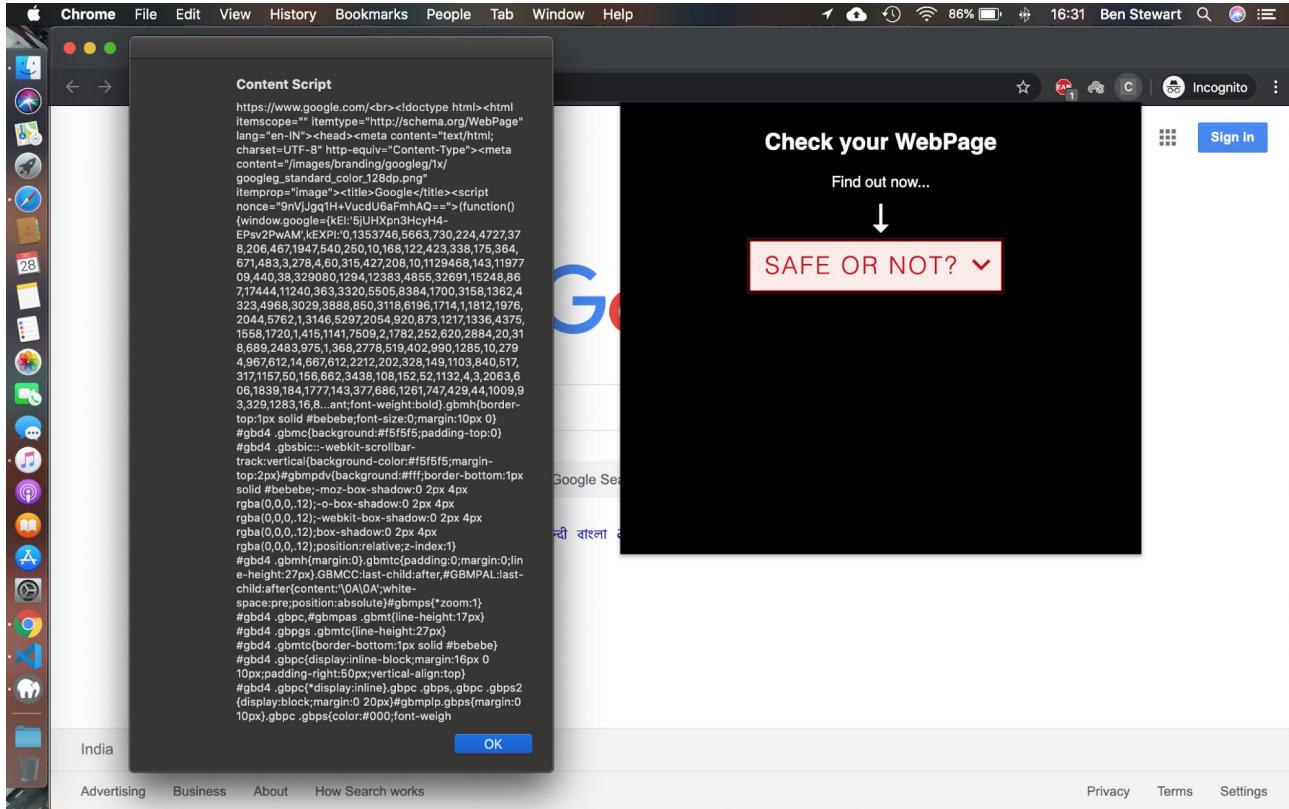
Display safe to proceed message

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

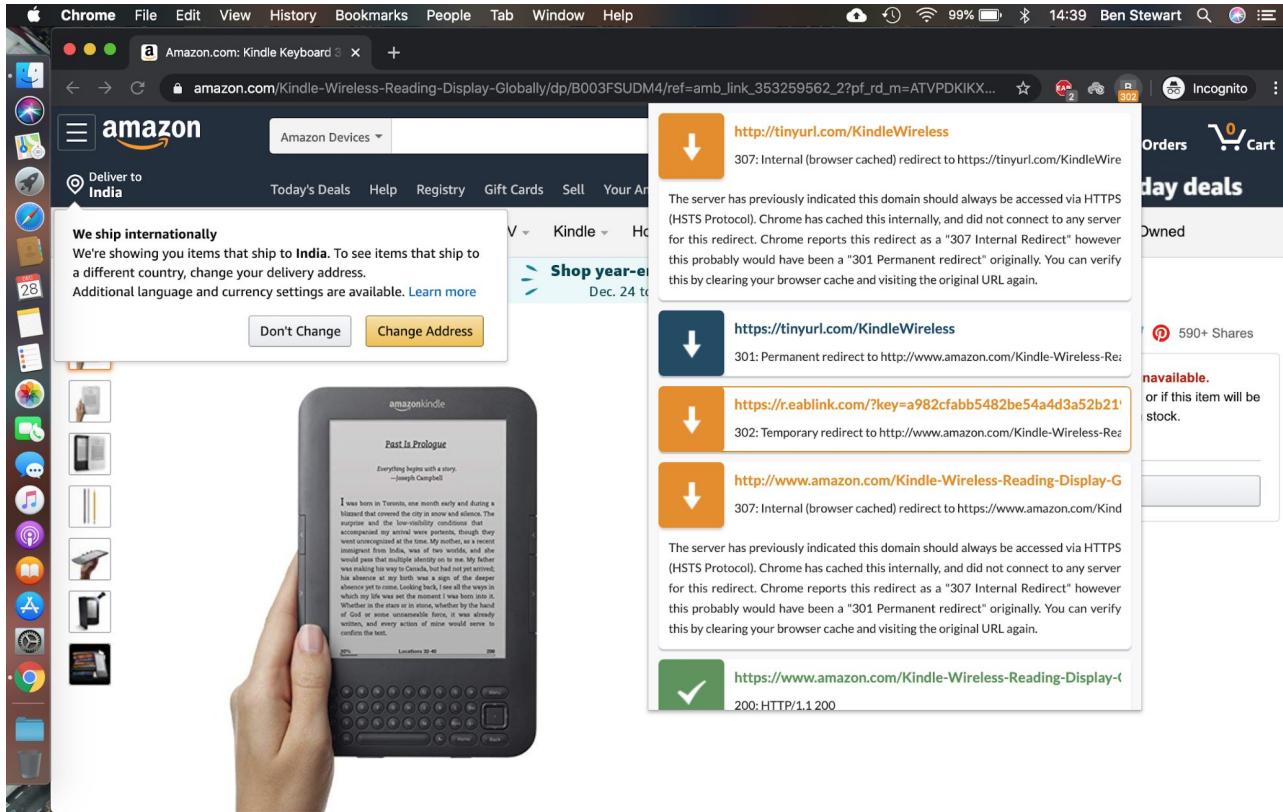


CONTENT SCRIPT

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

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

BACKGROUND SCRIPT



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". The request took 7.50 seconds and transferred 405 B.

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

1 requests | 405 B transferred | 4 B resources

Screenshot of the Network tab in the developer tools showing multiple requests. The total time is 6.92 s, with the last request "clientServer.php" taking 3.27 s.

