Phishing Website Detector

The dataset is from UCI Repository(https://archive.ics.uci.edu/ml/datasets/phishing+websites#).
It has 11055 instances and 31 attributes(=features) including the label, **Result**. The description on these attributes is on the website above.
Some of the attributes are url length, age of domain, whether domain name is separated by the dash(-) symbol.
Result is either 1 or -1 and the other 30 attributes are among -1, 0, and 1.

(1) Data preprocessing

The numbers in the original dataset are not integer type, so we had to preprocess the dataset.

(2) Feature selection

We had difficulty in getting all 30 attributes in the dataset.
So we measured the importance of each feature and tried to get the important features first.
After all we used the 11 features that we were able to get among the most important features.

(3) Correlation between the features

Because the feature values are among -1, 0, and 1, it was easy to see the correlation between the features.
Especially seeing the **Result** column below, we could see how each attribute was correlated to **Result**.
Prefix_Suffix, having_Sub_Domain, URL_of_Anchor were positively correlated to **Result**.

(4) Training-test dataset split

To get accuracy from the model, we split the dataset into training set(67%) and the test set(33%).
After measuring the accuracy, we will make a new model with the whole dataset, in order to increase the accuracy to the real data.

(5) Model selection

We tried some basic classifiers including Decision Tree, KNN and MLP first, and then tried some more complex classifiers including RandomForest, AdaBoost, and voting classifier.
The latter are called ensemble classifiers which are a combination of different classifiers. They are usually more powerful than other basic classifiers.
Voting classifier is the classifier we used for our final model.

In [1]:

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from joblib import dump, load

from scipy.io import arff

from sklearn.model_selection import train_test_split

from sklearn.metrics import f1_score,confusion_matrix
from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix

from sklearn import tree
from sklearn.neighbors import KNeighborsClassifier
from sklearn.neural_network import MLPClassifier

from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.ensemble import VotingClassifier
from sklearn.svm import SVC

import tensorflow as tf

%matplotlib inline
```

In [2]:

```
data, meta = arff.loadarff("phishingdataset.arff")
```

(1) Data preprocessing

In [3]:

```
data = pd.DataFrame(data)
data = data.astype(str)
r = {"b'1'": '1', "b'-1'": '-1', "b'0'": '0'}
data = data.replace(r)
data = data.astype(int)

X = data.iloc[:,:-1] # features
y = data.iloc[:,-1]  # class
```

In [4]:

```
data.head()
```

Out[4]:

	having_IP_Address	URL_Length	Shortining_Service	having_At_Symbol	double_slash_redirecting	Prefix_Suffix	h
0	-1	1	1	1	-1	-1	-
1	1	1	1	1	1	-1	0
2	1	0	1	1	1	-1	-
3	1	0	1	1	1	-1	-
4	1	0	-1	1	1	-1	1

5 rows × 31 columns

In [5]:

```
X.head()
```

Out[5]:

	having_IP_Address	URL_Length	Shortining_Service	having_At_Symbol	double_slash_redirecting	Prefix_Suffix	h
0	-1	1	1	1	-1	-1	-
1	1	1	1	1	1	-1	0
2	1	0	1	1	1	-1	-
3	1	0	1	1	1	-1	-
4	1	0	-1	1	1	-1	1

5 rows × 30 columns

(2) Feature selection

In [6]:

```
rf_for_emb = RandomForestClassifier()
rf_for_emb = rf_for_emb.fit(X, y)
importances = rf_for_emb.feature_importances_
std = np.std([tree.feature_importances_ for tree in rf_for_emb.estimators_], axis=0)
indices = np.argsort(importances)[::-1]

print("Feature ranking:")
```

```python
for f in range(X.shape[1]):
    print("%d. %s (%f)" % (f + 1, X.columns[indices[f]], importances[indices[f]]))
```

