Security Data Analysis - Detecting Anomalous Login Activity

Task 1 : Data Preprocessing

OBJECTIVES:

- Load the dataset into a Pandas DataFrame.
- Check for missing values and handle them appropriately.
- Convert the timestamp to a suitable format for analysis.

In [1]:
```
#To analyse the data these modules like pandas,numpy and matplotlib are used.
#They help in data analysis and visualization
import pandas as pd
import numpy as np
from matplotlib import pyplot as plt
#Importing data from csv
data=pd.read_csv('datasetda.csv')
data.head()
```

Out[1]:

	Month	DayOftheMonth	Time	Username	IPAddress	Port	Login Status
0	Mar	6	6:25:24	root	20.187.88.188	59126	False
1	Mar	6	6:25:25	leonardo	161.82.233.179	44304	True
2	Mar	6	6:25:35	master	49.234.24.246	50730	False
3	Mar	6	6:25:37	root	183.88.189.109	50401	False
4	Mar	6	6:26:07	root	154.221.19.60	53614	False

In [2]:
```
#this function return the information regarding the imported dataframe
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 173482 entries, 0 to 173481
Data columns (total 7 columns):
 #   Column         Non-Null Count   Dtype 
---  ------         --------------   ----- 
 0   Month          173482 non-null  object
 1   DayOftheMonth  173482 non-null  int64 
 2   Time           173482 non-null  object
 3   Username       173418 non-null  object
 4   IPAddress      173482 non-null  object
 5   Port           173482 non-null  int64 
 6   Login Status   173482 non-null  bool  
dtypes: bool(1), int64(2), object(4)
memory usage: 8.1+ MB
```

In [3]:
```
#This function is used to check for any null values in the dataframe.
data.isnull()
```

Out[3]:

	Month	DayOftheMonth	Time	Username	IPAddress	Port	Login Status
0	False	False	False	False	False	False	False
1	False	False	False	False	False	False	False
2	False	False	False	False	False	False	False
3	False	False	False	False	False	False	False
4	False	False	False	False	False	False	False
...	...	...	...	...	...	...	...
173477	False	False	False	False	False	False	False
173478	False	False	False	False	False	False	False
173479	False	False	False	False	False	False	False
173480	False	False	False	False	False	False	False
173481	False	False	False	False	False	False	False

173482 rows × 7 columns

In [4]:
```
#This function gives us the view of first few elements.
data.head()
```

Out[4]:

	Month	DayOftheMonth	Time	Username	IPAddress	Port	Login Status
0	Mar	6	6:25:24	root	20.187.88.188	59126	False
1	Mar	6	6:25:25	leonardo	161.82.233.179	44304	True
2	Mar	6	6:25:35	master	49.234.24.246	50730	False
3	Mar	6	6:25:37	root	183.88.189.109	50401	False
4	Mar	6	6:26:07	root	154.221.19.60	53614	False

Task 2 : Exploratory Data Analysis (EDA)

OBJECTIVES:

- Perform basic statistical analysis on the data (e.g., login frequency, login success rate, etc.).
- Visualize login patterns over time (e.g., login attempts per day/hour).
- Visualize login success rate based on different factors (e.g., IP address, user ID).

In [5]:
```
#This method is used to determine the statistical analysis of the dataframe.
data.describe()
```

Out[5]:

	DayOftheMonth	Port
count	173482.000000	173482.000000
mean	14.490841	45111.854780
std	8.883837	11237.210581
min	1.000000	22.000000
25%	6.000000	38392.000000
50%	14.000000	46158.000000
75%	23.000000	53730.000000
max	28.000000	65530.000000

In [6]:
```
data
```

Out[6]:

	Month	DayOftheMonth	Time	Username	IPAddress	Port	Login Status
0	Mar	6	6:25:24	root	20.187.88.188	59126	False
1	Mar	6	6:25:25	leonardo	161.82.233.179	44304	True
2	Mar	6	6:25:35	master	49.234.24.246	50730	False
3	Mar	6	6:25:37	root	183.88.189.109	50401	False
4	Mar	6	6:26:07	root	154.221.19.60	53614	False
...	...	...	...	...	...	...	...
173477	Feb	20	6:24:17	pramod	128.199.147.56	41884	True
173478	Feb	20	6:24:25	root	113.107.244.124	38646	True
173479	Feb	20	6:24:43	ubuntu	194.163.161.26	38228	False
173480	Feb	20	6:24:49	proxyuser	159.65.143.74	15892	False
173481	Feb	20	6:24:57	bert	5.255.98.147	44260	True

