Connect to Google Drive

```
from google.colab import drive
drive.mount('/content/drive', force_remount=True)

!ls /content/drive/MyDrive/EDA-STATPROB/
```

```
Mounted at /content/drive
 cybersecurity_intrusion_data.csv  'Eda StatProb.ipynb'   LossFromNetCrime.csv
```

```
!cp /content/drive/MyDrive/EDA-STATPROB/cybersecurity_intrusion_data.csv datase
```

Environment Setup

Setup environment by import all required libraries

```
# import required library
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from scipy import stats
```

```
df = pd.read_csv('datasets.csv')
```

1. Dataset Description

Source : https://www.kaggle.com/datasets/dnkumars/cybersecurity-intrusion-detection-dataset

Show the first 10 lines of the dataset (Overview)

```
# Using head(10) to show the first 10 lines of the dataset
df.head(10)
```

	session_id	network_packet_size	protocol_type	login_attempts	session_durat
0	SID_00001	599	TCP	4	492.983
1	SID_00002	472	TCP	3	1557.996
2	SID_00003	629	TCP	3	75.044
3	SID_00004	804	UDP	4	601.248
4	SID_00005	453	TCP	5	532.540
5	SID_00006	453	UDP	5	380.471
6	SID_00007	815	ICMP	4	728.107
7	SID_00008	653	TCP	3	12.599
8	SID_00009	406	TCP	2	542.558
9	SID_00010	608	UDP	6	531.944

Calculate dataset shape, missing value, duplicate records, descriptive statistics

```
# Dataset shape (row, column)
row, column = df.shape

print("Number of rows: ", row)
print("Number of columns: ", column)
```

```
Number of rows:  9537
Number of columns:  11
```

```
# Duplicate records
int(df.duplicated().sum())
```

```
0
```

```
# Missing value
df.isnull().sum()
```

	0
session_id	0
network_packet_size	0
protocol_type	0
login_attempts	0
session_duration	0
encryption_used	1966
ip_reputation_score	0
failed_logins	0
browser_type	0
unusual_time_access	0
attack_detected	0

dtype: int64

```
# Get info of the dataset
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 9537 entries, 0 to 9536
Data columns (total 11 columns):
 #   Column               Non-Null Count  Dtype  
---  ------               --------------  -----  
 0   session_id           9537 non-null   object 
 1   network_packet_size  9537 non-null   int64  
 2   protocol_type        9537 non-null   object 
 3   login_attempts       9537 non-null   int64  
 4   session_duration     9537 non-null   float64
 5   encryption_used      7571 non-null   object 
 6   ip_reputation_score  9537 non-null   float64
 7   failed_logins        9537 non-null   int64  
 8   browser_type         9537 non-null   object 
 9   unusual_time_access  9537 non-null   int64  
 10  attack_detected      9537 non-null   int64  
dtypes: float64(2), int64(5), object(4)
memory usage: 819.7+ KB
```

```
# Get statical summary
df.describe()
```

	network_packet_size	login_attempts	session_duration	ip_reputation_scor
count	9537.000000	9537.000000	9537.000000	9537.00000
mean	500.430639	4.032086	792.745312	0.33133
std	198.379364	1.963012	786.560144	0.17717
min	64.000000	1.000000	0.500000	0.00249
25%	365.000000	3.000000	231.953006	0.19194
50%	499.000000	4.000000	556.277457	0.31477
75%	635.000000	5.000000	1105.380602	0.45338
max	1285.000000	13.000000	7190.392213	0.92429

Data cleaning

```
df_clean = df.copy()
```

```
df['browser_type'].unique()
```

```
array(['Edge', 'Firefox', 'Chrome', 'Unknown', 'Safari'], dtype=object)
```

```
# Mapping categorical data to numbers

"""
ICMP = 0
TCP = 1
UDP = 2
"""
mapping_protocol_type = {"ICMP": 0, "TCP": 1, "UDP": 2}
df_clean["protocol_type"] = df["protocol_type"].map(mapping_protocol_type)


"""
DES = 0
AES = 1
ON ENCRYPTION = 2
"""
mapping_encryption_used = {"DES": 0, "AES": 1}
df_clean["encryption_used"] = df["encryption_used"].map(mapping_encryption_usec

df_clean["encryption_used"] = df_clean["encryption_used"].fillna(2).astype(int)


"""
Edge = 0
Firefox = 1
Chrome = 2
```

