In [1]:
```
# Importing Data Manipilation Libraries
import pandas as pd
import numpy as np

# Import Data Visualization Libraries

import matplotlib.pyplot as plt
import seaborn as sns
from scipy import stats

# Import Data Filter Libraries
import warnings
warnings.filterwarnings('ignore')

# Import Data Logging Libraries
import logging
logging.basicConfig(level = logging.INFO,
                        filename = 'model.log',
                        filemode = 'w',
                        format = '%(asctime)s - %(levelname)s - %(message)s')

# Multicolinearity test and treatment libraries
from statsmodels.stats.outliers_influence import variance_inflation_factor
from sklearn.decomposition import PCA
```

In [2]:
```
pd.set_option('display.max_columns', None)
pd.set_option('display.max_rows', 100)
```

Loading Dataset

In [3]:
```
# Loading the dataset

url = 'https://raw.githubusercontent.com/mukeshmagar543/CODEB_Internship/refs/heads

df = pd.read_csv(url)

df.sample(frac = 1) # Data Shuffle
```

Out[3]:

	url	length_url	length_hostname	ip	nb_d
291	https://www.internetslang.com/DNA-meaning-defi...	56	21	0	
3383	http://likeshare.hop.ru/#identifier	35	16	0	
7589	http://www.thefreedictionary.com/cladistics	43	25	0	
5927	http://www.arrowcase.com/wp-content/plugins/ba...	69	17	0	
1266	http://www.tv.pl/	17	9	0	
...	...	...	...	...	...
11141	https://ru.wikipedia.org/wiki/LATAM_Chile	41	16	0	
7012	http://kankakeetankwash.com/en	30	20	0	
10114	http://hortipower.co.uk/recepit46/customer_cen...	86	16	0	

8956	http://marthocendol.blogspot.com/	33	25	0
3650	https://dallas174.arvixeshared.com/~fosco999/	45	26	0

11430 rows × 89 columns

Getting Information about Dataset Like which column is object and which column is numerical

In [4]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 11430 entries, 0 to 11429
Data columns (total 89 columns):
 #   Column                      Non-Null Count  Dtype
---  ------                      --------------  -----
 0   url                         11430 non-null  object
 1   length_url                  11430 non-null  int64
 2   length_hostname             11430 non-null  int64
 3   ip                          11430 non-null  int64
 4   nb_dots                     11430 non-null  int64
 5   nb_hyphens                  11430 non-null  int64
 6   nb_at                       11430 non-null  int64
 7   nb_qm                       11430 non-null  int64
 8   nb_and                      11430 non-null  int64
 9   nb_or                       11430 non-null  int64
 10  nb_eq                       11430 non-null  int64
 11  nb_underscore               11430 non-null  int64
 12  nb_tilde                    11430 non-null  int64
 13  nb_percent                  11430 non-null  int64
 14  nb_slash                    11430 non-null  int64
 15  nb_star                     11430 non-null  int64
 16  nb_colon                    11430 non-null  int64
 17  nb_comma                    11430 non-null  int64
 18  nb_semicolumn               11430 non-null  int64
 19  nb_dollar                   11430 non-null  int64
 20  nb_space                    11430 non-null  int64
 21  nb_www                      11430 non-null  int64
 22  nb_com                      11430 non-null  int64
 23  nb_dslash                   11430 non-null  int64
 24  http_in_path                11430 non-null  int64
 25  https_token                 11430 non-null  int64
 26  ratio_digits_url            11430 non-null  float64
 27  ratio_digits_host           11430 non-null  float64
 28  punycode                    11430 non-null  int64
 29  port                        11430 non-null  int64
 30  tld_in_path                 11430 non-null  int64
 31  tld_in_subdomain            11430 non-null  int64
 32  abnormal_subdomain          11430 non-null  int64
 33  nb_subdomains               11430 non-null  int64
 34  prefix_suffix               11430 non-null  int64
 35  random_domain               11430 non-null  int64
 36  shortening_service          11430 non-null  int64
 37  path_extension              11430 non-null  int64
 38  nb_redirection              11430 non-null  int64
 39  nb_external_redirection     11430 non-null  int64
 40  length_words_raw            11430 non-null  int64
 41  char_repeat                 11430 non-null  int64
 42  shortest_words_raw          11430 non-null  int64
 43  shortest_word_host          11430 non-null  int64
```

```
 44  shortest_word_path          11430 non-null  int64
 45  longest_words_raw           11430 non-null  int64
 46  longest_word_host           11430 non-null  int64
 47  longest_word_path           11430 non-null  int64
 48  avg_words_raw               11430 non-null  float64
 49  avg_word_host               11430 non-null  float64
 50  avg_word_path               11430 non-null  float64
 51  phish_hints                 11430 non-null  int64
 52  domain_in_brand             11430 non-null  int64
 53  brand_in_subdomain          11430 non-null  int64
 54  brand_in_path               11430 non-null  int64
 55  suspecious_tld              11430 non-null  int64
 56  statistical_report          11430 non-null  int64
 57  nb_hyperlinks               11430 non-null  int64
 58  ratio_intHyperlinks         11430 non-null  float64
 59  ratio_extHyperlinks         11430 non-null  float64
 60  ratio_nullHyperlinks        11430 non-null  int64
 61  nb_extCSS                   11430 non-null  int64
 62  ratio_intRedirection        11430 non-null  int64
 63  ratio_extRedirection        11430 non-null  float64
 64  ratio_intErrors             11430 non-null  int64
 65  ratio_extErrors             11430 non-null  float64
 66  login_form                  11430 non-null  int64
 67  external_favicon            11430 non-null  int64
 68  links_in_tags               11430 non-null  float64
 69  submit_email                11430 non-null  int64
 70  ratio_intMedia              11430 non-null  float64
 71  ratio_extMedia              11430 non-null  float64
 72  sfh                         11430 non-null  int64
 73  iframe                      11430 non-null  int64
 74  popup_window                11430 non-null  int64
 75  safe_anchor                 11430 non-null  float64
 76  onmouseover                 11430 non-null  int64
 77  right_clic                  11430 non-null  int64
 78  empty_title                 11430 non-null  int64
 79  domain_in_title             11430 non-null  int64
 80  domain_with_copyright       11430 non-null  int64
 81  whois_registered_domain     11430 non-null  int64
 82  domain_registration_length  11430 non-null  int64
 83  domain_age                  11430 non-null  int64
 84  web_traffic                 11430 non-null  int64
 85  dns_record                  11430 non-null  int64
 86  google_index                11430 non-null  int64
 87  page_rank                   11430 non-null  int64
 88  status                      11430 non-null  object
dtypes: float64(13), int64(74), object(2)
memory usage: 7.8+ MB
```

Checking Null Values

- There is No Null Values are present in the given dataset.

In [5]:
```
df.isnull().sum()
```

Out[5]:
```
url                         0
length_url                  0
length_hostname             0
ip                          0
nb_dots                     0
nb_hyphens                  0
nb_at                       0
nb_qm                       0
nb_and                      0
nb_or                       0
nb_eq                       0
```