```
Feature ranking:
1. URL_of_Anchor (0.300594)
2. SSLfinal_State (0.298838)
3. web_traffic (0.073366)
4. having_Sub_Domain (0.059822)
5. Links_in_tags (0.044369)
6. Prefix_Suffix (0.023269)
7. Links_pointing_to_page (0.018241)
8. Request_URL (0.018214)
9. SFH (0.017234)
10. age_of_domain (0.015983)
11. Domain_registeration_length (0.013423)
12. Google_Index (0.012619)
13. DNSRecord (0.012305)
14. having_IP_Address (0.011518)
15. Page_Rank (0.009678)
16. URL_Length (0.008367)
17. HTTPS_token (0.006794)
18. having_At_Symbol (0.006735)
19. Statistical_report (0.006367)
20. Submitting_to_email (0.005795)
21. Abnormal_URL (0.005267)
22. Redirect (0.004855)
23. Favicon (0.004592)
24. popUpWidnow (0.004580)
25. Shortining_Service (0.004576)
26. on_mouseover (0.003488)
27. double_slash_redirecting (0.002995)
28. Iframe (0.002665)
29. port (0.001929)
30. RightClick (0.001522)
```

In [7]:

```python
data = data[['having_IP_Address','URL_Length','having_At_Symbol','Shortining_Service','double_slash_redirecting','Prefix_Suffix','having_Sub_Domain','HTTPS_token','URL_of_Anchor','age_of_domain','Page_Rank','Result']]

X = data.iloc[:,:-1] # features
y = data.iloc[:,-1]  # class
```

In [8]:

```python
X.head()
```

Out[8]:

	having_IP_Address	URL_Length	having_At_Symbol	Shortining_Service	double_slash_redirecting	Prefix_Suffix	h
0	-1	1	1	1	-1	-1	-
1	1	1	1	1	1	-1	0
2	1	0	1	1	1	-1	-
3	1	0	1	1	1	-1	-
4	1	0	1	-1	1	-1	1

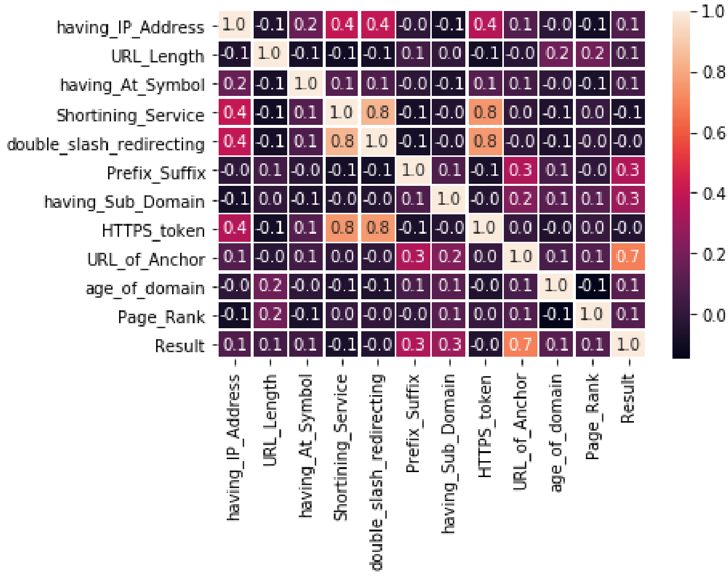
(3) Correlation between the features

In [9]:

```python
sns.heatmap(data.corr(), annot=True, linewidths=.5, fmt='.1f')
```

Out[9]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2493f141978>
```



(4) Training-test dataset split

In [10]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, random_state=42)

# X_train = (7406, 11), X_test = (3649, 11)
```

(5) Model selection

In [11]:

```
# Model Selection 1 (Basic classifiers)