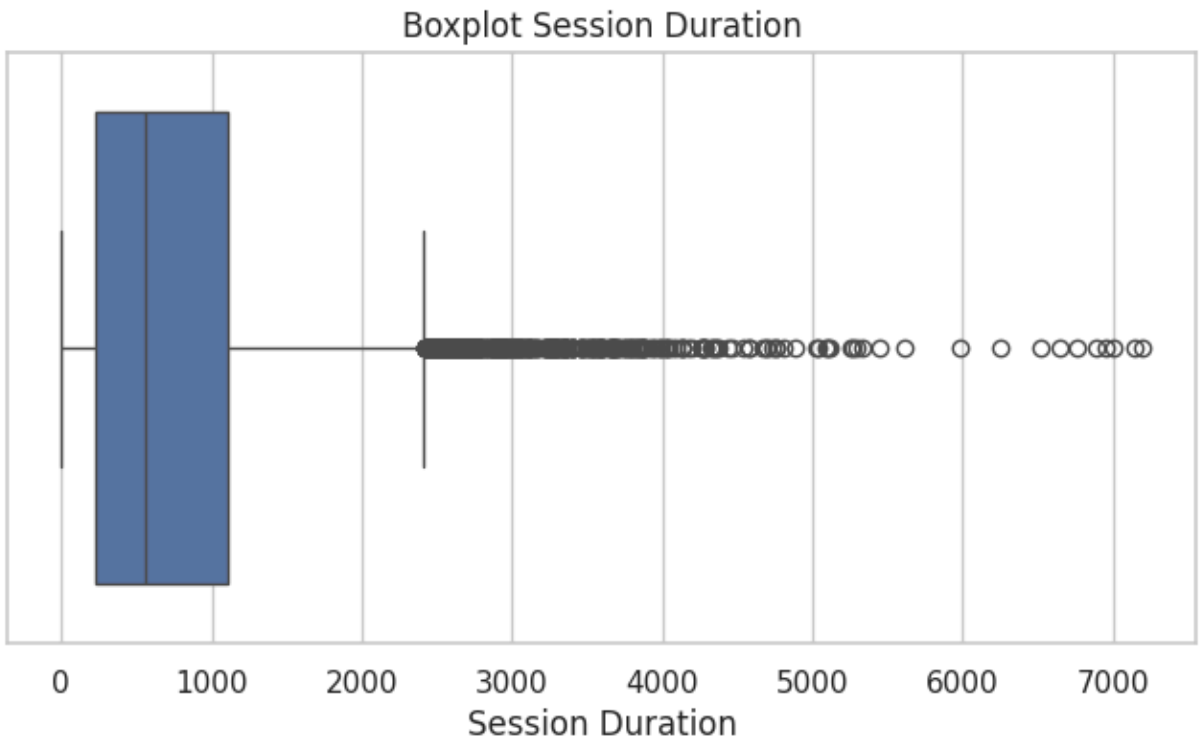
```
Safari = 3
Unknown = 4
"""
mapping_browser = {
    "Edge": 0,
    "Firefox": 1,
    "Chrome": 2,
    "Safari": 3,
    "Unknown": 4
}

df_clean["browser_type"] = df["browser_type"].map(mapping_browser).astype(int)

df_clean.head()
```

	session_id	network_packet_size	protocol_type	login_attempts	session_durat
0	SID_00001	599	1	4	492.983
1	SID_00002	472	1	3	1557.996
2	SID_00003	629	1	3	75.044
3	SID_00004	804	2	4	601.248
4	SID_00005	453	1	5	532.540