```
nb_eq                   0
nb_underscore           0
nb_tilde                0
nb_percent              0
nb_slash                0
nb_star                 0
nb_colon                0
nb_comma                0
nb_semicolumn           0
nb_dollar               0
nb_space                0
nb_www                  0
nb_com                  0
nb_dslash               0
http_in_path            0
https_token             0
ratio_digits_url        0
ratio_digits_host       0
punycode                0
port                    0
tld_in_path             0
tld_in_subdomain        0
abnormal_subdomain      0
nb_subdomains           0
prefix_suffix           0
random_domain           0
shortening_service      0
path_extension          0
nb_redirection          0
nb_external_redirection 0
length_words_raw        0
char_repeat             0
shortest_words_raw      0
shortest_word_host      0
shortest_word_path      0
longest_words_raw       0
longest_word_host       0
longest_word_path       0
avg_words_raw           0
avg_word_host           0
avg_word_path           0
phish_hints             0
domain_in_brand         0
brand_in_subdomain      0
brand_in_path           0
suspecious_tld          0
statistical_report      0
nb_hyperlinks           0
ratio_intHyperlinks     0
ratio_extHyperlinks     0
ratio_nullHyperlinks    0
nb_extCSS               0
ratio_intRedirection    0
ratio_extRedirection    0
ratio_intErrors         0
ratio_extErrors         0
login_form              0
external_favicon        0
links_in_tags           0
submit_email            0
ratio_intMedia          0
ratio_extMedia          0
sfh                     0
iframe                  0
popup_window            0
safe_anchor             0
onmouseover             0
right_clic              0
```

```
empty_title                0
domain_in_title            0
domain_with_copyright      0
whois_registered_domain    0
domain_registration_length 0
domain_age                 0
web_traffic                0
dns_record                 0
google_index               0
page_rank                  0
status                     0
dtype: int64
```

Descriptive Analysis

In [6]:
```
df.describe()
```

Out[6]:

	length_url	length_hostname	ip	nb_dots	nb_hyphens	nl
count	11430.000000	11430.000000	11430.000000	11430.000000	11430.000000	11430.000
mean	61.126684	21.090289	0.150569	2.480752	0.997550	0.022
std	55.297318	10.777171	0.357644	1.369686	2.087087	0.155
min	12.000000	4.000000	0.000000	1.000000	0.000000	0.000
25%	33.000000	15.000000	0.000000	2.000000	0.000000	0.000
50%	47.000000	19.000000	0.000000	2.000000	0.000000	0.000
75%	71.000000	24.000000	0.000000	3.000000	1.000000	0.000
max	1641.000000	214.000000	1.000000	24.000000	43.000000	4.000

Separating numerical and categorical columns. Then, for each numeric feature, you analyze spread, skewness, and outliers — very helpful for choosing scaling techniques or detecting which features might need transformation.

In [7]:
```
numerical_columns = df.select_dtypes(exclude= 'object')
numerical_columns
```

Out[7]:

	length_url	length_hostname	ip	nb_dots	nb_hyphens	nb_at	nb_qm	nb_and	nb_
0	37	19	0	3	0	0	0	0	
1	77	23	1	1	0	0	0	0	
2	126	50	1	4	1	0	1	2	
3	18	11	0	2	0	0	0	0	
4	55	15	0	2	2	0	0	0	
...	...	...	...	...	...	...	...	...	
11425	45	17	0	2	0	0	0	0	
11426	84	18	0	5	0	1	1	0	
11427	105	16	1	2	6	0	1	0	
11428	38	30	0	2	0	0	0	0	

11429	477		14	1	24		0	1	1	9

11430 rows × 87 columns

In [8]:

```
# Descriptive statistics
from collections import OrderedDict

stats = []

for col in df.columns:
    if df[col].dtype != 'object':
        numerical_stats = OrderedDict({
            'Feature': col,
            'Minimum': df[col].min(),
            'Maximum': df[col].max(),
            'Mean': df[col].mean(),
            'Mode': df[col].mode()[0] if not df[col].mode().empty else None,
            '25%': df[col].quantile(0.25),
            '75%': df[col].quantile(0.75),
            'IQR': df[col].quantile(0.75) - df[col].quantile(0.25),
            'Standard Deviation': df[col].std(),
            'Skewness': df[col].skew(),
            'Kurtosis': df[col].kurt()
        })
        stats.append(numerical_stats)