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	

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

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

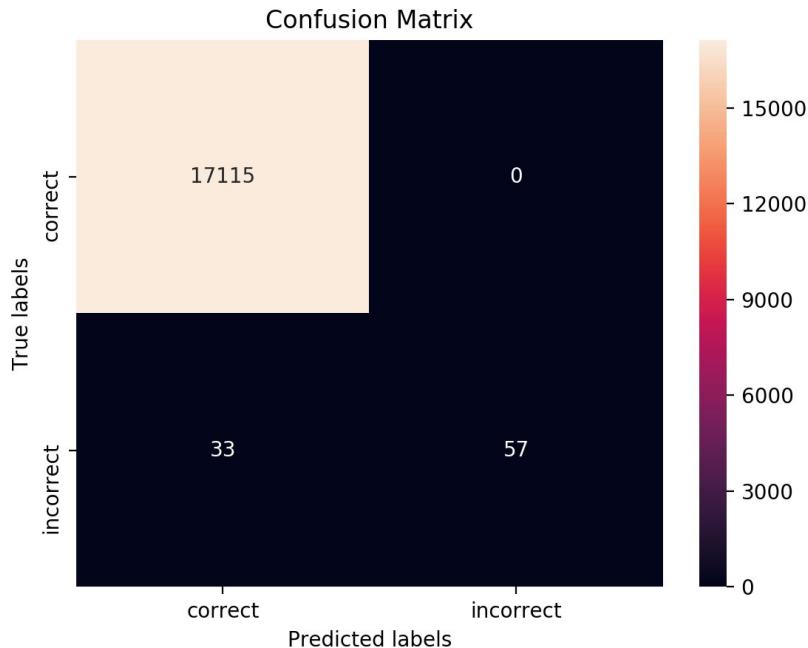
5. Temporal resilience accuracy

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

PHISH DETECTION ACCURACY



TARGET DETECTION RATIO

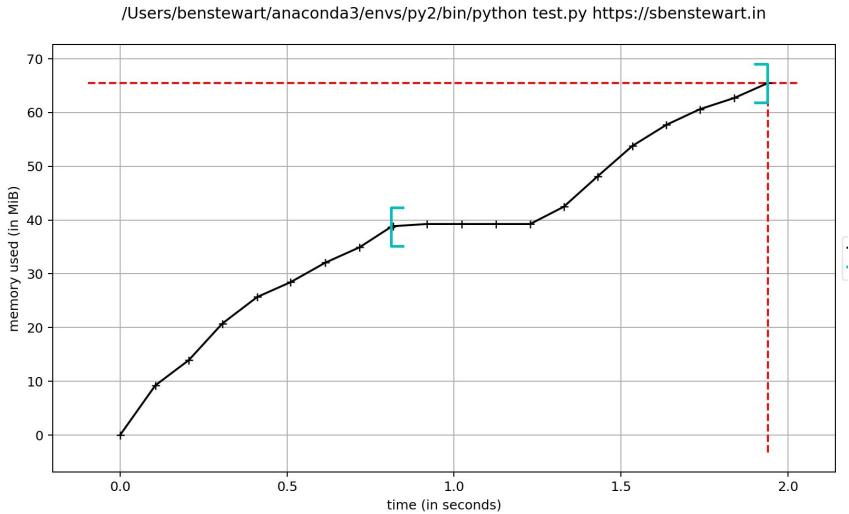