# (1) Decision Trees

dt0 = tree.DecisionTreeClassifier()
dt0.fit(X_train, y_train)
print("Decision tree :", dt0.score(X_test, y_test))

dt1 = tree.DecisionTreeClassifier(min_samples_leaf=4)
dt1.fit(X_train, y_train)
print("Decision tree, min_samples_leaf = 4 :", dt1.score(X_test, y_test))

dt2 = tree.DecisionTreeClassifier(min_samples_leaf=6)
dt2.fit(X_train, y_train)
print("Decision tree, min_samples_leaf = 6 :", dt2.score(X_test, y_test))
print()


# (2) KNN

knn0 = KNeighborsClassifier(n_neighbors = 18)
knn0.fit(X_train, y_train)
print("KNN, K=18 :", knn0.score(X_test, y_test))

knn1 = KNeighborsClassifier(n_neighbors = 25)
knn1.fit(X_train, y_train)
print("KNN, K=25 :", knn1.score(X_test, y_test))
print()


# (3) MLP

mlp0 = MLPClassifier(hidden_layer_sizes=(15, 15))
mlp0.fit(X_train, y_train)
```

```python
print("MLP, (15, 15) :", mlp0.score(X_test, y_test))

mlp1 = MLPClassifier(hidden_layer_sizes=(15, 15, 15))
mlp1.fit(X_train, y_train)
print("MLP, (15, 15, 15) :", mlp1.score(X_test, y_test))

mlp2 = MLPClassifier(hidden_layer_sizes=(20, 20))
mlp2.fit(X_train, y_train)
print("MLP, (20, 20) :", mlp2.score(X_test, y_test))

mlp3 = MLPClassifier(hidden_layer_sizes=(30, 30))
mlp3.fit(X_train, y_train)
print("MLP, (30, 30) :", mlp3.score(X_test, y_test))
print()


# (4) SVM
svc0 = SVC()
svc0.fit(X_train, y_train)
print("SVM :", svc0.score(X_test, y_test))
print()


# (5) Neural Network
onehoty_train = pd.get_dummies(y_train, prefix='Result', columns=['Result'])
onehoty_test = pd.get_dummies(y_test, prefix='Result', columns=['Result'])

n_nodes_input = 11 # number of input features
n_nodes_hl = 11     # number of units in a hidden layer
n_classes = 2       # classes
a = tf.placeholder('float', [None, 11])
b = tf.placeholder('float')

def neural_network_model(data):
    # define weights and biases for all each layer
    hidden_layer = {'weights':tf.Variable(tf.truncated_normal([n_nodes_input, n_nodes_hl], stddev=0.3))
,
                    'biases':tf.Variable(tf.constant(0.1, shape=[n_nodes_hl]))}
    output_layer = {'weights':tf.Variable(tf.truncated_normal([n_nodes_hl, n_classes], stddev=0.3)),
                   'biases':tf.Variable(tf.constant(0.1, shape=[n_classes]))}
    # feed forward and activations
    l1 = tf.add(tf.matmul(data, hidden_layer['weights']), hidden_layer['biases'])
    l1 = tf.nn.sigmoid(l1)
    output = tf.matmul(l1, output_layer['weights']) + output_layer['biases']

    return output

def train_neural_network(a):
    prediction = neural_network_model(a)
    cost = tf.reduce_mean(tf.nn.sigmoid_cross_entropy_with_logits(labels=b,logits=prediction))
    optimizer = tf.train.AdamOptimizer().minimize(cost)

    sess = tf.InteractiveSession()
    tf.global_variables_initializer().run()
    for epoch in range(1000):
        loss = 0
        _, c = sess.run([optimizer, cost], feed_dict = {a: X_train, b: onehoty_train})
        loss += c
        if (epoch % 100 == 0 and epoch != 0):
            print('Epoch', epoch, 'completed out of', 1000, 'Training loss:', loss)
    correct = tf.equal(tf.argmax(prediction,1), tf.argmax(b,1))
    accuracy = tf.reduce_mean(tf.cast(correct, tf.float32), name='op_accuracy')

    print('Train set Accuracy:', sess.run(accuracy, feed_dict = {a: X_train, b: onehoty_train}))
    print('Test set Accuracy:', sess.run(accuracy, feed_dict = {a: X_test, b: onehoty_test}))

train_neural_network(a)
```

```
Decision tree : 0.8799671142778843
Decision tree, min_samples_leaf = 4 : 0.8755823513291313
Decision tree, min_samples_leaf = 6 : 0.8769525897506166