# Convert to DataFrame
report = pd.DataFrame(stats)

report
```

Out[8]:

	Feature	Minimum	Maximum	Mean	Mode	25%
0	length_url	12.0	1.641000e+03	61.126684	26.0	33.000000
1	length_hostname	4.0	2.140000e+02	21.090289	16.0	15.000000
2	ip	0.0	1.000000e+00	0.150569	0.0	0.000000
3	nb_dots	1.0	2.400000e+01	2.480752	2.0	2.000000
4	nb_hyphens	0.0	4.300000e+01	0.997550	0.0	0.000000
5	nb_at	0.0	4.000000e+00	0.022222	0.0	0.000000
6	nb_qm	0.0	3.000000e+00	0.141207	0.0	0.000000
7	nb_and	0.0	1.900000e+01	0.162292	0.0	0.000000
8	nb_or	0.0	0.000000e+00	0.000000	0.0	0.000000
9	nb_eq	0.0	1.900000e+01	0.293176	0.0	0.000000
10	nb_underscore	0.0	1.800000e+01	0.322660	0.0	0.000000
11	nb_tilde	0.0	1.000000e+00	0.006649	0.0	0.000000
12	nb_percent	0.0	9.600000e+01	0.123097	0.0	0.000000
13	nb_slash	2.0	3.300000e+01	4.289589	3.0	3.000000
14	nb_star	0.0	1.000000e+00	0.000700	0.0	0.000000
15	nb_colon	1.0	7.000000e+00	1.027909	1.0	1.000000

16	nb_comma	0.0	4.000000e+00	0.004024	0.0	0.000000
17	nb_semicolumn	0.0	2.000000e+01	0.062292	0.0	0.000000
18	nb_dollar	0.0	6.000000e+00	0.001925	0.0	0.000000
19	nb_space	0.0	1.800000e+01	0.034821	0.0	0.000000
20	nb_www	0.0	2.000000e+00	0.448469	0.0	0.000000
21	nb_com	0.0	6.000000e+00	0.127997	0.0	0.000000
22	nb_dslash	0.0	1.000000e+00	0.006562	0.0	0.000000
23	http_in_path	0.0	4.000000e+00	0.016710	0.0	0.000000
24	https_token	0.0	1.000000e+00	0.610936	1.0	0.000000
25	ratio_digits_url	0.0	7.238806e-01	0.053137	0.0	0.000000
26	ratio_digits_host	0.0	8.000000e-01	0.025024	0.0	0.000000
27	punycode	0.0	1.000000e+00	0.000350	0.0	0.000000
28	port	0.0	1.000000e+00	0.002362	0.0	0.000000
29	tld_in_path	0.0	1.000000e+00	0.065617	0.0	0.000000
30	tld_in_subdomain	0.0	1.000000e+00	0.050131	0.0	0.000000
31	abnormal_subdomain	0.0	1.000000e+00	0.021610	0.0	0.000000
32	nb_subdomains	1.0	3.000000e+00	2.231671	2.0	2.000000
33	prefix_suffix	0.0	1.000000e+00	0.202450	0.0	0.000000
34	random_domain	0.0	1.000000e+00	0.083290	0.0	0.000000
35	shortening_service	0.0	1.000000e+00	0.123447	0.0	0.000000
36	path_extension	0.0	1.000000e+00	0.000175	0.0	0.000000
37	nb_redirection	0.0	6.000000e+00	0.498250	0.0	0.000000
38	nb_external_redirection	0.0	1.000000e+00	0.003150	0.0	0.000000
39	length_words_raw	1.0	1.060000e+02	6.232808	2.0	2.000000
40	char_repeat	0.0	1.460000e+02	2.927472	3.0	1.000000
41	shortest_words_raw	1.0	3.100000e+01	3.127297	3.0	2.000000
42	shortest_word_host	1.0	3.900000e+01	5.019773	3.0	3.000000
43	shortest_word_path	0.0	4.000000e+01	2.398950	0.0	0.000000
44	longest_words_raw	2.0	8.290000e+02	15.393876	9.0	9.000000
45	longest_word_host	1.0	6.200000e+01	10.467979	9.0	7.000000
46	longest_word_path	0.0	8.290000e+02	10.561505	0.0	0.000000
47	avg_words_raw	2.0	1.282500e+02	7.258882	6.0	5.250000
48	avg_word_host	1.0	3.900000e+01	7.678075	5.0	5.250000
49	avg_word_path	0.0	2.500000e+02	5.092425	0.0	0.000000
50	phish_hints	0.0	1.000000e+01	0.327734	0.0	0.000000
51	domain_in_brand	0.0	1.000000e+00	0.104199	0.0	0.000000
52	brand_in_subdomain	0.0	1.000000e+00	0.004112	0.0	0.000000

53	brand_in_path	0.0	1.000000e+00	0.004899	0.0	0.000000
54	suspecious_tld	0.0	1.000000e+00	0.017935	0.0	0.000000
55	statistical_report	0.0	2.000000e+00	0.059755	0.0	0.000000
56	nb_hyperlinks	0.0	4.659000e+03	87.189764	0.0	9.000000
57	ratio_intHyperlinks	0.0	1.000000e+00	0.602457	0.0	0.224991
58	ratio_extHyperlinks	0.0	1.000000e+00	0.276720	0.0	0.000000
59	ratio_nullHyperlinks	0.0	0.000000e+00	0.000000	0.0	0.000000
60	nb_extCSS	0.0	1.240000e+02	0.784864	0.0	0.000000
61	ratio_intRedirection	0.0	0.000000e+00	0.000000	0.0	0.000000
62	ratio_extRedirection	0.0	2.000000e+00	0.158926	0.0	0.000000
63	ratio_intErrors	0.0	0.000000e+00	0.000000	0.0	0.000000
64	ratio_extErrors	0.0	1.000000e+00	0.062469	0.0	0.000000
65	login_form	0.0	1.000000e+00	0.063605	0.0	0.000000
66	external_favicon	0.0	1.000000e+00	0.442170	0.0	0.000000
67	links_in_tags	0.0	1.000000e+02	51.978211	0.0	0.000000
68	submit_email	0.0	0.000000e+00	0.000000	0.0	0.000000
69	ratio_intMedia	0.0	1.000000e+02	42.870444	0.0	0.000000
70	ratio_extMedia	0.0	1.000000e+02	23.236293	0.0	0.000000
71	sfh	0.0	0.000000e+00	0.000000	0.0	0.000000
72	iframe	0.0	1.000000e+00	0.001312	0.0	0.000000
73	popup_window	0.0	1.000000e+00	0.006037	0.0	0.000000
74	safe_anchor	0.0	1.000000e+02	37.063922	0.0	0.000000
75	onmouseover	0.0	1.000000e+00	0.001137	0.0	0.000000
76	right_clic	0.0	1.000000e+00	0.001400	0.0	0.000000
77	empty_title	0.0	1.000000e+00	0.124759	0.0	0.000000
78	domain_in_title	0.0	1.000000e+00	0.775853	1.0	1.000000
79	domain_with_copyright	0.0	1.000000e+00	0.439545	0.0	0.000000
80	whois_registered_domain	0.0	1.000000e+00	0.072878	0.0	0.000000
81	domain_registration_length	-1.0	2.982900e+04	492.532196	0.0	84.000000
82	domain_age	-12.0	1.287400e+04	4062.543745	-1.0	972.250000
83	web_traffic	0.0	1.076799e+07	856756.643307	0.0	0.000000
84	dns_record	0.0	1.000000e+00	0.020122	0.0	0.000000
85	google_index	0.0	1.000000e+00	0.533946	1.0	0.000000
86	page_rank	0.0	1.000000e+01	3.185739	0.0	1.000000

Frequency distribution for categorical

Frequency distribution for categorical features

Several features showed significant skewness, suggesting non-normal distributions.

Wide ranges and high standard deviations in some columns (e.g., web_traffic, length_url) indicate the presence of outliers.

Features with high kurtosis are likely to have heavy tails or sharp peaks.

Checking frequency counts for categorical columns — this helps you see whether categories are balanced or dominated by one class (like the target label status).

In [9]:
```
# Frequency distribution for categorical features (if any)
for col in df.columns:
    if df[col].dtype == 'object':
        print(f"\nFrequency distribution for {col}:\n")
        print(df[col].value_counts())
```