Det. Ratio 0.994
F1 score 0.944
Precision 0.955
Recall 0.933

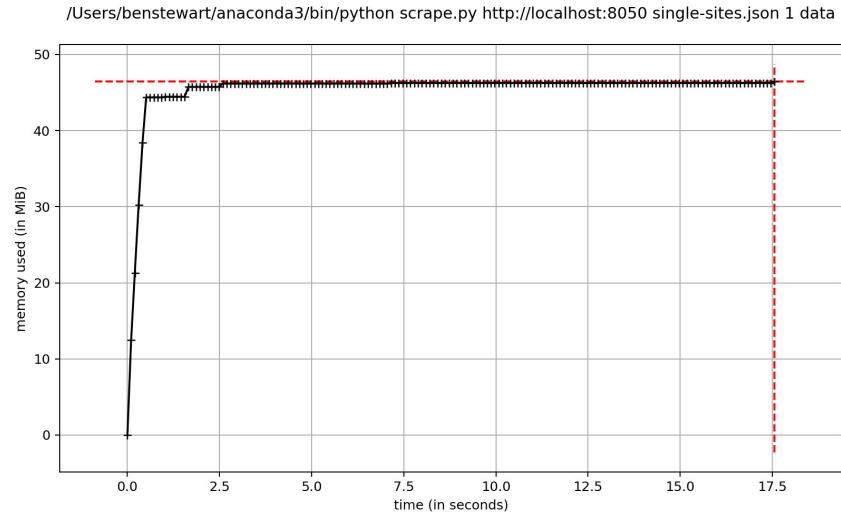
Computed for
threshold=35

MEMORY USAGE PROFILING

PHISH DETECTOR 65 MB

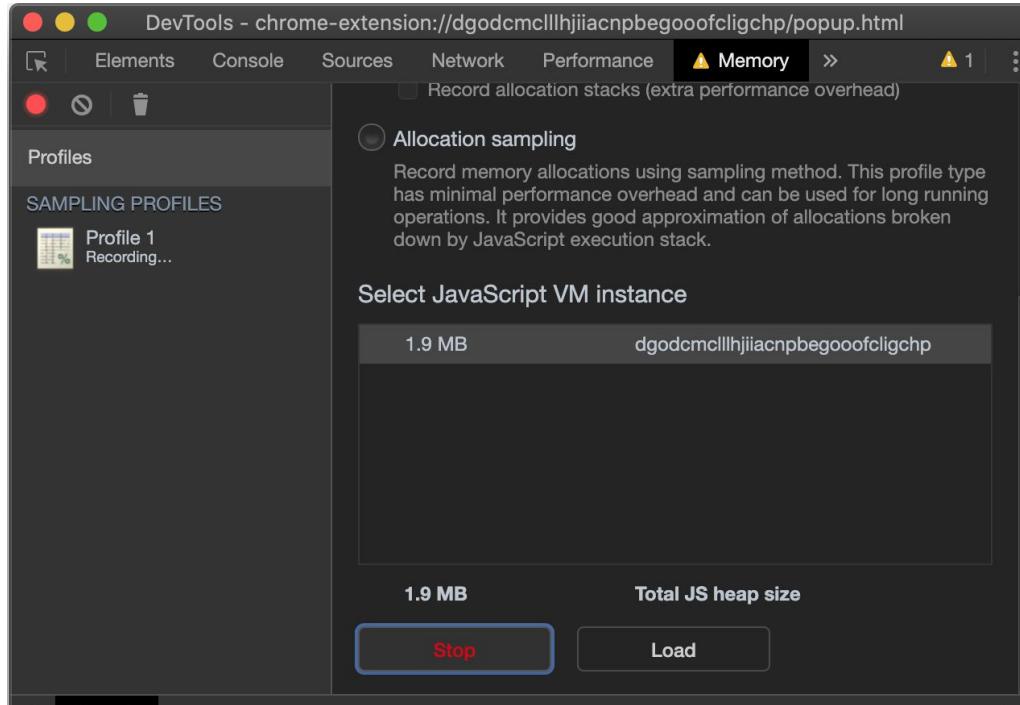


TARGET IDENTIFIER 45 MB

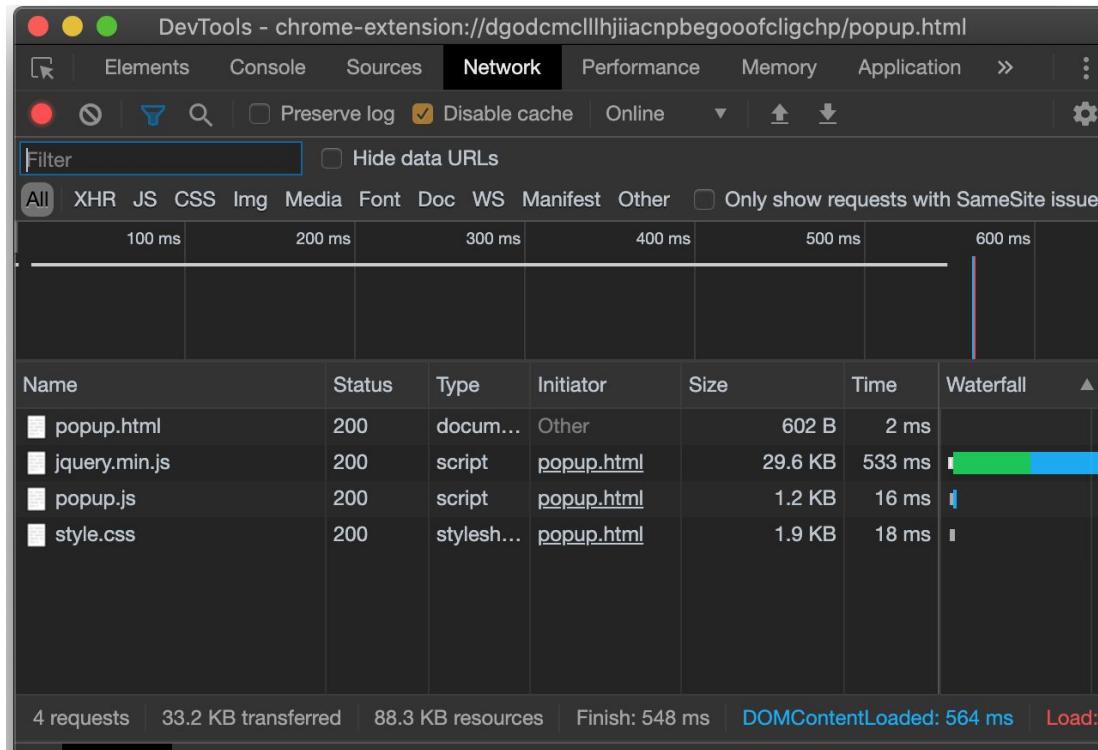


MEMORY USAGE PROFILING

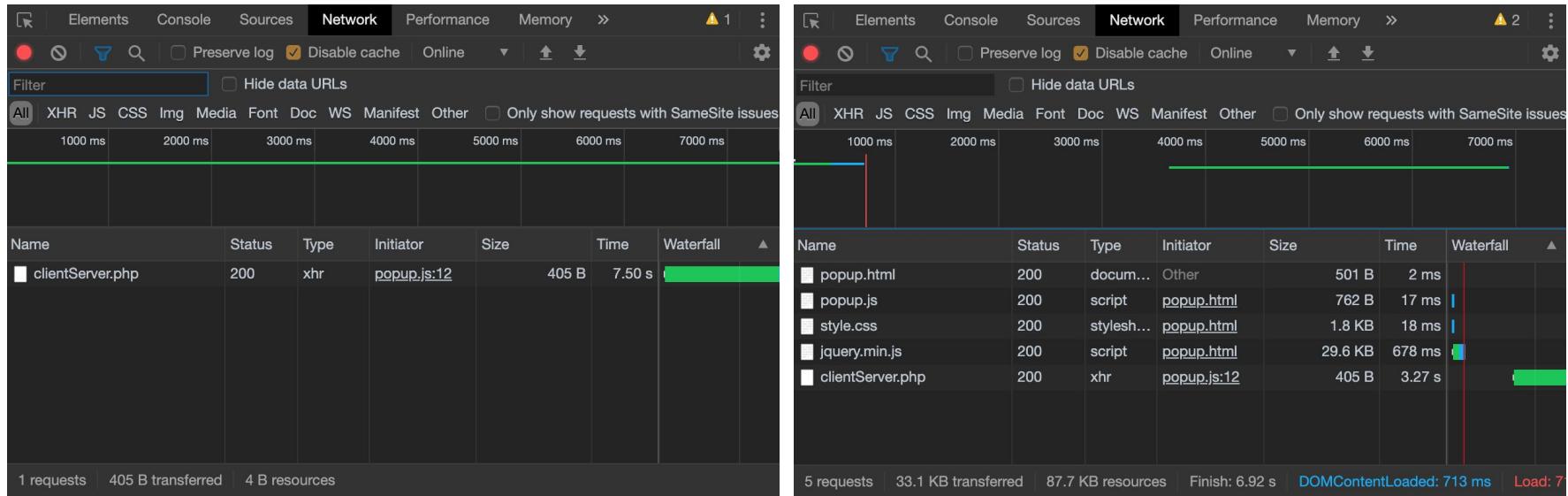
ADDON 1.9 MB