KNN, K=18 : 0.8646204439572486
KNN, K=25 : 0.8648944916415456

MLP, (15, 15) : 0.882159495752260?
```

```
MLP, (15, 15) : 0.8821594957522609
MLP, (15, 15, 15) : 0.8780487804878049
MLP, (20, 20) : 0.8859961633324198
MLP, (30, 30) : 0.8862702110167169

SVM : 0.8851740202795286

Epoch 100 completed out of 1000 Training loss: 0.639824390411377
Epoch 200 completed out of 1000 Training loss: 0.5855611562728882
Epoch 300 completed out of 1000 Training loss: 0.5258331298828125
Epoch 400 completed out of 1000 Training loss: 0.475236713886261
Epoch 500 completed out of 1000 Training loss: 0.4353886544704437
Epoch 600 completed out of 1000 Training loss: 0.40431588888168335
Epoch 700 completed out of 1000 Training loss: 0.3802022337913513
Epoch 800 completed out of 1000 Training loss: 0.36199402809143066
Epoch 900 completed out of 1000 Training loss: 0.34853559732437134
Train set Accuracy: 0.8537672
Test set Accuracy: 0.8613319
```

In [12]:

```python
# Model Selection 2 (Ensemble)

# (1) RandomForest

RFclf0 = RandomForestClassifier()
RFclf0.fit(X_train, y_train)
print("RandomForest :", RFclf0.score(X_test, y_test))

RFclf1 = RandomForestClassifier(n_estimators = 20)
RFclf1.fit(X_train, y_train)
print("RandomForest, n_estimators=20 :", RFclf1.score(X_test, y_test))
print()


# (2) Bagging

bag0 = BaggingClassifier()
bag0.fit(X_train, y_train)
print("Bagging :", bag0.score(X_test, y_test))

bag1 = BaggingClassifier(base_estimator=KNeighborsClassifier(n_neighbors=3))
bag1.fit(X_train, y_train)
print("Bagging, base_estimator=KNN(k=3) :", bag1.score(X_test, y_test))

bag2 = BaggingClassifier(base_estimator=KNeighborsClassifier(n_neighbors=28))
bag2.fit(X_train, y_train)
print("Bagging, base_estimator=KNN(k=28) :", bag2.score(X_test, y_test))
print()


# (3) AdaBoost

ABclf0 = AdaBoostClassifier() #n_estimators=50, learning_rate = 1
ABclf0.fit(X_train, y_train)
print("AdaBoost :", ABclf0.score(X_test, y_test))

ABclf1 = AdaBoostClassifier(n_estimators=200, learning_rate = 0.5)
ABclf1.fit(X_train, y_train)
print("AdaBoost, n_estimators=200, learning_rate=0.5 :", ABclf1.score(X_test, y_test))

ABclf2 = AdaBoostClassifier(n_estimators=400, learning_rate = 0.5)
ABclf2.fit(X_train, y_train)
print("AdaBoost, n_estimators=400, learning_rate=0.5 :", ABclf2.score(X_test, y_test))
print()
```

```
RandomForest : 0.8802411619621814
RandomForest, n_estimators=20 : 0.8843518772266374

Bagging : 0.8821594957522609
Bagging, base_estimator=KNN(k=3) : 0.8701013976431899
Bagging, base_estimator=KNN(k=28) : 0.8640723485886544

AdaBoost : 0.8553028226911482
AdaBoost, n_estimators=200, learning_rate=0.5 : 0.8555768703754453
```