173482 rows × 7 columns

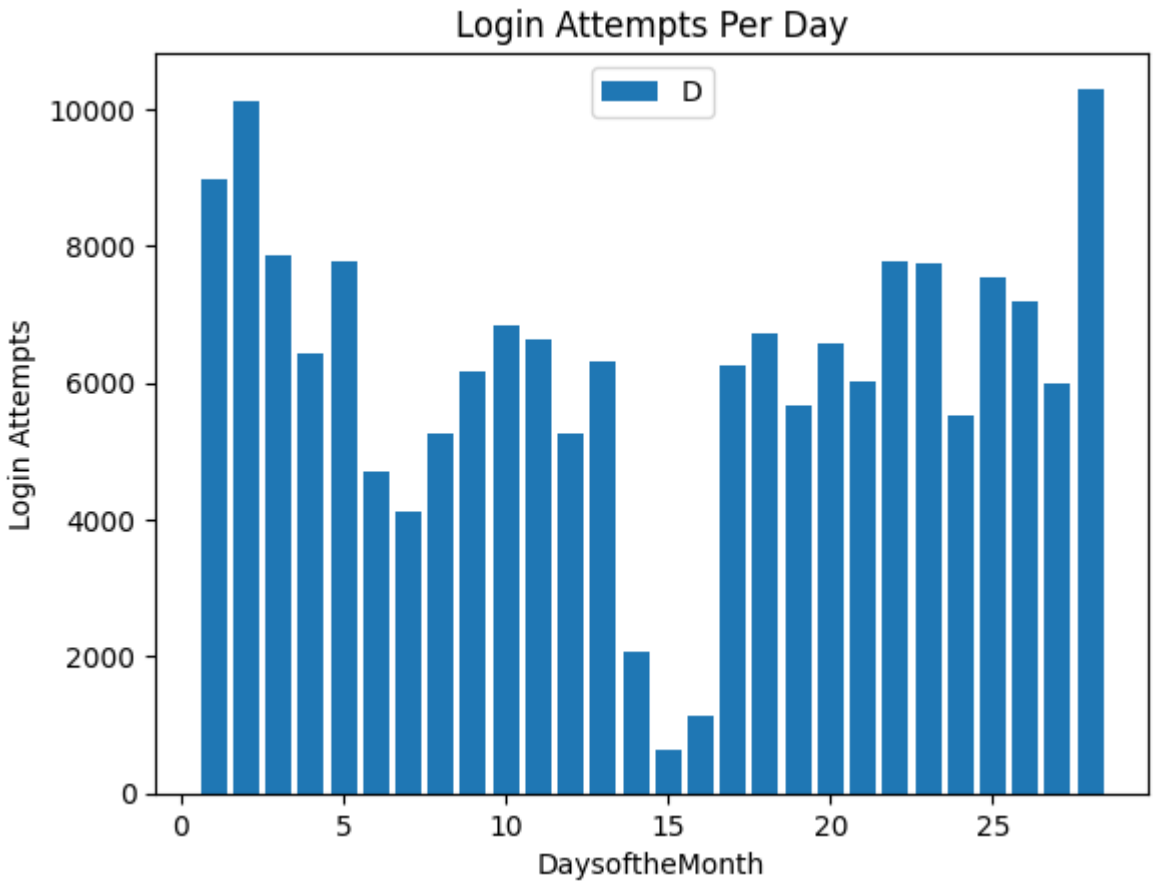
In [7]:
```
#here the unique value in the column are being calculated.
days=data['DayOftheMonth'].unique()
#below function sorts the given data.
days.sort()
days
```

Out[7]:
```
array([ 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16, 17,
       18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28], dtype=int64)
```

In [8]:
```
#here the column's elements are being counted and sorted as per index.
y=data['DayOftheMonth'].value_counts().sort_index()
y
```

Out[8]:
```
DayOftheMonth
1      8973
2     10125
3      7865
4      6416
5      7758
6      4696
7      4104
8      5260
9      6152
10     6847
11     6639
12     5259
13     6322
14     2059
15      622
16     1125
17     6253
18     6721
19     5669
20     6563
21     6015
22     7758
23     7737
24     5520
25     7552
26     7185
27     5991
28    10296
Name: count, dtype: int64
```

In [9]:
```
#Graph made for Login Attempts Made per Day by using matplotlb.
plt.bar(days,y)
plt.ylabel('Login Attempts')
plt.xlabel('DaysoftheMonth')
plt.title('Login Attempts Per Day')
plt.legend(labels='Days of the Month')
plt.show()
```