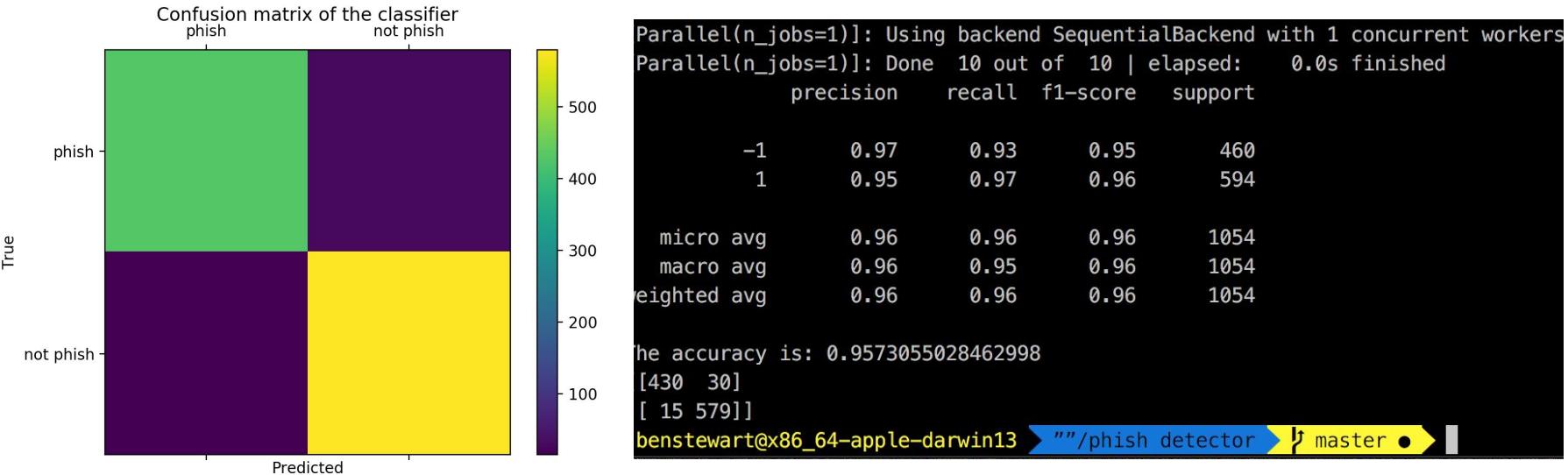
ADDON RENDERING BASE TIME



ADDON RENDERING TIME WITHOUT/WITH AUTO UPDATED WHITELIST



TEMPORAL RESILIENCY ACCURACY



METRICS COMPARISON TABLE

METRIC	PREVIOUS BENCHMARK	OFF-THE-HOOK-PLUS
Phish Detection Accuracy (Percent)	95.54	96.11
Memory Usage (MB)	295	111.9
Execution Time (seconds)	8.74	7.5
Temporal Resiliency (Percent Decrease)	6.44	0.35

