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

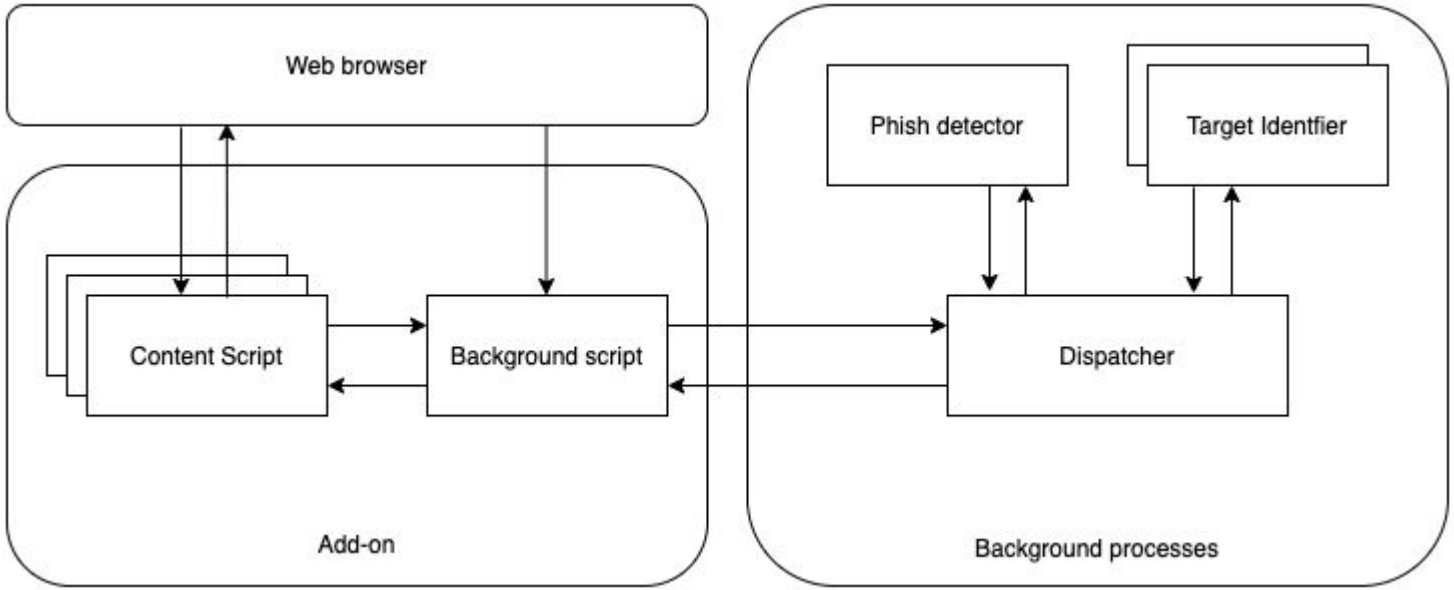
- Mahdieh Zabihimayvan and Derek Doran
- IEEE International Conference on Fuzzy Systems, June 2019
- Fuzzy Rough Set (FRS) theory
- Feature selection algorithm
- Random Forest classification
- No third party features

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.