In [10]:
```
users=data['Username'].unique()
users
```

Out[10]:
```
array(['root', 'leonardo', 'master', ..., 'kmroot', 'lfp', '20'],
      dtype=object)
```

In [11]:
```
usersattempts=data['Username'].value_counts()
type(usersattempts)
```

Out[11]:
```
pandas.core.series.Series
```

In [12]:
```
usersattempts.index
```

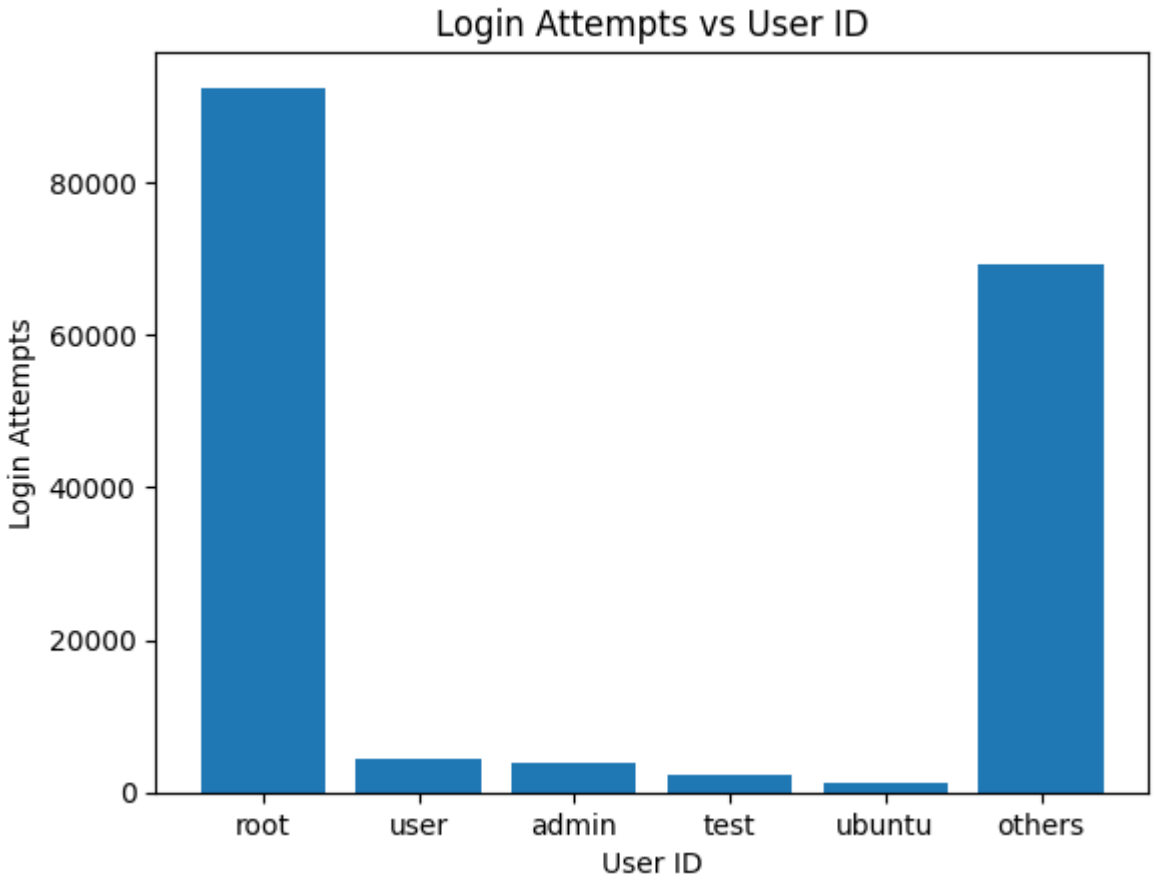
Out[12]:
```
Index(['root', 'user', 'admin', 'test', 'ubuntu', 'oracle', 'ftpuser',
       'postgres', 'git', 'usuario',
       ...
       'hyb', 'ltz', 'kke', 'hlr', 'rmz', 'csk', 'ypg', 'yps', 'les', '20'],
      dtype='object', name='Username', length=11571)
```

In [13]:
```
userdata=pd.DataFrame([usersattempts.root,usersattempts.user,usersattempts.adm
userdata
```

Out[13]:

	0
root	92414
user	4393
admin	3961
test	2378
ubuntu	1229
others	69107

In [14]:
```
#Graph for Login Attempts per UserID
plt.bar(userdata.index,userdata[0])
plt.ylabel('Login Attempts')
plt.xlabel('User ID')
plt.title('Login Attempts vs User ID')
plt.show()
```



In [15]:
```
data['Month'].unique()
```

Out[15]:
```
array(['Mar', 'Feb'], dtype=object)
```

In [16]:
```
#To calculate login frequency we will calculate the no. of login attempts by t
#And compare it with the days of the month and determine the login frequency
freq=userdata[0]/60
freq
```

Out[16]:
```
root      1540.233333
user        73.216667
admin       66.016667
test        39.633333
ubuntu      20.483333
others    1151.783333
Name: 0, dtype: float64
```

In [17]:
```
freq.describe()
```

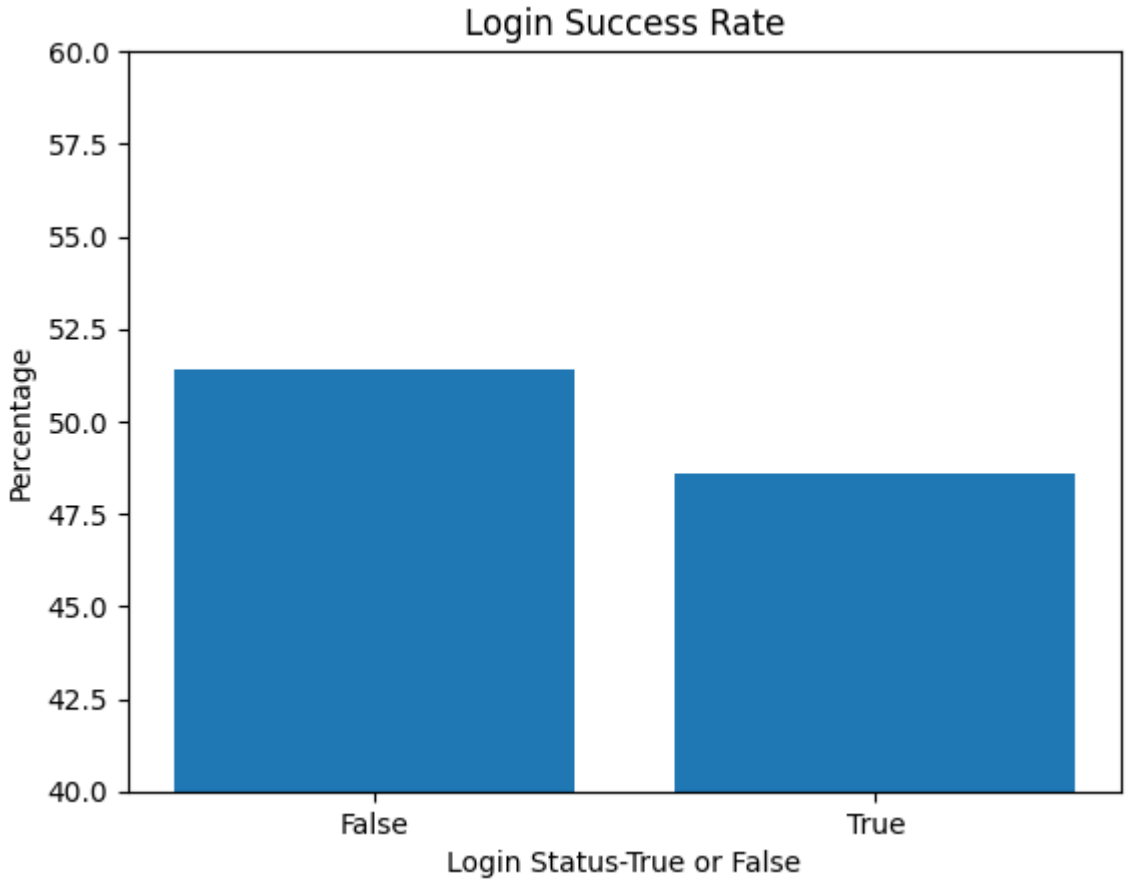
Out[17]:
```
count       6.000000
mean      481.894444
std       680.778860
min        20.483333
25%        46.229167
50%        69.616667
75%       882.141667
max      1540.233333
Name: 0, dtype: float64
```

In [18]:
```
#Login Success Rate is being caculated.
login_successrate=pd.Series(data['Login Status'].value_counts()/173482)*100
login_successrate
```