```
Frequency distribution for url:

url
http://e710z0ear.du.r.appspot.com/c:/users/user/downlo
2
https://lt.mydplr.com/16672ac75448ecdb528e1c663c0df3a7-f10ed321df1a4fbc893c86fbb12f0
913
1
http://appleid.apple.com-app.es/
1
http://174.139.46.123/ap/signin?openid.pape.max_auth_age=0&amp;openid.return_to=http
s%3A%2F%2Fwww.amazon.co.jp%2F%3Fref_%3Dnav_em_hd_re_signin&amp;openid.identity=http%
3A%2F%2Fspecs.openid.net%2Fauth%2F2.0%2Fidentifier_select&amp;openid.assoc_handle=jp
flex&amp;openid.mode=checkid_setup&amp;key=a@b.c&amp;openid.claimed_id=http%3A%2F%2F
specs.openid.net%2Fauth%2F2.0%2Fidentifier_select&amp;openid.ns=http%3A%2F%2Fspecs.o
penid.net%2Fauth%2F2.0&amp;&amp;ref_=nav_em_hd_clc_signin    1
http://www.crestonwood.com/router.php
1

..
https://www.dissernet.org/
1
https://workprotocoles-com.webs.com/
1
http://www.vg247.com/2017/04/24/best-nintendo-switch-games/
1
https://www.facebook.com/Publictransporthub/
1
http://www.game.co.uk/en/games/nintendo-switch/nintendo-switch/
1
Name: count, Length: 11429, dtype: int64

Frequency distribution for status:

status
legitimate    5715
phishing      5715
Name: count, dtype: int64
```

The target label is balanced — There is no need to use SMOTE techniques to Blanace the Target columm.

In [10]:
```
df['status'].mode()
```

Out[10]:
```
0    legitimate
1      phishing
Name: status, dtype: object
```

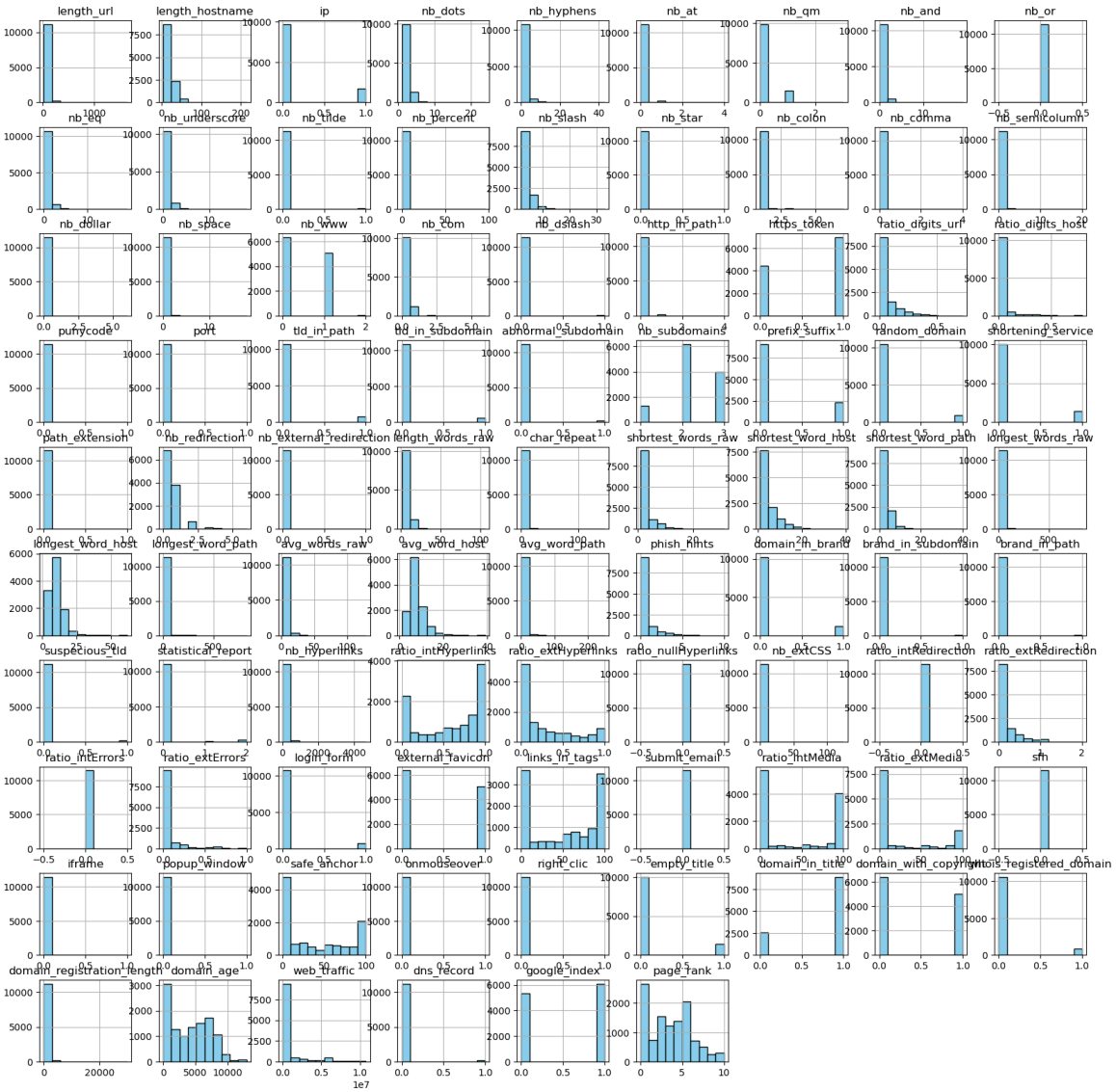
In [11]:
```
df['url'].mode()
```

Out[11]:
```
0    http://e710z0ear.du.r.appspot.com/c:/users/use...
Name: url, dtype: object
```

Histogram

Histograms Reveal skewed features and possible outliers. Some features like web_traffic or length_url may need scaling or normalization.

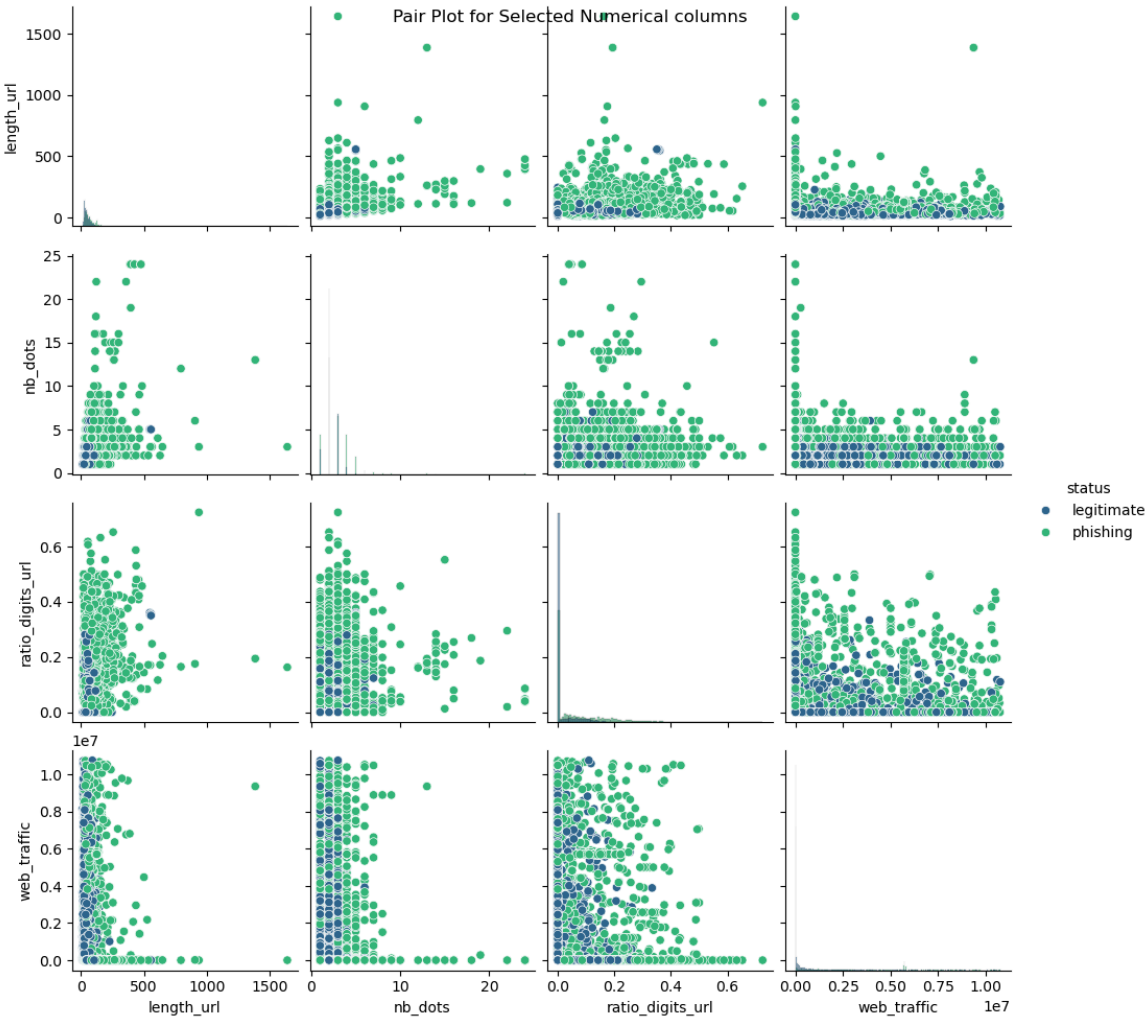
In [12]:
```
# Histograms for numerical features
numerical_columns.hist(figsize=(20, 20),bins= 10, color= 'skyblue', edgecolor= 'bl
plt.title("Histogram")
plt.xlabel("Value")
plt.ylabel("Frequency")
plt.show()
```



Pair Plot

- We have use only selected important features to create the Pair Plot
- The pairplot shows some visual separation between phishing and legitimate classes in selected features — especially in ratio_digits_url and web_traffic. That means these features might be strong indicators for classification.

In [13]:
```
selected_features = ['length_url', 'nb_dots', 'ratio_digits_url', 'web_traffic', '
# plot pair plot
sns.pairplot(df[selected_features], hue='status', diag_kind='hist', palette= 'viri
plt.suptitle('Pair Plot for Selected Numerical columns')
plt.show()
```



Using Replace function to 'legitimate' and 'phishing' into 0 and 1 — readying the target for machine learning models.

In [14]:
```
df['status'] = df['status'].replace({'legitimate' : 0, 'phishing' : 1})
```

Label encoding to url column — to convert the categorical data into numerical

In [15]:
```
# Using Label Encoding in Url column
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()