```
AdaBoost, n_estimators=400, learning_rate=0.5 : 0.8547547273225541
```

In [13]:

```python
# (4) Voting
voteclf1 = VotingClassifier(
    estimators=[('dt0', tree.DecisionTreeClassifier()),
                ('mlp0', MLPClassifier(hidden_layer_sizes=(15, 15))),
                ('mlp3', MLPClassifier(hidden_layer_sizes=(30, 30))),
                ('RFclf1', RandomForestClassifier(n_estimators = 20)),
                ('bag0', BaggingClassifier())],
    voting='soft')
voteclf1.fit(X_train, y_train)
print("Voting, DT & MLP & RF & BAGGING :", voteclf1.score(X_test, y_test))
```

```
Voting, DT & MLP & RF & BAGGING : 0.8879144971224994
```

```
C:\Users\user\Anaconda3\envs\deeplearning\lib\site-packages\sklearn\preprocessing\label.py:151: Depreca
tionWarning: The truth value of an empty array is ambiguous. Returning False, but in future this will r
esult in an error. Use `array.size > 0` to check that an array is not empty.
  if diff:
```

In [14]:

```python
# Prediction examples using KNN
#print(knn0.predict([[1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1]]))
#print(knn0.predict([[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]]))
```

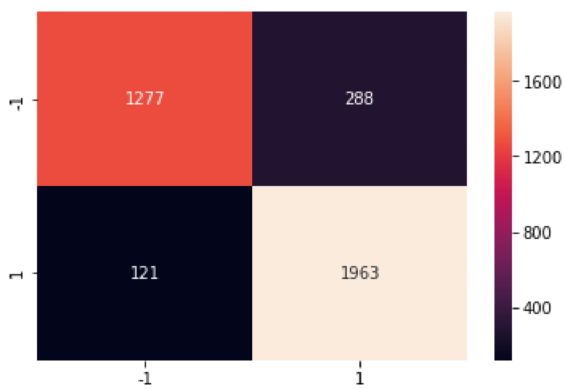
In [15]:

```python
cm = confusion_matrix(y_test, voteclf1.predict(X_test), labels = [-1, 1])
sns.heatmap(cm, annot = True, fmt = "d", xticklabels = [-1, 1], yticklabels = [-1, 1])
```

```
C:\Users\user\Anaconda3\envs\deeplearning\lib\site-packages\sklearn\preprocessing\label.py:151: Depreca
tionWarning: The truth value of an empty array is ambiguous. Returning False, but in future this will r
esult in an error. Use `array.size > 0` to check that an array is not empty.
  if diff:
```

Out[15]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x24941afbf98>
```



In [16]:

```python
voteclf1 = VotingClassifier(
    estimators=[('dt0', tree.DecisionTreeClassifier()),
                ('mlp0', MLPClassifier(hidden_layer_sizes=(15, 15))),
                ('mlp3', MLPClassifier(hidden_layer_sizes=(30, 30))),
                ('RFclf1', RandomForestClassifier(n_estimators = 20)),
                ('bag0', BaggingClassifier())],
    voting='soft')
voteclf1.fit(X, y) # Here we used all the instances to train a new model
```

```python
voteclf1.fit(X, y) # here we used all the instances to train a new model
```

Out[16]:

```
VotingClassifier(estimators=[('dt0', DecisionTreeClassifier(class_weight=None, criterion='gini', max_de
pth=None,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_lea...estimators=10, n_jobs=1, oob_score=False, random_state=None,
         verbose=0, warm_start=False))],
         flatten_transform=None, n_jobs=1, voting='soft', weights=None)
```

In [17]:

```python
dump(voteclf1, 'model.joblib')
```

Out[17]:

```
['model.joblib']
```

In [ ]:

```python
# from joblib import dump, load
# dump(clf, 'filename.joblib')
# clf = load('filename.joblib')
```