TEST CASES

ID	MODULE NAME	ASSUMPTIONS	INPUT	EXPECTED OUTPUT
1_01	Background Script	The user loads a web page using the browser	The URL to the web page	<ul style="list-style-type: none">• Start a background listener• Make the listener data available for the content script
2_01	Content Script	The webpage is fully loaded	The user clicks on the “Safe or not” button	<ul style="list-style-type: none">• Get background script data• Get the web page content• Send to dispatcher
3_01	Dispatcher	The content script dispatches content	The content from the content script	<ul style="list-style-type: none">• Search for URL in whitelist• If yes, send safe message to the output UI
3_02	Dispatcher	The content script dispatches content	The content from the content script	<ul style="list-style-type: none">• Search for URL in whitelist• If no, send the content to the phish detector

TEST CASES - Contd.

ID	MODULE NAME	ASSUMPTIONS	INPUT	EXPECTED OUTPUT
3_03	Dispatcher	The phish detector is sent the content	Phish output from phish detector	<ul style="list-style-type: none">Send the content to the target identifier
3_04	Dispatcher	The phish detector is sent the content	Safe output from phish detector	<ul style="list-style-type: none">Update the whitelistSend safe message to the output UI
3_05	Dispatcher	The target identifier is sent the content	Target output from target identifier	<ul style="list-style-type: none">Send warning message along with the target web page to the output UI

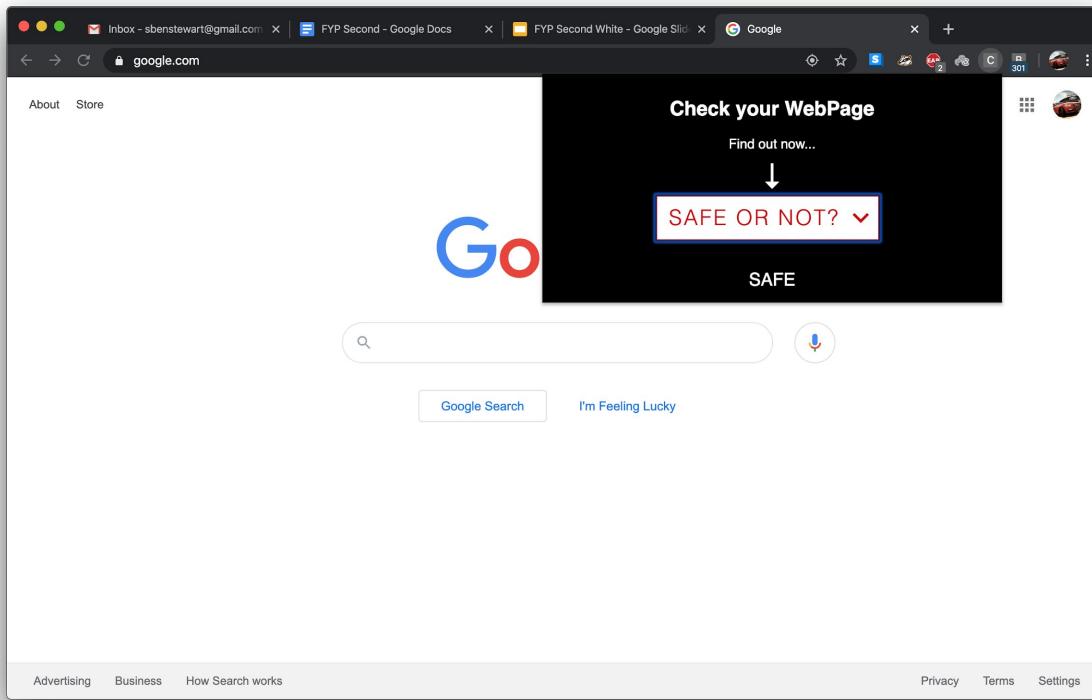
TEST CASES - Contd.