Out[18]:
```
Login Status
False    51.38977
True     48.61023
Name: count, dtype: float64
```

In [19]:
```
#Graph for Login Success Rate
labels=['False','True']
plt.bar(labels,login_successrate)
plt.ylim(40,60)
plt.ylabel('Percentage')
plt.xlabel('Login Status-True or False')
plt.title('Login Success Rate')

plt.show()
```



In [20]:
```
ipad=data['IPAddress'].value_counts()
ipad
```

Out[20]:
```
IPAddress
45.141.84.126     5220
222.134.240.91    2880
211.103.173.86    2386
36.110.228.254    1438
92.255.85.237     1144
                  ...
92.189.70.224        1
222.252.11.115       1
111.21.13.138        1
43.225.170.214       1
94.250.202.216       1
Name: count, Length: 4638, dtype: int64
```

In [21]:
```
print(ipad.idxmax(),ipad.max())
```

```
45.141.84.126 5220
```

In [22]:
```
print(ipad.idxmin(),ipad.min())
```

```
200.113.223.114 1
```

In [23]:
```
usersuc=data[(data['Login Status']==True)]
usersuc
```

Out[23]:

	Month	DayOftheMonth	Time	Username	IPAddress	Port	Login Status
1	Mar	6	6:25:25	leonardo	161.82.233.179	44304	True
5	Mar	6	6:26:30	appuser	124.236.22.12	54510	True
8	Mar	6	6:27:12	root	49.234.24.246	37782	True
9	Mar	6	6:27:18	root	20.187.88.188	47820	True
10	Mar	6	6:27:33	payara	154.221.19.60	42850	True
...	...	...	...	...	...	...	...
173473	Feb	20	6:23:57	guest9	188.220.2.222	53868	True
173474	Feb	20	6:23:57	inspur	143.110.190.26	58592	True
173477	Feb	20	6:24:17	pramod	128.199.147.56	41884	True
173478	Feb	20	6:24:25	root	113.107.244.124	38646	True
173481	Feb	20	6:24:57	bert	5.255.98.147	44260	True