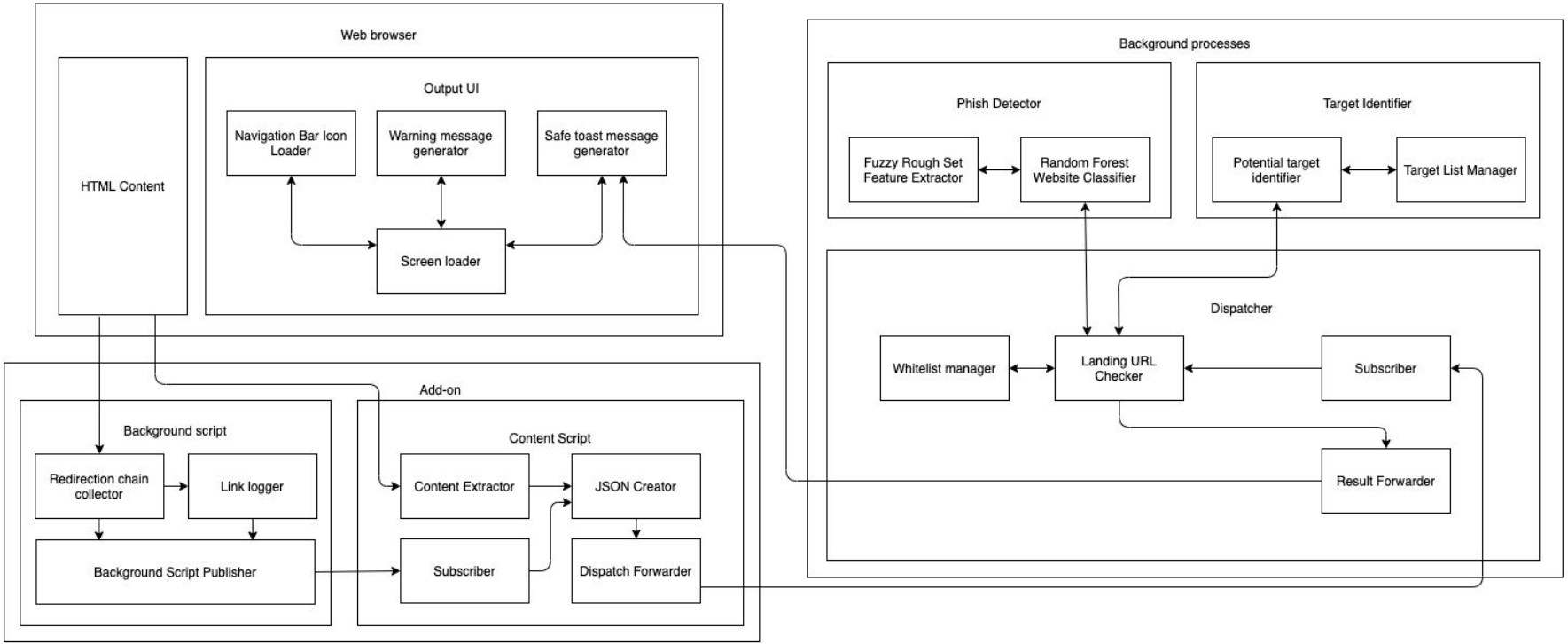
PROPOSED SYSTEM

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

SYSTEM ARCHITECTURE



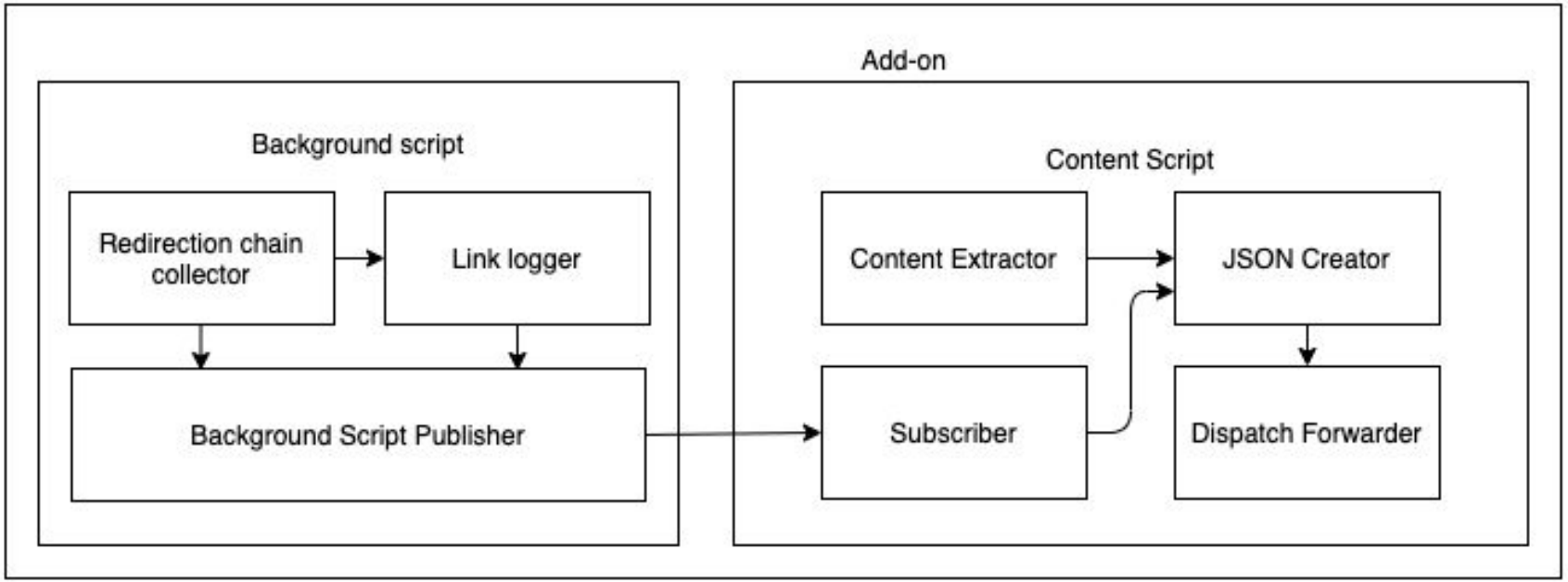
HIGH LEVEL BLOCK DIAGRAM



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


Add-on
Background script
Redirection chain collector
Link logger
Background Script Publisher
Content Script
Content Extractor
JSON Creator
Subscriber
Dispatch Forwarder

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

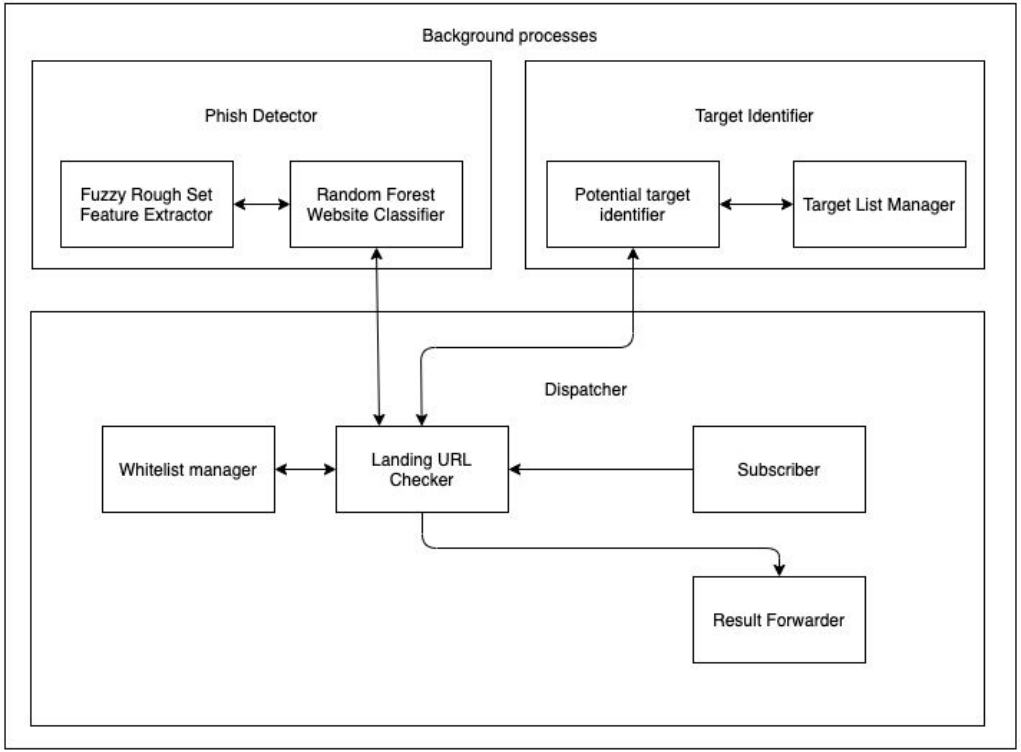
Get redirection list from background script

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

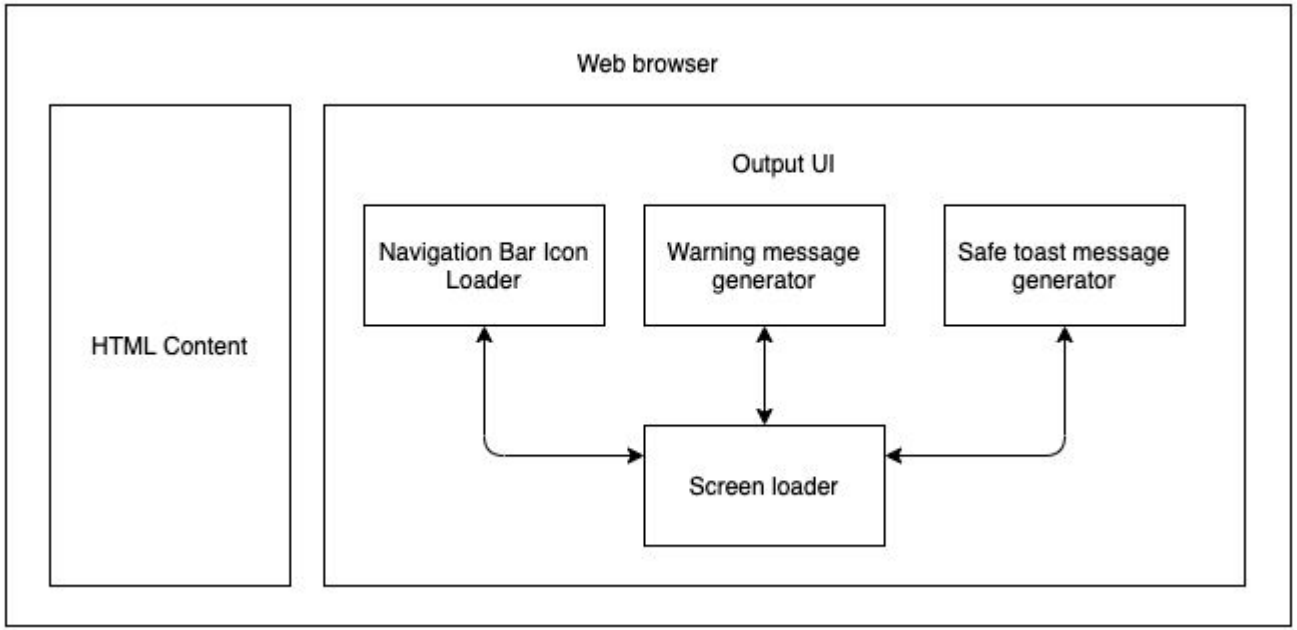
Store (MA + mod2) AND 2^31 as mod3

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


Web browser
HTML Content
Output UI
Navigation Bar Icon Loader
Warning message generator
Safe toast message generator
Screen loader