df['url'] = le.fit_transform(df['url'])
df['url'].value_counts()
```

Out[15]:
```
url
1065    2
8258    1
363     1
62      1
4501    1
       ..
9799    1
9324    1
6684    1
9920    1
4919    1
Name: count, Length: 11429, dtype: int64
```

Insights and Recommendations

- Features like `web_traffic`, `SSLfinal_State`, and `page_rank` are crucial indicators.
- The Dataset has huge amount of Outliers.
- Outliers can be capped using the IQR method.
- Use `RobustScaler` to normalize numerical features.
- Remove redundant features with high multicollinearity.
- The target is balance hence, there is no need for SMOTE.
- We can use Feature Engineering.
- The Dataset have doesn't have any null values.

Checking Duplicates

Label Encoding was applied to the url column to convert categorical values into numeric form. One-Hot Encoding was avoided because it would have significantly increased the number of columns due to the high number of unique URLs. Label Encoding keeps the dataset compact and efficient without adding unnecessary dimensions.

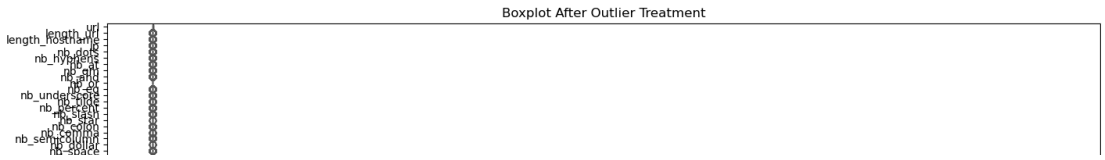
In [16]:
```
# Checking Duplicates
duplicates = df.duplicated()
duplicates.value_counts()
```

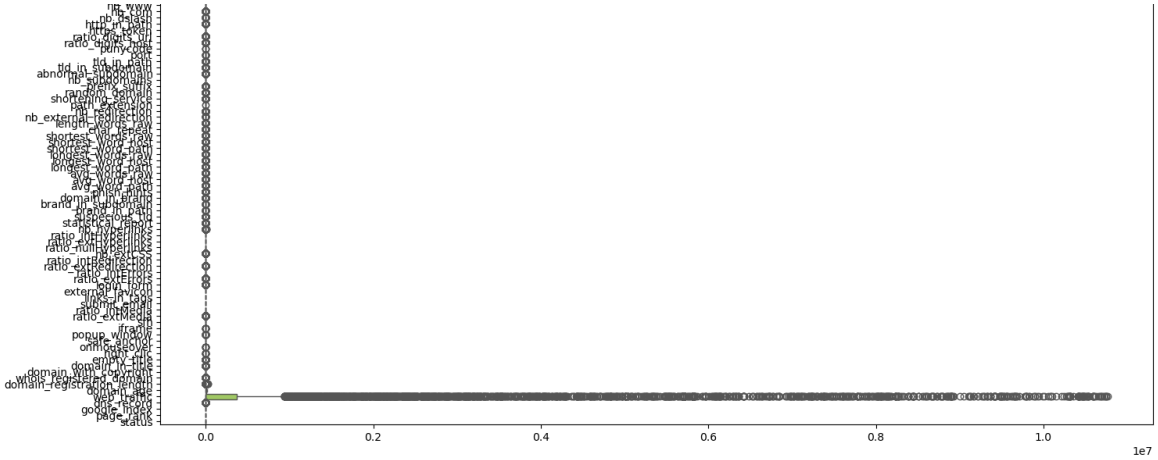
Out[16]:
```
False    11430
Name: count, dtype: int64
```

In [17]:
```
# Set figure size
plt.figure(figsize=(15, 8))