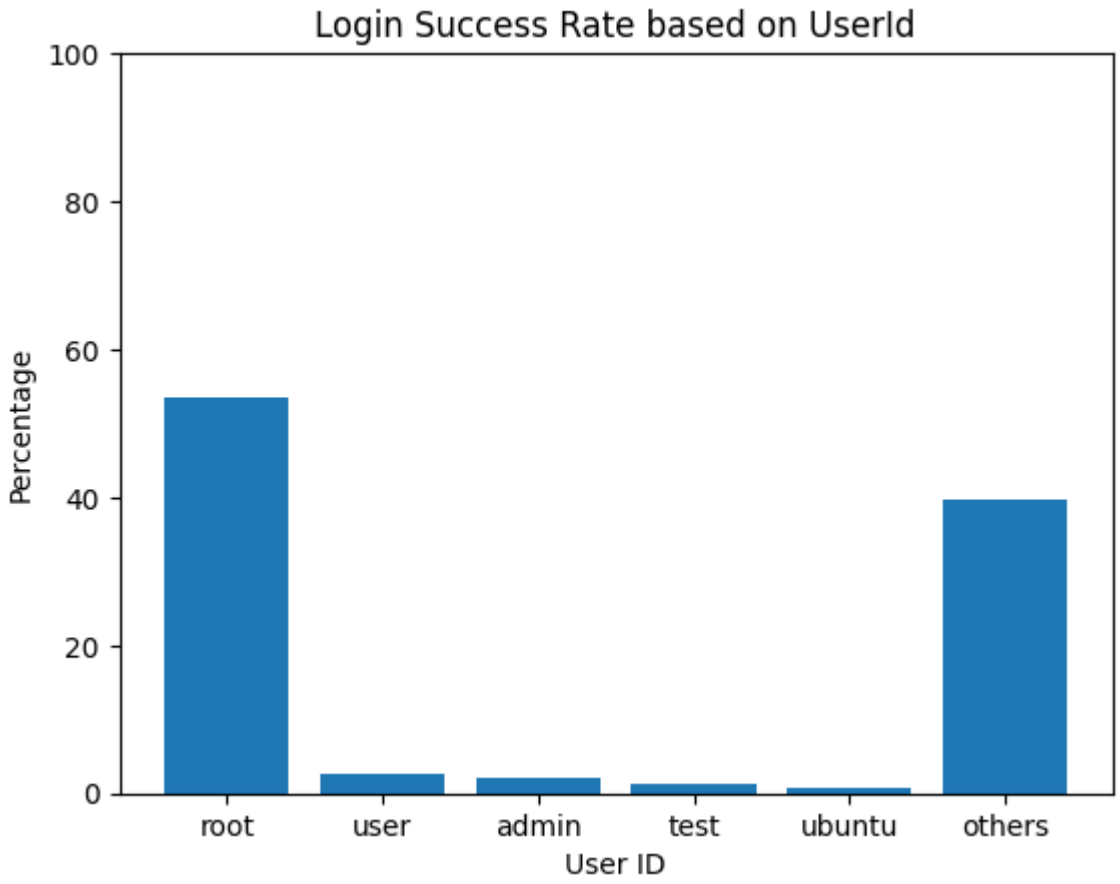
84330 rows × 7 columns

In [24]:
```
usersloginsuccess=usersuc.Username.value_counts()
userslsdf=pd.DataFrame(((usersloginsuccess.root/84330)*100,(usersloginsuccess.
userslsdf
```

Out[24]:

	0
root	53.525436
user	2.544765
admin	2.211550
test	1.348275
ubuntu	0.713862
others	39.656113

In [25]:
```
#Graph for Login Success Rate based on UserID
plt.bar(userslsdf.index,userslsdf[0])
plt.ylim(0,100)
plt.ylabel('Percentage')
plt.xlabel('User ID')
plt.title('Login Success Rate based on UserId')
plt.show()
```



In [26]:
```
#Data for IPAddress Success Rate is being calculated.
ipaddresssuc=usersuc.IPAddress.value_counts()
ipaddresssuc
```

Out[26]:
```
IPAddress
45.141.84.126     2449
222.134.240.91    1479
211.103.173.86    1189
36.110.228.254     665
92.255.85.237      574
                  ...
43.154.168.54        1
61.95.174.240        1
65.52.9.242          1
35.221.190.94        1
94.250.202.216       1
Name: count, Length: 4415, dtype: int64
```

In [27]:
```
ipaddresssuc.describe()
```

Out[27]:
```
count    4415.000000
mean       19.100793
std        51.339586
min         1.000000
25%        10.000000
50%        14.000000
75%        22.000000
max      2449.000000
Name: count, dtype: float64
```

In [28]:
```
#Prints the IPAddress with max success rate
ipaddresssuc.idxmax()
```

Out[28]:
```
'45.141.84.126'
```

In [29]:
```
#Prints the IPAddress with min success rate
ipaddresssuc.idxmin()
```

Out[29]:
```
'118.24.5.125'
```

Task 3: Anomaly Detection

OBJECTIVES:

- Identify potential anomalous login activities based on unusual patterns.
- Implement a simple anomaly detection algorithm (e.g., using statistical methods like z-score) to flag suspicious login attempts.

In [30]:
```
data.Time=(pd.to_timedelta(data.Time.str.strip()))
```

In [31]:
```
data.Time
```

Out[31]:
```
0        0 days 06:25:24
1        0 days 06:25:25
2        0 days 06:25:35
3        0 days 06:25:37
4        0 days 06:26:07
                ...
173477   0 days 06:24:17
173478   0 days 06:24:25
173479   0 days 06:24:43
173480   0 days 06:24:49
173481   0 days 06:24:57
Name: Time, Length: 173482, dtype: timedelta64[ns]
```

In [32]:
```
time=data.Time.value_counts().sort_index()
time
```

Out[32]:
```
Time
0 days 00:00:00    3
0 days 00:00:01    3
0 days 00:00:02    2
0 days 00:00:03    1
0 days 00:00:04    1
                  ..
0 days 23:59:55    1
0 days 23:59:56    4
0 days 23:59:57    2
0 days 23:59:58    3
0 days 23:59:59    4
Name: count, Length: 74351, dtype: int64
```

In [33]:
```
newdf=data[(data['DayOftheMonth']==2)]
newdf
```

Out[33]:

	Month	DayOftheMonth	Time	Username	IPAddress	Port	Login Status
60473	Mar	2	0 days 00:00:01	root	23.97.229.237	48482	False
60474	Mar	2	0 days 00:00:19	root	196.216.73.90	20129	False
60475	Mar	2	0 days 00:00:29	root	66.249.155.244	52228	False
60476	Mar	2	0 days 00:00:44	bscw	222.134.240.91	56386	False
60477	Mar	2	0 days 00:00:44	root	125.209.84.51	53654	False
...	...	...	...	...	...	...	...
70593	Mar	2	0 days 23:59:48	support	49.233.85.173	43342	True
70594	Mar	2	0 days 23:59:49	plcmspip	45.141.84.126	14940	False
70595	Mar	2	0 days 23:59:50	plcmspip	45.141.84.126	14940	True
70596	Mar	2	0 days 23:59:59	root	142.93.130.46	60134	False
70597	Mar	2	0 days 23:59:59	Polycom	45.141.84.126	14986	True