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

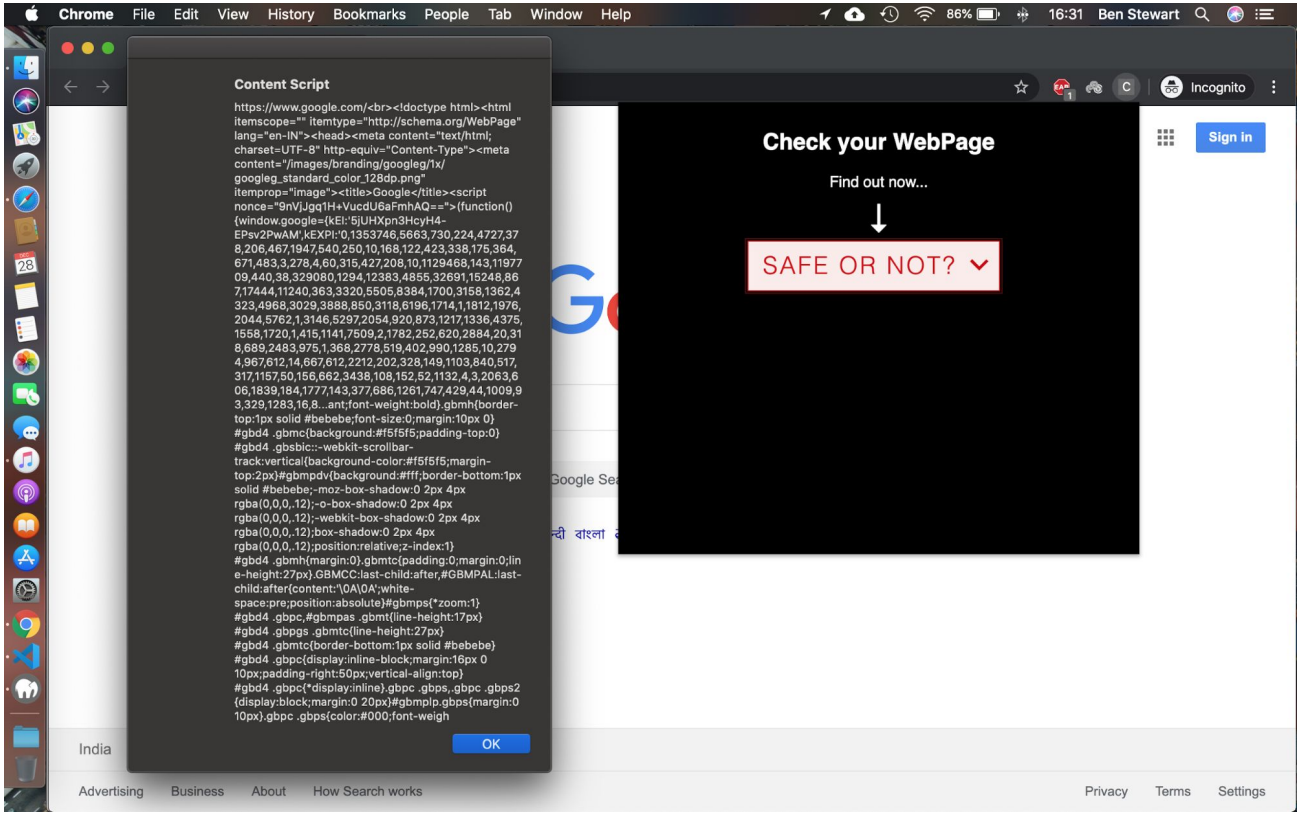
Display safe to proceed message

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

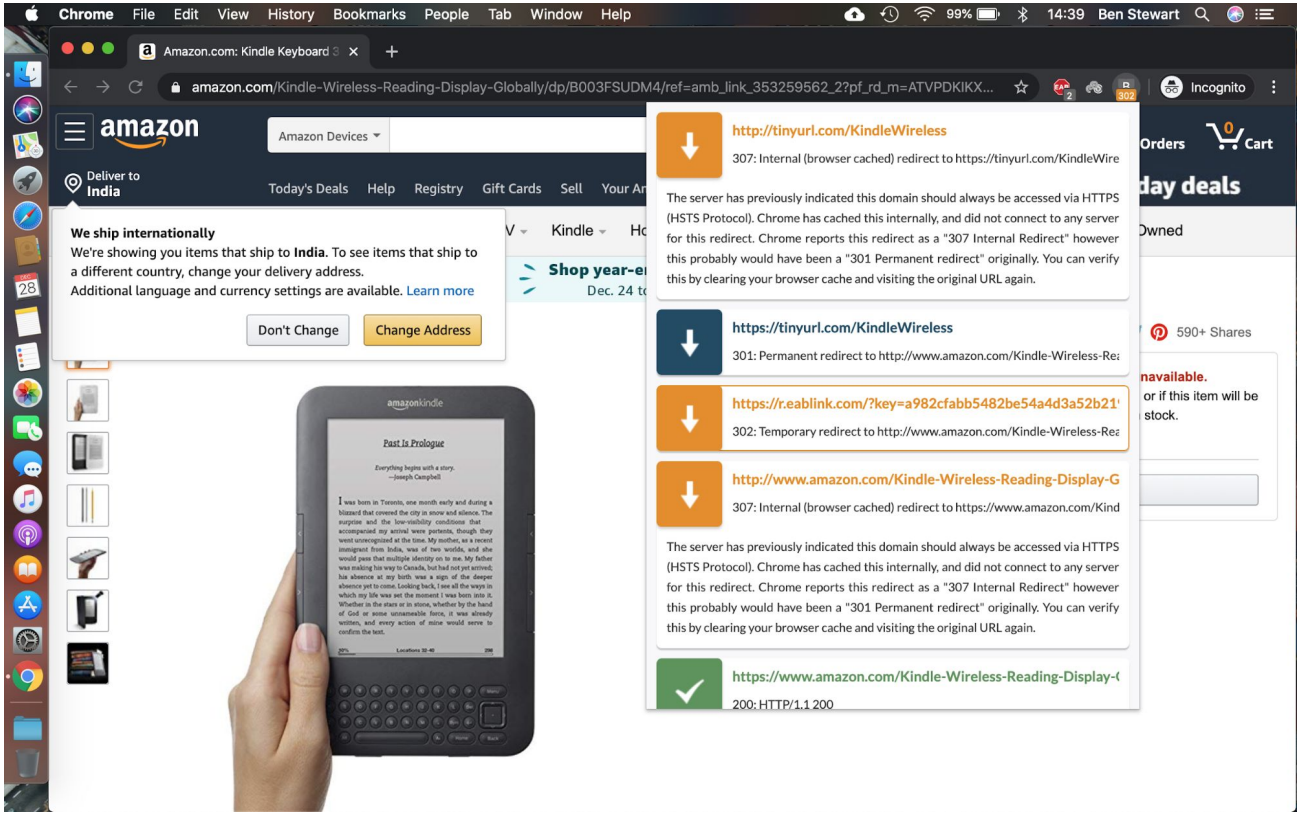


CONTENT SCRIPT

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

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

BACKGROUND SCRIPT



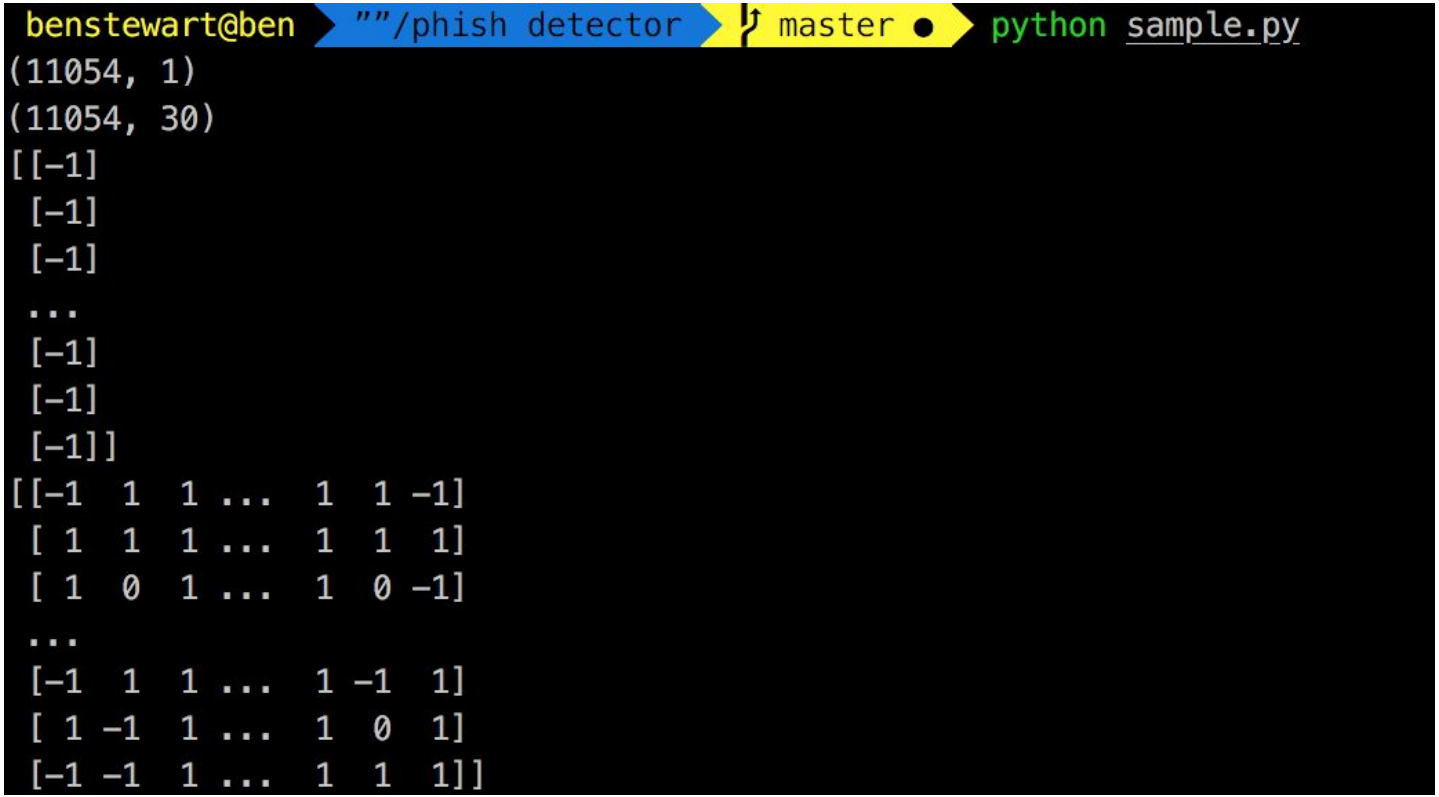
BACKGROUND SCRIPT

```
//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
- Scraped from PhishTank
- Up-to-date

FEATURE SELECTION



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  master ● ?
```

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