# Create boxplot for all numerical columns
sns.boxplot(data=df, orient='h', palette='Set2')

# Set title
plt.title('Boxplot After Outlier Treatment')
plt.tight_layout()
plt.show()
```





In [18]:

```
# Replace Outliers with Median Statergy

for col in df.select_dtypes(include='number').columns:
    Q1 = df[col].quantile(0.25)
    Q3 = df[col].quantile(0.75)
    IQR = Q3 - Q1

    lower_bound = Q1 - 1.5 * IQR
    upper_bound = Q3 + 1.5 * IQR

    # Identify outliers
    outliers = (df[col] < lower_bound) | (df[col] > upper_bound)
    outlier_count = outliers.sum()

    if outlier_count > 0:
        replacement = df[col].median()
        df.loc[outliers, col] = replacement
        print(f"Replaced {outlier_count} outliers in '{col}' with median.")
    else:
        print(f"No outliers found in '{col}'.")
```

```
No outliers found in 'url'.
Replaced 620 outliers in 'length_url' with median.
Replaced 775 outliers in 'length_hostname' with median.
Replaced 1721 outliers in 'ip' with median.
Replaced 567 outliers in 'nb_dots' with median.
Replaced 1371 outliers in 'nb_hyphens' with median.
Replaced 245 outliers in 'nb_at' with median.
Replaced 1555 outliers in 'nb_qm' with median.
Replaced 761 outliers in 'nb_and' with median.
No outliers found in 'nb_or'.
Replaced 1564 outliers in 'nb_eq' with median.
Replaced 1695 outliers in 'nb_underscore' with median.
Replaced 76 outliers in 'nb_tilde' with median.
Replaced 355 outliers in 'nb_percent' with median.
Replaced 401 outliers in 'nb_slash' with median.
Replaced 8 outliers in 'nb_star' with median.
Replaced 197 outliers in 'nb_colon' with median.
Replaced 24 outliers in 'nb_comma' with median.
Replaced 248 outliers in 'nb_semicolumn' with median.
Replaced 11 outliers in 'nb_dollar' with median.
Replaced 210 outliers in 'nb_space' with median.
No outliers found in 'nb_www'.
Replaced 1327 outliers in 'nb_com' with median.
Replaced 75 outliers in 'nb_dslash' with median.
Replaced 150 outliers in 'http_in_path' with median.
No outliers found in 'https_token'.
Replaced 933 outliers in 'ratio_digits_url' with median.
Replaced 1503 outliers in 'ratio_digits_host' with median.
Replaced 4 outliers in 'punycode' with median.
Replaced 27 outliers in 'port' with median.
```

```
Replaced 750 outliers in 'tld_in_path' with median.
Replaced 573 outliers in 'tld_in_subdomain' with median.
Replaced 247 outliers in 'abnormal_subdomain' with median.
No outliers found in 'nb_subdomains'.
Replaced 2314 outliers in 'prefix_suffix' with median.
Replaced 952 outliers in 'random_domain' with median.
Replaced 1411 outliers in 'shortening_service' with median.
Replaced 2 outliers in 'path_extension' with median.
Replaced 166 outliers in 'nb_redirection' with median.
Replaced 36 outliers in 'nb_external_redirection' with median.
Replaced 264 outliers in 'length_words_raw' with median.
Replaced 310 outliers in 'char_repeat' with median.
Replaced 1435 outliers in 'shortest_words_raw' with median.
Replaced 1093 outliers in 'shortest_word_host' with median.
Replaced 428 outliers in 'shortest_word_path' with median.
Replaced 1035 outliers in 'longest_words_raw' with median.
Replaced 220 outliers in 'longest_word_host' with median.
Replaced 929 outliers in 'longest_word_path' with median.
Replaced 725 outliers in 'avg_words_raw' with median.
Replaced 568 outliers in 'avg_word_host' with median.
Replaced 282 outliers in 'avg_word_path' with median.
Replaced 2041 outliers in 'phish_hints' with median.
Replaced 1191 outliers in 'domain_in_brand' with median.
Replaced 47 outliers in 'brand_in_subdomain' with median.
Replaced 56 outliers in 'brand_in_path' with median.
Replaced 205 outliers in 'suspecious_tld' with median.
Replaced 377 outliers in 'statistical_report' with median.
Replaced 953 outliers in 'nb_hyperlinks' with median.
No outliers found in 'ratio_intHyperlinks'.
No outliers found in 'ratio_extHyperlinks'.
No outliers found in 'ratio_nullHyperlinks'.
Replaced 1019 outliers in 'nb_extCSS' with median.
No outliers found in 'ratio_intRedirection'.
Replaced 999 outliers in 'ratio_extRedirection' with median.
No outliers found in 'ratio_intErrors'.
Replaced 2149 outliers in 'ratio_extErrors' with median.
Replaced 727 outliers in 'login_form' with median.
No outliers found in 'external_favicon'.
No outliers found in 'links_in_tags'.
No outliers found in 'submit_email'.
No outliers found in 'ratio_intMedia'.
Replaced 2012 outliers in 'ratio_extMedia' with median.
No outliers found in 'sfh'.
Replaced 15 outliers in 'iframe' with median.
Replaced 69 outliers in 'popup_window' with median.
No outliers found in 'safe_anchor'.
Replaced 13 outliers in 'onmouseover' with median.
Replaced 16 outliers in 'right_clic' with median.
Replaced 1426 outliers in 'empty_title' with median.
Replaced 2562 outliers in 'domain_in_title' with median.
No outliers found in 'domain_with_copyright'.
Replaced 833 outliers in 'whois_registered_domain' with median.
Replaced 1529 outliers in 'domain_registration_length' with median.
No outliers found in 'domain_age'.
Replaced 2138 outliers in 'web_traffic' with median.
Replaced 230 outliers in 'dns_record' with median.
No outliers found in 'google_index'.
No outliers found in 'page_rank'.
No outliers found in 'status'.
```

A ranked list of features based on Variance Variance Inflation Factor (VIF)

In [19]:

```
# Checking VIF:
def calculate_vif(dataset):
```

```
def calculate_vif(dataset):
    vif = pd.DataFrame()
    vif['features'] = dataset.columns
    vif['VIF_Values'] = [variance_inflation_factor(dataset.values,i) for i in rang
    vif['VIF_Values'] = round(vif['VIF_Values'], 2)
    vif = vif.sort_values(by = 'VIF_Values', ascending=False)
    return (vif)

calculate_vif(df.drop('status',axis = 1))
```

Out[19]:

	features	VIF_Values
0	url	9.42
25	https_token	7.70
47	longest_word_path	5.86
33	nb_subdomains	5.36
46	longest_word_host	5.18
4	nb_dots	4.88
58	ratio_intHyperlinks	4.49
45	longest_words_raw	4.38
21	nb_www	4.21
50	avg_word_path	4.16
40	length_words_raw	4.08
1	length_url	3.81
49	avg_word_host	3.45
68	links_in_tags	3.04
48	avg_words_raw	2.49
2	length_hostname	2.36
44	shortest_word_path	2.35
67	external_favicon	2.33
59	ratio_extHyperlinks	2.32
41	char_repeat	2.25
87	page_rank	2.20
86	google_index	1.88
42	shortest_words_raw	1.88
14	nb_slash	1.80
43	shortest_word_host	1.76
83	domain_age	1.70
70	ratio_intMedia	1.65
57	nb_hyperlinks	1.54
61	nb_extCSS	1.49
75	safe_anchor	1.47

26	ratio_digits_url	1.28
38	nb_redirection	1.24
63	ratio_extRedirection	1.20
80	domain_with_copyright	1.18
82	domain_registration_length	1.18
5	nb_hyphens	1.15
71	ratio_extMedia	1.11
65	ratio_extErrors	1.08
84	web_traffic	1.07
16	nb_colon	0.00
79	domain_in_title	0.00
3	ip	NaN
6	nb_at	NaN
7	nb_qm	NaN
8	nb_and	NaN
9	nb_or	NaN
10	nb_eq	NaN
11	nb_underscore	NaN
12	nb_tilde	NaN
13	nb_percent	NaN
15	nb_star	NaN
17	nb_comma	NaN
18	nb_semicolumn	NaN
19	nb_dollar	NaN
20	nb_space	NaN
22	nb_com	NaN
23	nb_dslash	NaN
24	http_in_path	NaN
27	ratio_digits_host	NaN
28	punycode	NaN
29	port	NaN
30	tld_in_path	NaN
31	tld_in_subdomain	NaN
32	abnormal_subdomain	NaN
34	prefix_suffix	NaN
35	random_domain	NaN
36	shortening_service	NaN

37	path_extension	NaN
39	nb_external_redirection	NaN
51	phish_hints	NaN
52	domain_in_brand	NaN
53	brand_in_subdomain	NaN
54	brand_in_path	NaN
55	suspecious_tld	NaN
56	statistical_report	NaN
60	ratio_nullHyperlinks	NaN
62	ratio_intRedirection	NaN
64	ratio_intErrors	NaN
66	login_form	NaN
69	submit_email	NaN
72	sfh	NaN
73	iframe	NaN
74	popup_window	NaN
76	onmouseover	NaN
77	right_clic	NaN
78	empty_title	NaN
81	whois_registered_domain	NaN
85	dns_record	NaN

In [20]:
```
# Spliting Data into Independent And target Column
X=df.drop(columns='status')
y=df['status']
```

In [21]:
```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test=train_test_split(X,y,train_size=0.70,random_state=42
```

In [22]:
```
X_train_original = X_train.copy()
```

Scaling Technique:- Robust Scaler

Robust Scaler was used to handle outliers effectively, as boxplots showed many extreme values in the numerical features. It scales data based on the median and IQR, making it less sensitive to outliers compared to StandardScaler or MinMaxScaler.

In [23]:
```
from sklearn.preprocessing import MinMaxScaler,StandardScaler,RobustScaler
scaler=RobustScaler()
```

```
X_train=scaler.fit_transform(X_train)
X_test=scaler.transform(X_test)
```

In [24]:

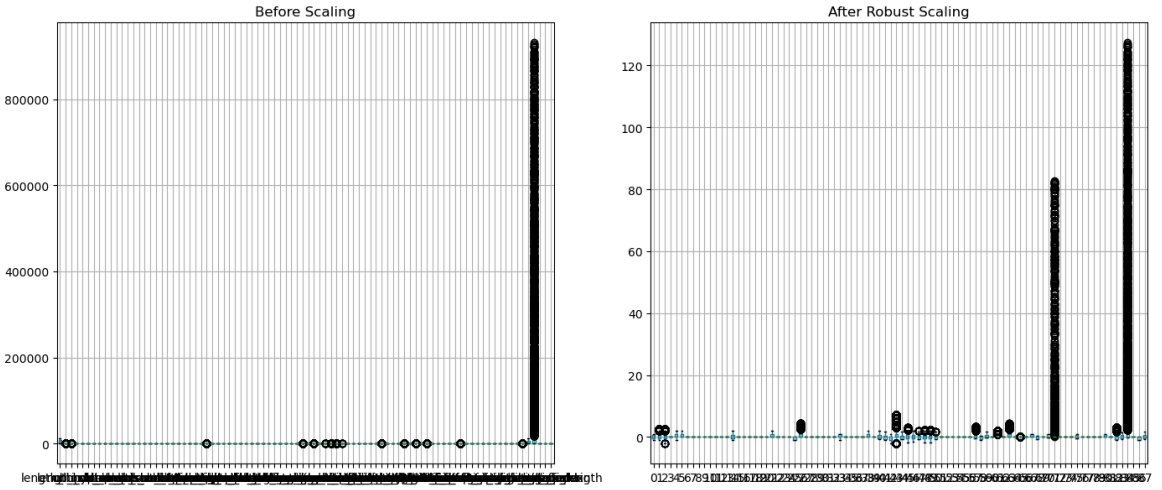
```
X_train_scaled=X_train.copy()
# If X_train is a NumPy array, convert it to a DataFrame
X_train_df = pd.DataFrame(X_train_original)
X_train_scaled_df = pd.DataFrame(X_train_scaled)

# Plot before and after scaling side by side
plt.figure(figsize=(14, 6))

plt.subplot(1, 2, 1)
X_train_df.boxplot()
plt.title("Before Scaling")

plt.subplot(1, 2, 2)
X_train_scaled_df.boxplot()
plt.title("After Robust Scaling")

plt.tight_layout()
plt.show()
```



In [25]:

```
# Table summarizing feature correlations
df.corr()['status']
```

Out[25]:

```
url                          -0.290971
length_url                    0.217898
length_hostname               0.105306
ip                                 NaN
nb_dots                       0.109748
nb_hyphens                    0.158158
nb_at                              NaN
nb_qm                              NaN
nb_and                             NaN
nb_or                              NaN
nb_eq                              NaN
nb_underscore                      NaN
nb_tilde                           NaN
nb_percent                         NaN
nb_slash                      0.201618
nb_star                            NaN
nb_colon                           NaN
nb_comma                           NaN
nb_semicolumn                      NaN
nb_dollar                          NaN
nb_space                           NaN
nb_www                       -0.443468
nb_com                             NaN
nb_dslash                          NaN
```