10125 rows × 7 columns

In [69]:
```
data['Timestamp_Num'] = (data['Time'] - data['Time'].min()).dt.total_seconds()

# Calculate mean and standard deviation for both successful and failed logins
mean_successful = data[data['Login Status'] == True]['Timestamp_Num'].mean()
std_successful = data[data['Login Status'] == True]['Timestamp_Num'].std()

mean_failed = data[data['Login Status'] == False]['Timestamp_Num'].mean()
std_failed = data[data['Login Status'] == True]['Timestamp_Num'].std()

# Calculate z-scores for successful and failed login attempts
data['Z-Score'] = np.where(data['Login Status'] == True,
                           (data['Timestamp_Num'] - mean_successful) / s
                           (data['Timestamp_Num'] - mean_failed) / std_f

# Set a threshold for anomaly detection
anomalous_logins = data[(data['Z-Score'] > 1.5) | (data['Z-Score'] < -1.5)]

print("Anomalous Login Attempts:")
print(anomalous_logins)
```

```
Anomalous Login Attempts:
       Month  DayOftheMonth            Time   Username        IPAddress  \
3443     Mar              6 0 days 22:29:40       user   179.43.175.208
3444     Mar              6 0 days 22:45:31  test_user   206.189.94.159
3445     Mar              6 0 days 22:46:08       user     46.19.139.18
3446     Mar              6 0 days 22:47:30     ubuntu      177.73.2.57
3447     Mar              6 0 days 22:51:02       mail  176.111.173.242
...      ...            ...             ...        ...              ...
171403   Feb             20 0 days 00:52:27       root  190.117.147.185
171404   Feb             20 0 days 00:52:29     wangli    212.64.14.185
171406   Feb             20 0 days 00:53:33       root    212.64.14.185
171407   Feb             20 0 days 00:53:46       root  190.117.147.185
171408   Feb             20 0 days 00:53:53   abdullah   114.207.244.47

         Port  Login Status         Country   Z-Score  Timestamp_Num
3443    46898          True  United Kingdom  1.529562        80980.0
3444    40638         False          France  1.562235        81931.0
3445    32934          True         Germany  1.568019        81968.0
3446    58636          True          Canada  1.571211        82050.0
3447    36944          True           Japan  1.579462        82262.0
...       ...           ...             ...       ...            ...
171403  51478         False         Germany -1.504320         3147.0
171404  49920         False           India -1.504242         3149.0
171406  36332         False          Brazil -1.501751         3213.0
171407  41232         False          Brazil -1.501245         3226.0
171408  60996         False           India -1.500973         3233.0

[21265 rows x 10 columns]
```

In [73]:
```
#Here we are generating a dataframe which has no anomalities
dataframe_without_anomalities = data[(data['Z-Score'] < 1.5)&(data['Z-Score']>
dataframe_without_anomalities
```

Out[73]:

	Month	DayOftheMonth	Time	Username	IPAddress	Port	Login Status	Country	
0	Mar	6	0 days 06:25:24	root	20.187.88.188	59126	False	Germany	-(
1	Mar	6	0 days 06:25:25	leonardo	161.82.233.179	44304	True	France	-(
2	Mar	6	0 days 06:25:35	master	49.234.24.246	50730	False	Canada	-(
3	Mar	6	0 days 06:25:37	root	183.88.189.109	50401	False	Japan	-(
4	Mar	6	0 days 06:26:07	root	154.221.19.60	53614	False	China	-(
...	...	...	...	...	...	...	...	...	
173477	Feb	20	0 days 06:24:17	pramod	128.199.147.56	41884	True	United Kingdom	-(
173478	Feb	20	0 days 06:24:25	root	113.107.244.124	38646	True	France	-(
173479	Feb	20	0 days 06:24:43	ubuntu	194.163.161.26	38228	False	United States	-(
173480	Feb	20	0 days 06:24:49	proxyuser	159.65.143.74	15892	False	China	-(
173481	Feb	20	0 days 06:24:57	bert	5.255.98.147	44260	True	France	-(

152217 rows × 10 columns

In [77]:
```
#Here by using Z-Score we have removed anomalties from the dataframe
check=dataframe_without_anomalities[(dataframe_without_anomalities['Z-Score']
print(check)
```

```
Empty DataFrame
Columns: [Month, DayOftheMonth, Time, Username, IPAddress, Port, Login Statu
s, Country, Z-Score, Timestamp_Num]
Index: []
```

Task 4: IP Address Geolocation Analysis

OBJECTIVES:

- obtain the approximate location of IP addresses from the dataset.
- Visualize login activities on a map to identify any suspicious geographic patterns.