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   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)
```

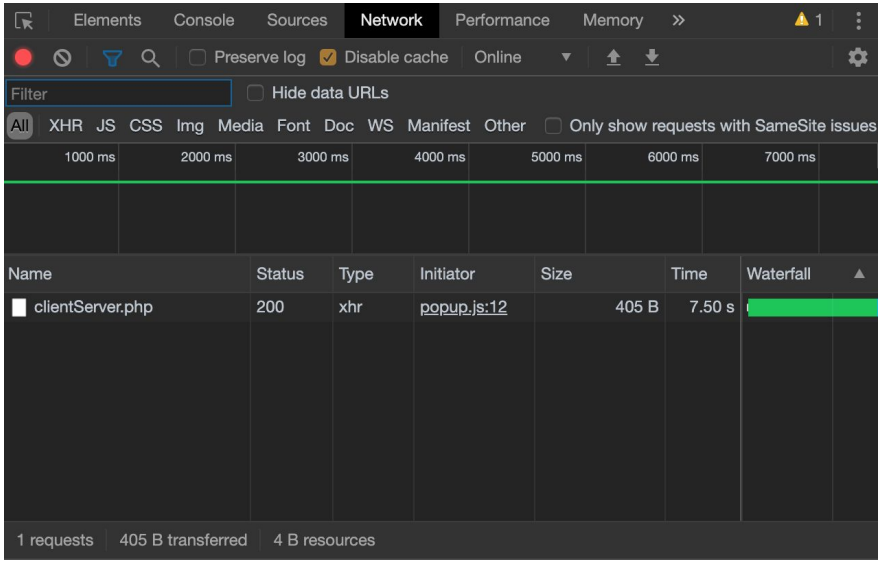
TARGET IDENTIFIER

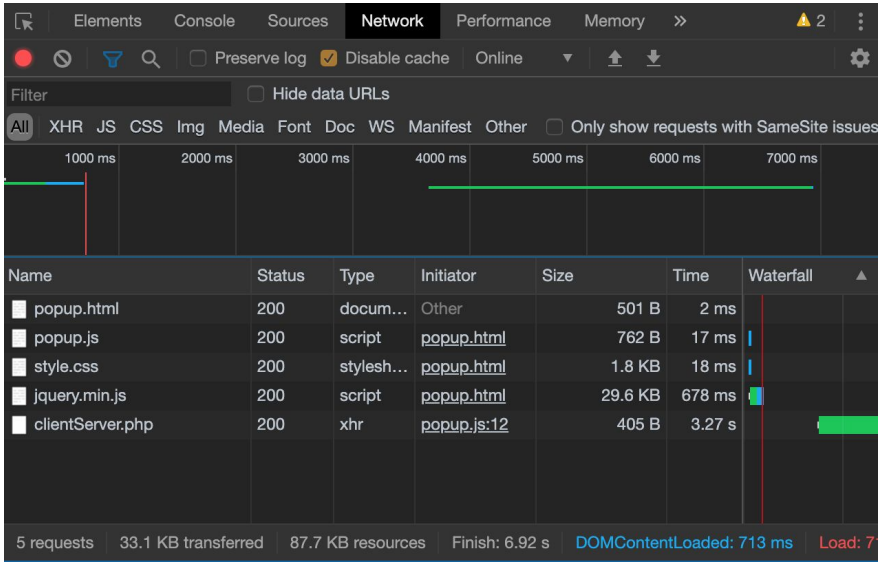
```
[ benstewart@ben  ""/target identifier  python3 score-compare-tags.py compare-tags.json
Maximum f1 0.944 at threshold=35 tp=84 fp=4 fn=6 prec=0.955 rec=0.933
 benstewart@ben  ""/target identifier
```

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





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)

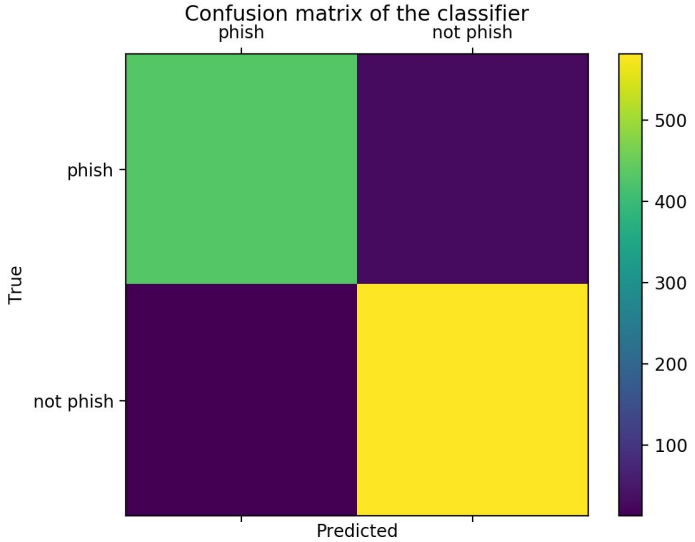
4. Addon rendering time

Rendering Time = End time - Start time

5. Temporal resilience accuracy

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

PHISH DETECTION ACCURACY