```
nb_qslash                       NaN
http_in_path                    NaN
https_token                0.114669
ratio_digits_url           0.222690
ratio_digits_host               NaN
punycode                        NaN
port                            NaN
tld_in_path                     NaN
tld_in_subdomain                NaN
abnormal_subdomain              NaN
nb_subdomains              0.112891
prefix_suffix                   NaN
random_domain                   NaN
shortening_service              NaN
path_extension                  NaN
nb_redirection            -0.043685
nb_external_redirection         NaN
length_words_raw           0.195110
char_repeat               -0.122545
shortest_words_raw        -0.167907
shortest_word_host         0.102649
shortest_word_path         0.094549
longest_words_raw          0.164277
longest_word_host          0.094016
longest_word_path          0.187312
avg_words_raw              0.122929
avg_word_host              0.140864
avg_word_path              0.229877
phish_hints                     NaN
domain_in_brand                 NaN
brand_in_subdomain              NaN
brand_in_path                   NaN
suspecious_tld                  NaN
statistical_report              NaN
nb_hyperlinks             -0.442032
ratio_intHyperlinks       -0.243982
ratio_extHyperlinks        0.083357
ratio_nullHyperlinks            NaN
nb_extCSS                 -0.080464
ratio_intRedirection            NaN
ratio_extRedirection      -0.267394
ratio_intErrors                 NaN
ratio_extErrors           -0.179422
login_form                      NaN
external_favicon          -0.146565
links_in_tags             -0.184401
submit_email                    NaN
ratio_intMedia            -0.193333
ratio_extMedia            -0.098609
sfh                             NaN
iframe                          NaN
popup_window                    NaN
safe_anchor               -0.173397
onmouseover                     NaN
right_clic                      NaN
empty_title                     NaN
domain_in_title                 NaN
domain_with_copyright     -0.173098
whois_registered_domain         NaN
domain_registration_length -0.146138
domain_age                -0.331889
web_traffic               -0.203653
dns_record                      NaN
google_index               0.731171
page_rank                 -0.511137
status                     1.000000
Name: status, dtype: float64
```

Appling PCA for Dimenstion Reduction

Displaying Variance Ratio

In [26]:
```
# Using PCA Concept:

# Step 1: Standardize the data
from sklearn.preprocessing import RobustScaler
scaler = RobustScaler()

X_scaled = scaler.fit_transform(df)

# Step 2: Determine number of components to retain 90% variance

for i in range(1, df.shape[1] + 1):
    pca = PCA(n_components=i)
    pca.fit(X_scaled)
    evr = np.cumsum(pca.explained_variance_ratio_)
    if evr[i - 1] >= 0.90:
        pcs = i
        break

print("Explained Variance Ratio:", evr)
print("Number of components selected:", pcs)

# Step 3: Apply PCA

pca = PCA(n_components=pcs)
pca_data = pca.fit_transform(X_scaled)

# Step 4: Create DataFrame

pca_columns = [f'PC{j+1}' for j in range(pcs)]
pca_df = pd.DataFrame(pca_data, columns=pca_columns)

# Step 5: Join Target Column with PCA:

pca_df = pca_df.join(df['status'], how = 'left')

pca_df
```

```
Explained Variance Ratio: [0.57046592 0.970943  ]
Number of components selected: 2
```

Out[26]:

	PC1	PC2	status
0	-7.873171	-5.366775	0
1	-6.311023	14.559213	1
2	-7.736537	-5.395951	1
3	5.910682	-2.885161	0
4	-6.772865	-5.403439	0
...	...	...	...
11425	-1.094859	73.295599	0
11426	-7.901367	-5.380939	1
11427	-7.912587	-5.342337	0
11428	-7.664649	-5.369196	0
11429	-7.893053	-5.346426	1

11430 rows × 3 columns

Training Machine Learning Model

*1 *Logistic Regression**

In [27]:
```
from sklearn.model_selection import train_test_split
X = pca_df.drop(columns= 'status', axis=1)
y = pca_df['status']

X_train, X_test, y_train, y_test = train_test_split(X,y, test_size= 0.2, random_st

from sklearn.linear_model import LogisticRegression
LR = LogisticRegression()

LR.fit(X_train, y_train)

y_pred_LR = LR.predict(X_test)

from sklearn.metrics import accuracy_score,confusion_matrix
accuracy_score_LR = accuracy_score(y_pred_LR, y_test)

print(f'Accuracy : {round(accuracy_score_LR * 100,2)}%')
```

```
Accuracy : 61.42%
```

2 Decision Tree Classifier

In [28]:
```
from sklearn.tree import DecisionTreeClassifier
DT = DecisionTreeClassifier()
DT.fit(X_train, y_train)

y_pred_DT = DT.predict(X_test)

accuracy_score_DT = accuracy_score(y_pred_DT, y_test)

print(f'Accuracy : {round(accuracy_score_DT * 100,2)}%')
```

```
Accuracy : 80.53%
```

3 Random Forest Classifier

In [29]:
```
from sklearn.ensemble import RandomForestClassifier
RF = RandomForestClassifier()

RF.fit(X_train,y_train)

y_pred_RF = RF.predict(X_test)

from sklearn.metrics import accuracy_score
accuracy_score_RF = accuracy_score(y_pred_RF,y_test)

print(f'Accuracy : {round(accuracy_score_RF * 100,2)}%')
```

```
Accuracy : 84.73%
```

In [30]:

```
# Using SGD classifier
from sklearn.linear_model import SGDClassifier
SGD = SGDClassifier()

SGD.fit(X_train,y_train)

y_pred_SGD = SGD.predict(X_test)
accuracy_score_SGD = accuracy_score(y_pred_SGD,y_test)

print(f'Accuracy : {round(accuracy_score_SGD * 100,2)}%')
```

```
Accuracy : 62.07%
```

In [31]:

```
from sklearn.model_selection import cross_val_score

scores = cross_val_score(RF, X_train, y_train, cv= 10, scoring= 'accuracy')

print('Accuracy for each fold : ', scores)
print('Average Accuracy across 10 folds : ', np.mean(scores))
```

```
Accuracy for each fold :  [0.83497268 0.84918033 0.85245902 0.84153005 0.84026258 0.
85995624
 0.84463895 0.83479212 0.84135667 0.85229759]
Average Accuracy across 10 folds :  0.8451446234051968
```

In [33]:

```
import pickle

# RandomForestClassifier model save ho raha hai
with open('random_forest_model.pkl', 'wb') as file:
    pickle.dump(RF, file)
```