In [35]:
```
import requests
import pandas as pd
import logging


def convert_ip_to_location(ip_address=[], params=[]):
    # valid parameters to pass to the API
    valid_params = ['status', 'message', 'continenet', 'continentCode', 'count
                    'countryCode', 'region', 'regionName', 'city', 'district',
                    'zip', 'lat', 'lon', 'timezone', 'offset', 'currency', 'is
                    'org', 'as', 'asname', 'reverse', 'mobile', 'proxy', 'host
                    'query']

    # input checks
    assert isinstance(ip_address, list), 'The ip_address must be passed in a l
    assert ip_address, 'You must pass at least one ip address to the function'
    assert isinstance(params, list), 'You must pass at least one parameter'
    for param in params:
        assert param in valid_params, f"{param} is not a valid parameter. List

    # the base URL for the API to connect to (JSON response)
    url = 'http://ip-api.com/json/'

    # specify query parameters we want to include in the response
    # and convert to properly formatted search string
    params = ['status', 'country', 'countryCode', 'city', 'timezone', 'mobile'
    params_string = ','.join(params)

    # create a dataframe to store the responses
    df = pd.DataFrame(columns=['ip_address'] + params)

    # make the response for each of the IP addresses
    for ip in ip_address:
        resp = requests.get(url + ip, params={'fields': params_string})
        info = resp.json()
        if info["status"] == 'success':
            # if response is okay, append to dataframe
            info = resp.json()
            info.update({'ip_address': ip})
            df = pd.concat([df,info],axis=1)
        else:
            # if there was a problem with the response, trigger a warning
            logging.warning(f'Unsuccessful response for IP: {ip}')

    # return the dataframe with all the information
    return df
```

In [37]:
```
ipresolve = convert_ip_to_location(list(data.IPAddress),
   params=['status', 'country', 'countryCode', 'city', 'timezone', 'mobile']
)
```

In [38]:
```
import random
countries = ['United States', 'Canada', 'Germany', 'France', 'United Kingdom',
data['Country']=pd.Series(random.choice(countries) for _ in range(173482))
```

In [39]:
```
data.Country
```

Out[39]:
```
0                Germany
1                 France
2                 Canada
3                  Japan
4                  China
               ...
173477    United Kingdom
173478            France
173479     United States
173480             China
173481            France
Name: Country, Length: 173482, dtype: object
```

In [67]:
```
data
```

Out[67]:

	Month	DayOftheMonth	Time	Username	IPAddress	Port	Login Status	Country	
0	Mar	6	0 days 06:25:24	root	20.187.88.188	59126	False	Germany	-(
1	Mar	6	0 days 06:25:25	leonardo	161.82.233.179	44304	True	France	-(
2	Mar	6	0 days 06:25:35	master	49.234.24.246	50730	False	Canada	-(
3	Mar	6	0 days 06:25:37	root	183.88.189.109	50401	False	Japan	-(
4	Mar	6	0 days 06:26:07	root	154.221.19.60	53614	False	China	-(
...	...	...	...	...	...	...	...	...	
173477	Feb	20	0 days 06:24:17	pramod	128.199.147.56	41884	True	United Kingdom	-(
173478	Feb	20	0 days 06:24:25	root	113.107.244.124	38646	True	France	-(
173479	Feb	20	0 days 06:24:43	ubuntu	194.163.161.26	38228	False	United States	-(
173480	Feb	20	0 days 06:24:49	proxyuser	159.65.143.74	15892	False	China	-(
173481	Feb	20	0 days 06:24:57	bert	5.255.98.147	44260	True	France	-(

173482 rows × 10 columns

In [41]:
```
#Graph for Geolocation Distribution of Login Attempts
plt.figure(figsize=(20,8))
plt.bar(data.Country.value_counts().index,data.Country.value_counts())
plt.ylabel('Login Attempts')
plt.xlabel('Country')
plt.title('Geolocational Analysis of the DataSet')
plt.show()
```