```
[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

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The accuracy is: 0.961100569259962
[[435  25]
 [ 16 578]]
 benstewart@ben  ""/phish detector  master ● ?
```
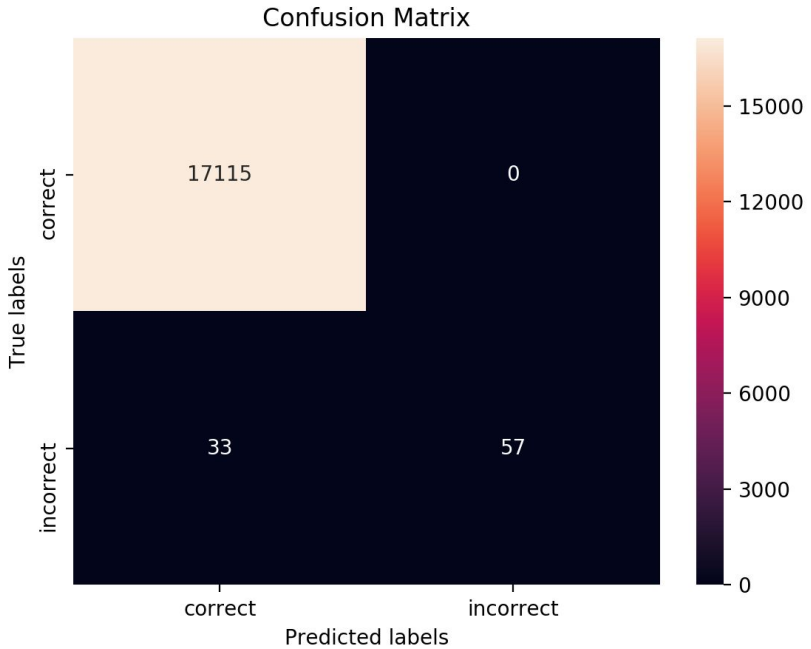

TARGET DETECTION RATIO

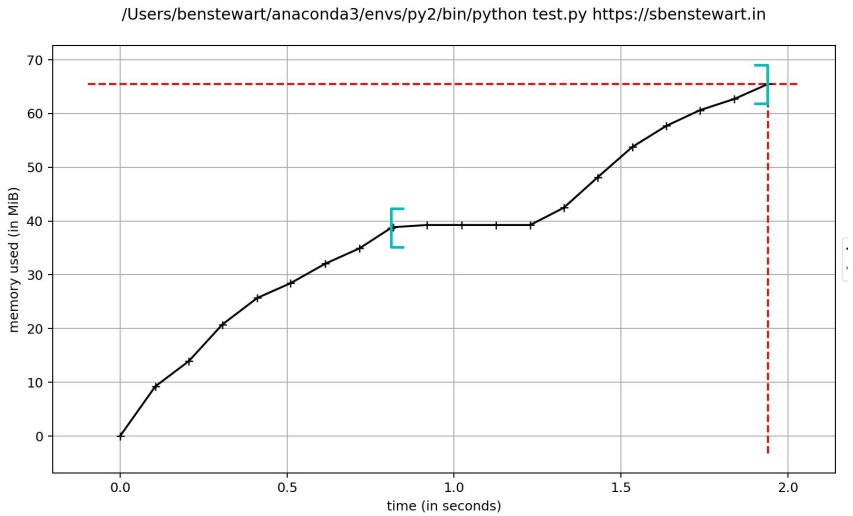


Det. Ratio	0.994
F1 score	0.944
Precision	0.955
Recall	0.933

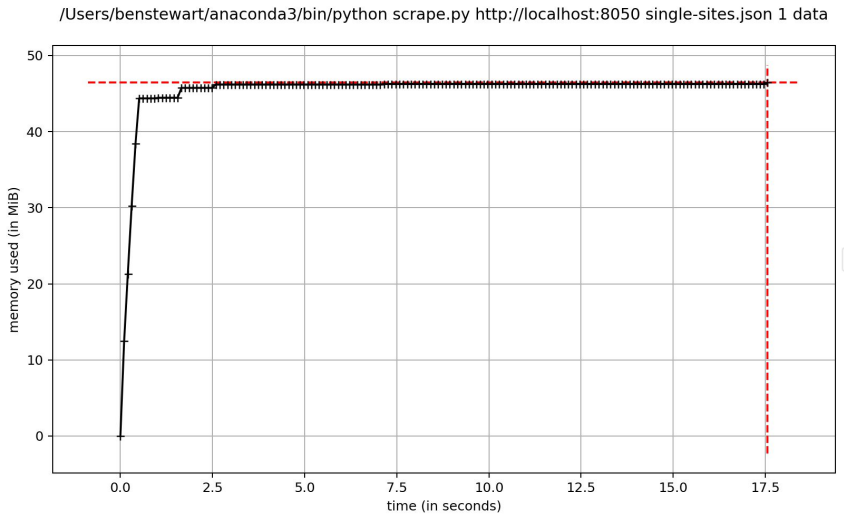
Computed for threshold=35