ID	MODULE NAME	ASSUMPTIONS	INPUT	EXPECTED OUTPUT
4_01	Phish Detector	The dispatcher sends the content	The content from the dispatcher	<ul style="list-style-type: none">• Run the model• Publish the result to the dispatcher
5_01	Target Identifier	The dispatcher sends the content	The content from the dispatcher	<ul style="list-style-type: none">• Run the model• Publish the target web page to the dispatcher
6_01	Output UI	The Output UI gets the content from the dispatcher	Safe message from the dispatcher	<ul style="list-style-type: none">• Set the safe message on the user interface
6_02	Output UI	The Output UI gets the content from the dispatcher	Warning message from the dispatcher	<ul style="list-style-type: none">• Set the warning message on the user interface• Display the target web page

RESULTS

- Developed with languages with support for cross platforms
- Google index and web traffic for temporal resilience
- Feature selection to reduce the memory requirements
- Target identification using SHA based similarity
- Scraper for target identifier to maintain identification accuracy over time
- Lightweight addon that needs only 2MB for Chrome

SAFE HTML CONTENT

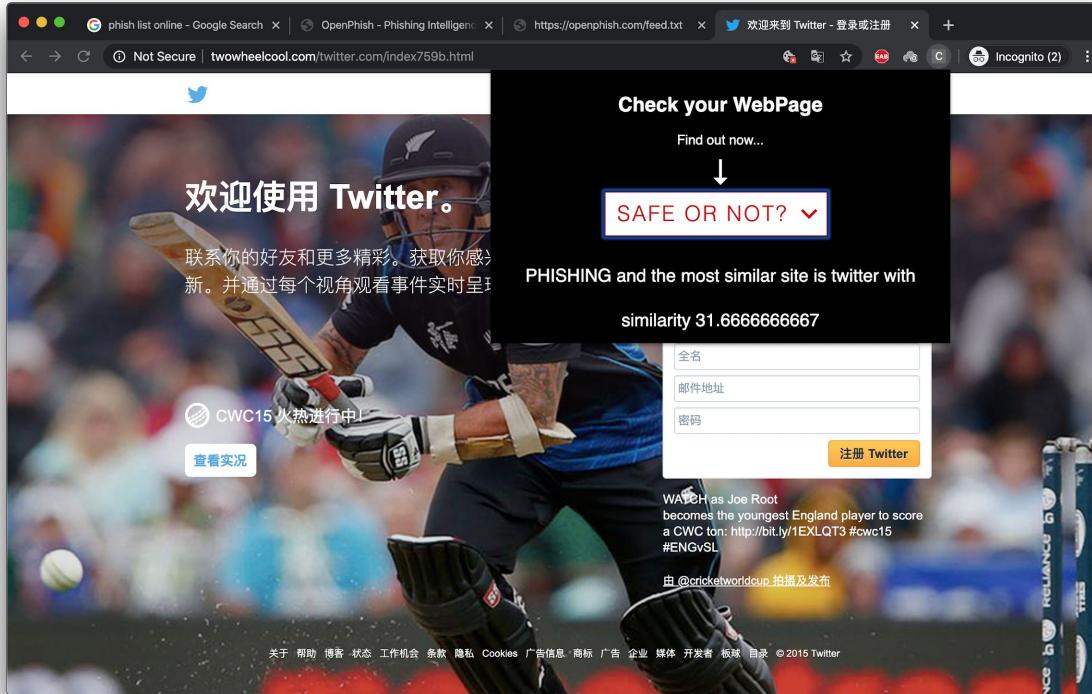


SAFE HTML CONTENT

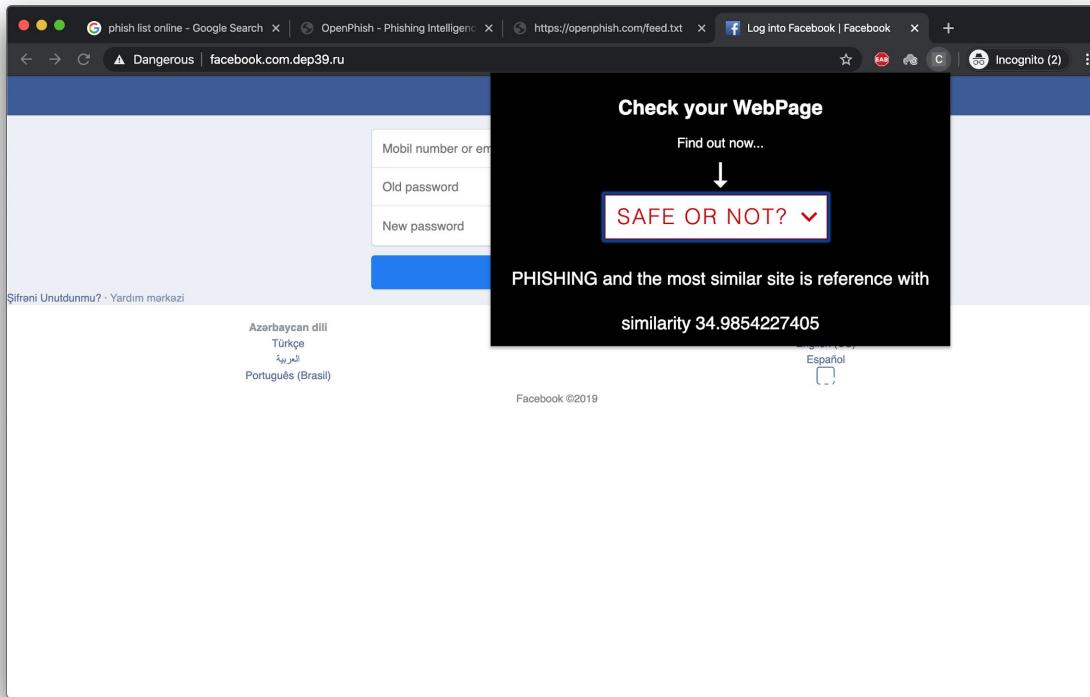
The screenshot shows a browser window with the URL annauniv.edu. The main content is the official website of Anna University, featuring sections for TANCET 2020, GRADUATION DAY 2019, and TANCA 2019. A central sidebar displays news items and links to various university services. Overlaid on the right 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

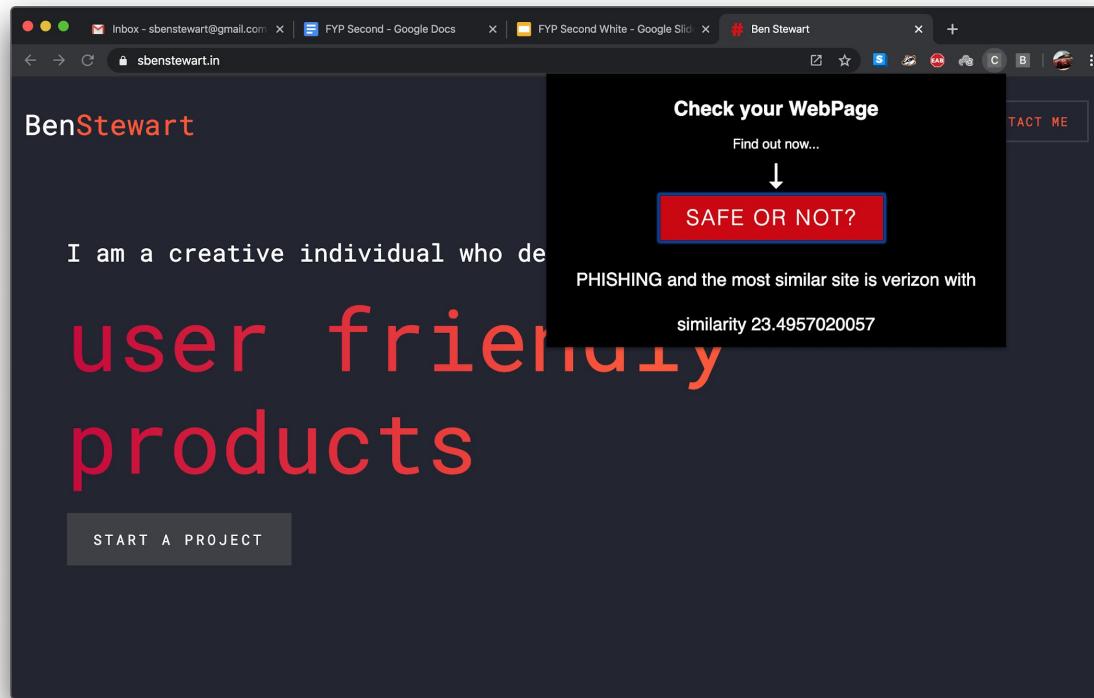
PHISHING HTML CONTENT



PHISHING HTML CONTENT



WRONG HTML CONTENT



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.