MEMORY USAGE PROFILING

PHISH DETECTOR 65 MB

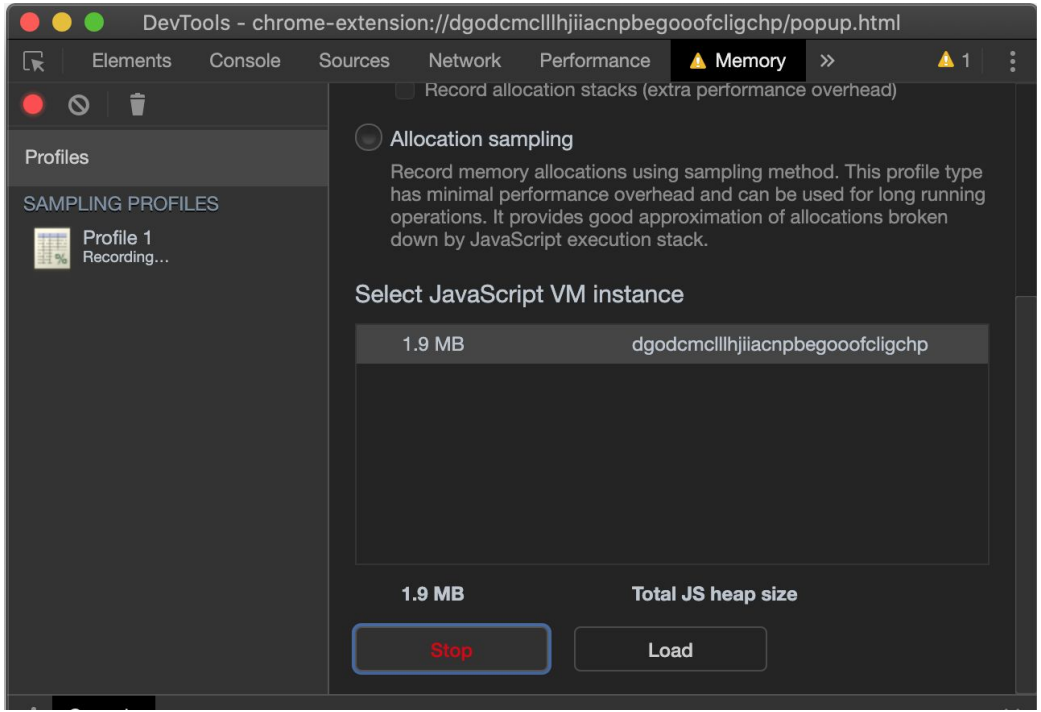


TARGET IDENTIFIER 45 MB

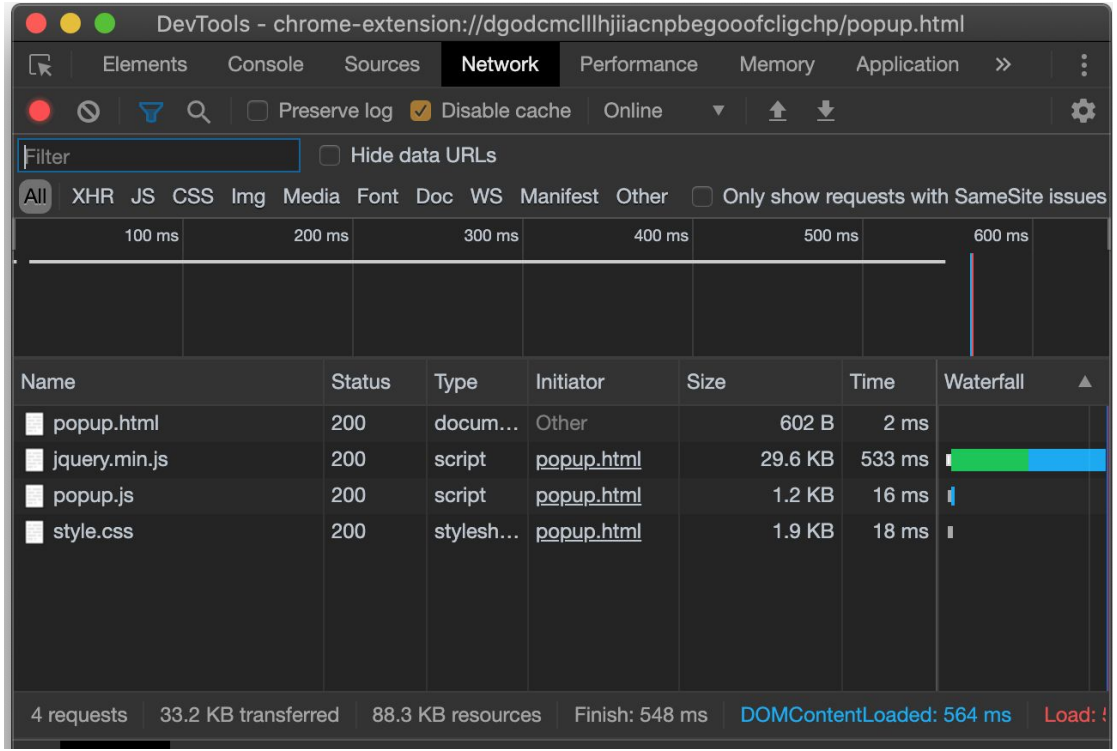


MEMORY USAGE PROFILING

ADDON 1.9 MB

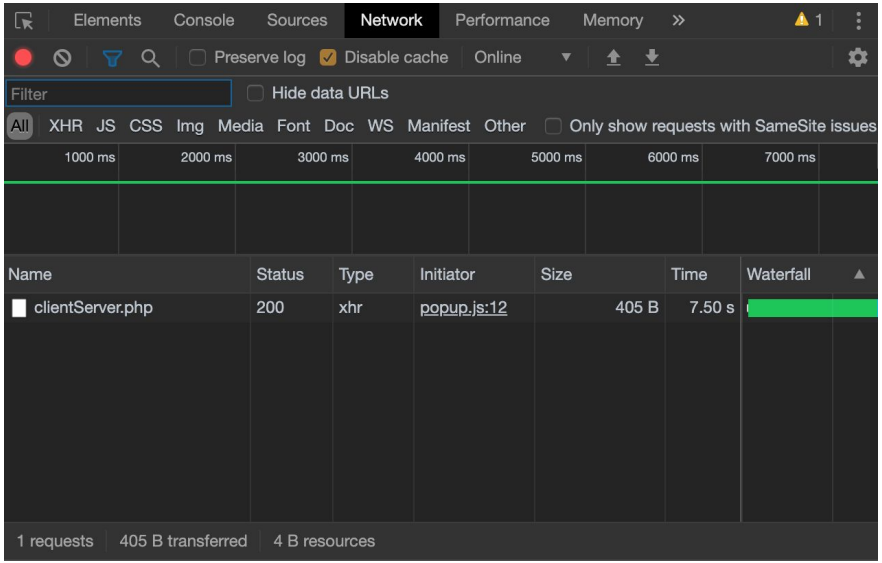


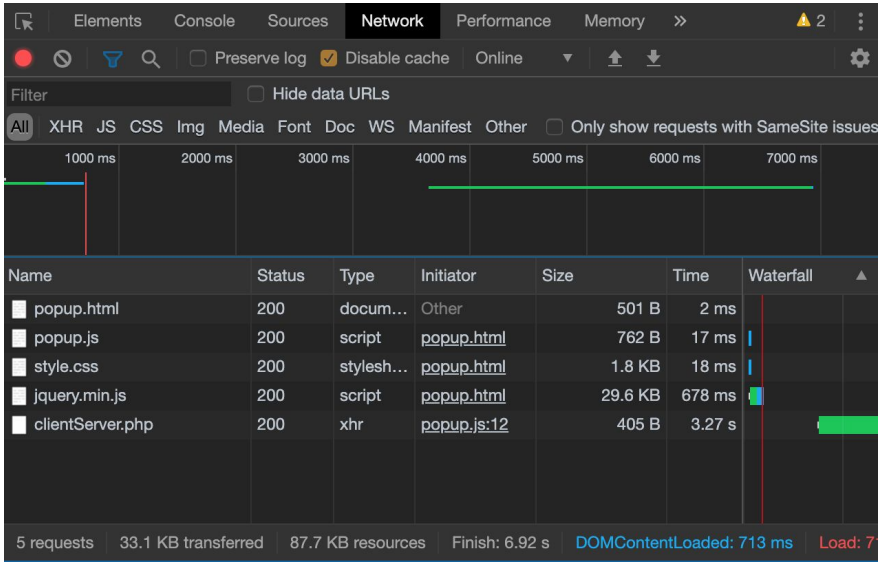
ADDON RENDERING BASE TIME



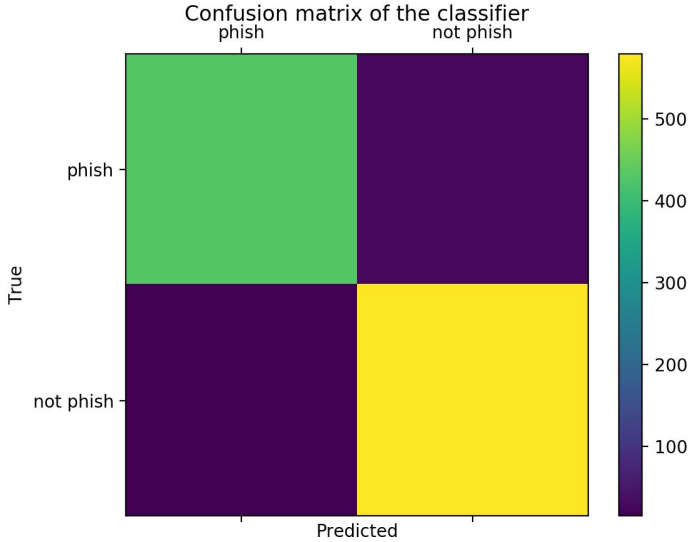
ADDON RENDERING TIME

WITHOUT/WITH AUTO UPDATED WHITELIST





TEMPORAL RESILIENCY ACCURACY




```
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       0.97      0.93      0.95       460
           1       0.95      0.97      0.96       594

   micro avg       0.96      0.96      0.96      1054
   macro avg       0.96      0.95      0.96      1054
eighted avg       0.96      0.96      0.96      1054

he accuracy is: 0.9573055028462998
[430  30]
[ 15 579]]
benstewart@x86_64-apple-darwin13  ""/phish detector  master ●
```

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	• 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	• 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	• 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	• 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	• Send the content to the target identifier
3_04	Dispatcher	The phish detector is sent the content	Safe output from phish detector	• Update the whitelist • Send safe message to the output UI
3_05	Dispatcher	The target identifier is sent the content	Target output from target identifier	• Send warning message along with the target web page to the output UI

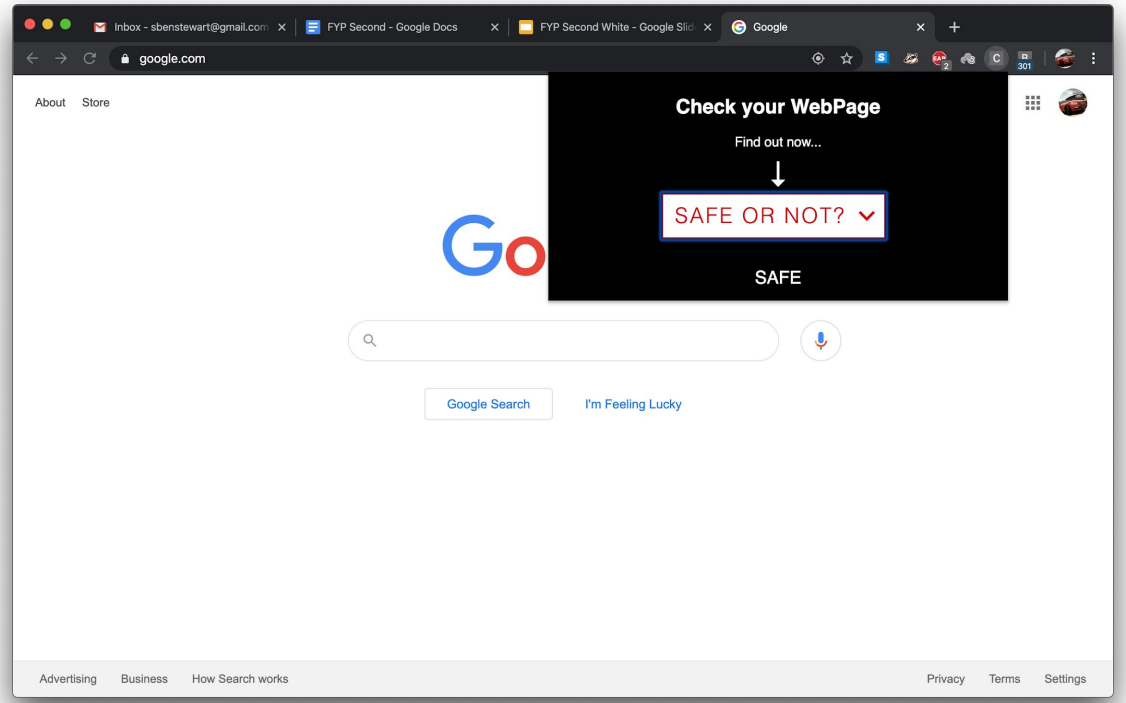
TEST CASES - Contd.

ID	MODULE NAME	ASSUMPTIONS	INPUT	EXPECTED OUTPUT
4_01	Phish Detector	The dispatcher sends the content	The content from the dispatcher	• Run the model • Publish the result to the dispatcher
5_01	Target Identifier	The dispatcher sends the content	The content from the dispatcher	• 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	• 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	• Set the warning message on the user interface • Display the target web page

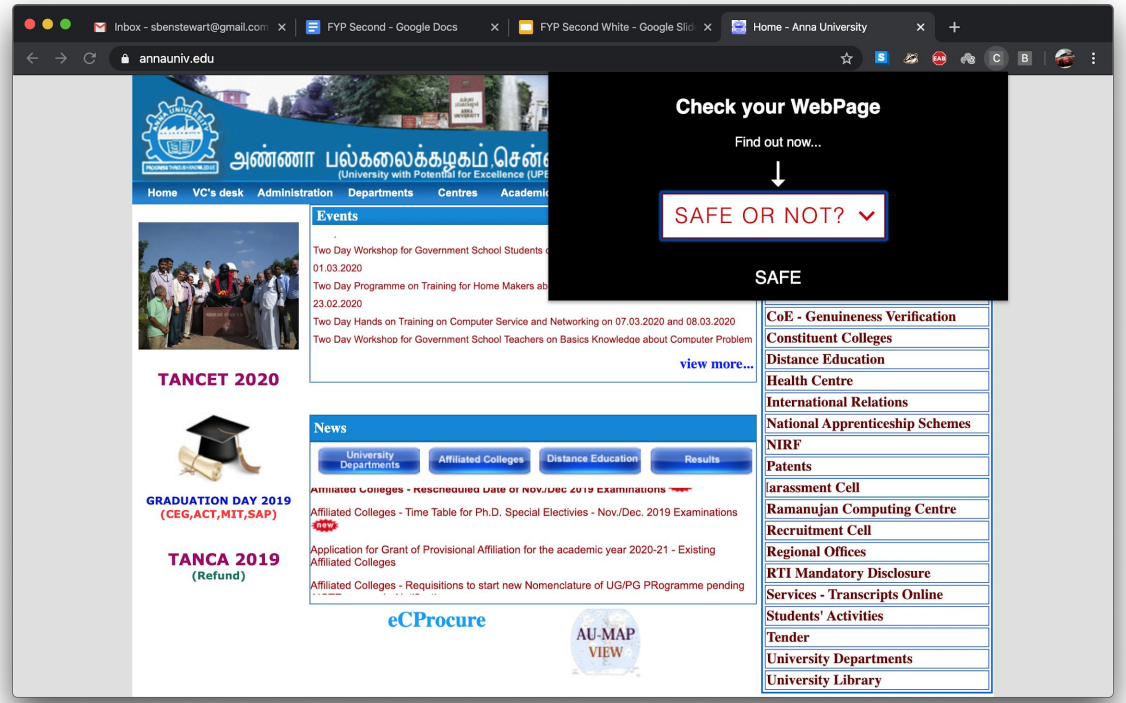
RESULTS

- 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

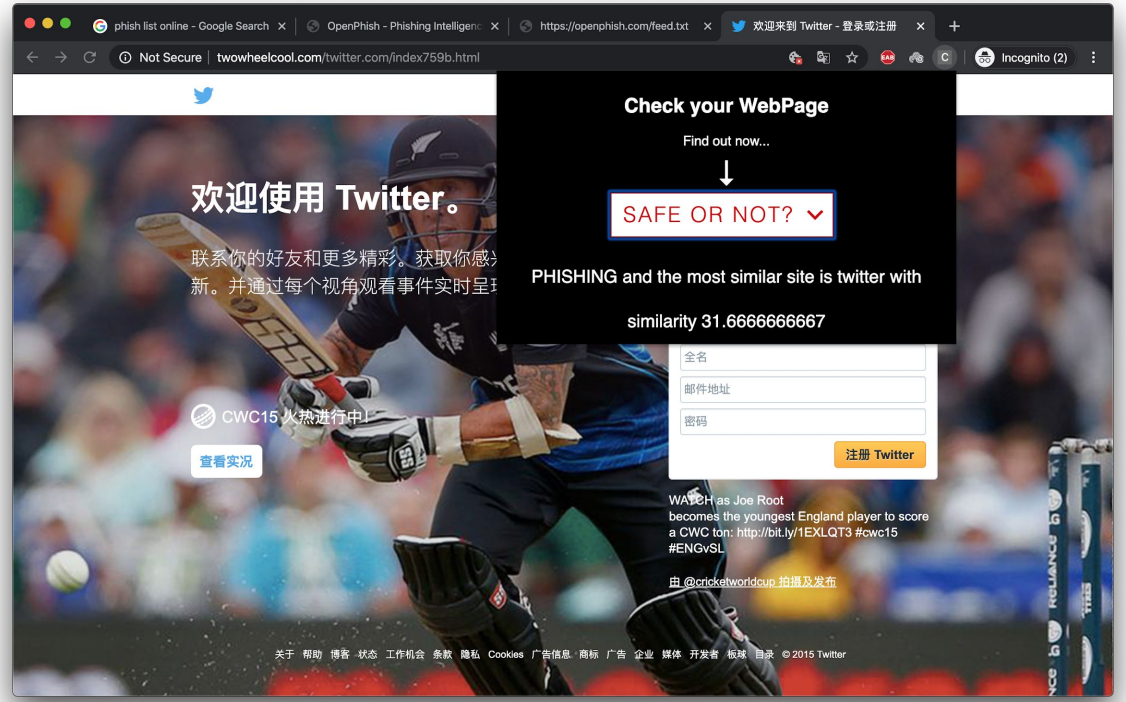
SAFE HTML CONTENT



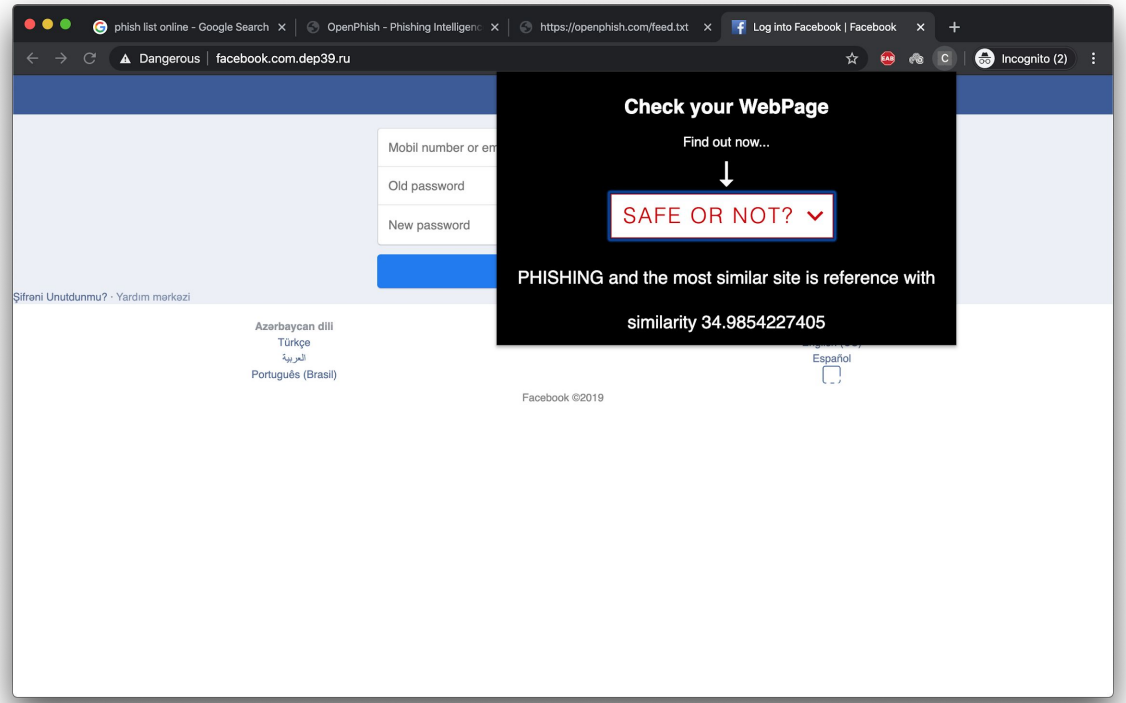
SAFE HTML CONTENT



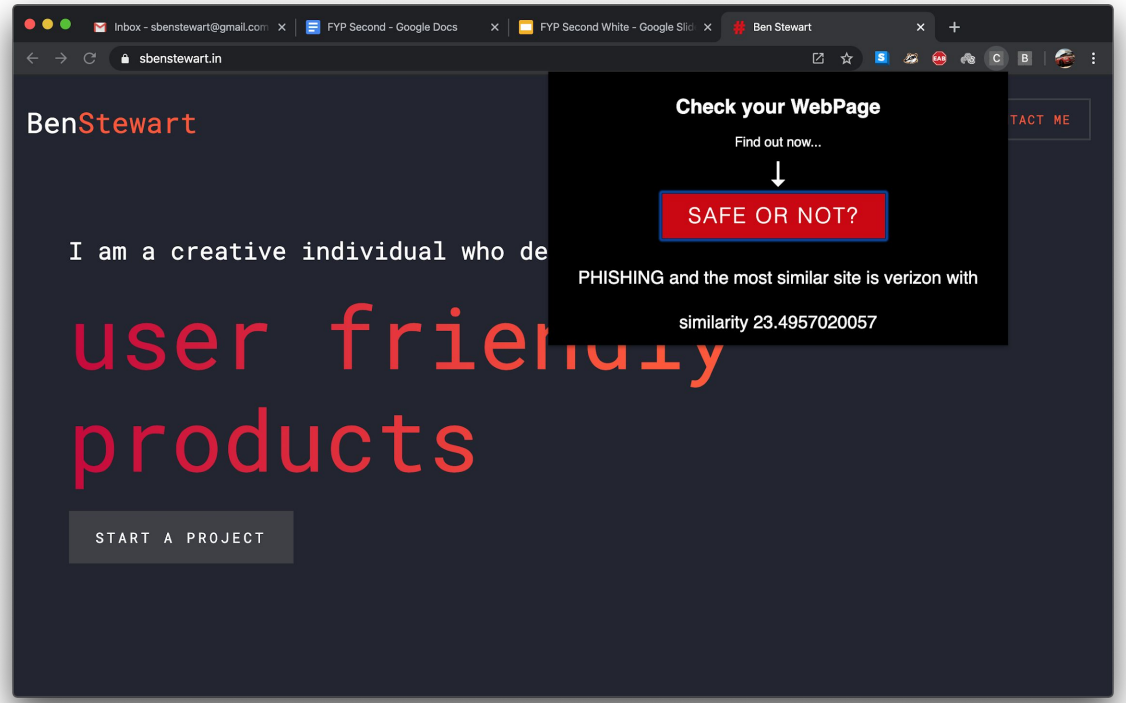
PHISHING HTML CONTENT



PHISHING HTML CONTENT



WRONG HTML CONTENT



CONCLUSION

- Off-the-hook-plus
- Client side
- Cross platform compatible
- Time constraints
- Resource constraints
- Target detection

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.