Code below will visualize login attempts into histogram

2. Outlier Analysis

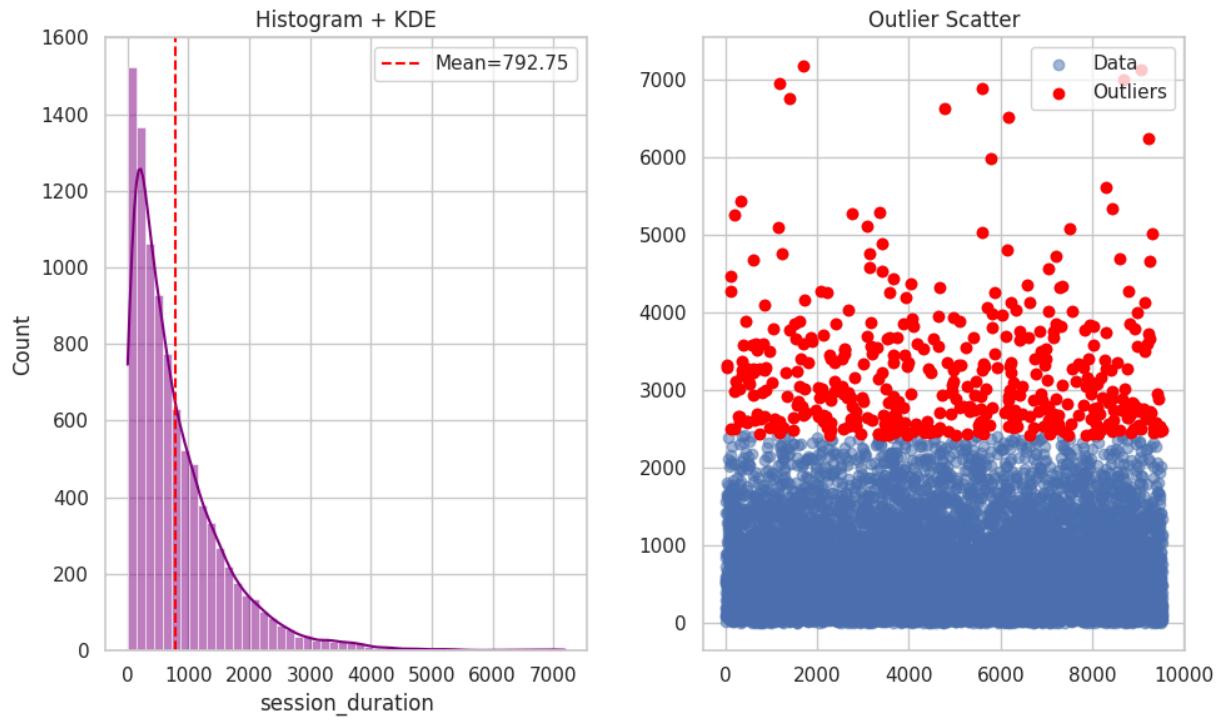
```
# Visualize login attempts

sns.set(style="whitegrid")

# Histogram login_attempts
plt.figure(figsize=(8,4))
sns.boxplot(x=df_clean["session_duration"])
plt.title("Boxplot Session Duration")
plt.xlabel("Session Duration")
plt.show()
```




```
session_time = df_clean['session_duration']
range_val = session_time.max() - session_time.min()

# Mean & Std Deviation
mean_val = session_time.mean()
std_val = session_time.std()

# Q1, Q3, IQR
Q1 = session_time.quantile(0.25)
Q3 = session_time.quantile(0.75)
IQR = Q3 - Q1

# Outlier threshold (rule of thumb)
lower_bound = Q1 - 1.5 * IQR
upper_bound = Q3 + 1.5 * IQR

outliers = session_time[(session_time < lower_bound) | (session_time > upper_bc

# Print result
print(f"Range: {range_val}")
print(f"Mean: {mean_val:.2f}")
print(f"Std Dev: {std_val:.2f}")
print(f"Q1: {Q1}, Q3: {Q3}, IQR: {IQR}")
print(f"Lower Bound: {lower_bound}, Upper Bound: {upper_bound}")
print(f"Total : {len(outliers)}")
```

```
Range: 7189.892212563188
Mean: 792.75
Std Dev: 786.56
Q1: 231.95300642419463, Q3: 1105.3806022240433, IQR: 873.4275957998486
Lower Bound: -1078.1883872755782, Upper Bound: 2415.521995923816
Total : 418
```

```
plt.figure(figsize=(14, 6))

# 1. Histogram + KDE
plt.subplot(1, 3, 2)
sns.histplot(session_time, bins=50, kde=True, color="purple")
plt.axvline(mean_val, color='red', linestyle='--', label=f"Mean={mean_val:.2f}"
plt.legend()
plt.title("Histogram + KDE")

# 3. Outlier scatter (using index)
plt.subplot(1, 3, 3)
plt.scatter(range(len(session_time)), session_time, alpha=0.5, label="Data")
plt.scatter(outliers.index, outliers, color="red", label="Outliers")
plt.title("Outlier Scatter")
plt.legend()

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



Outlier analysis result

During the analysis of the session_duration variable, several extreme values (outliers) were detected. These outliers represent unusually long sessions compared to the majority of the data.

Instead of removing them, the decision is to keep the outliers in the dataset. The reasoning is:

- Part of the phenomenon – Long sessions may indicate real-world cases such as prolonged attacks, brute-force attempts, or unusual user behavior.
- Potentially informative – Outliers might correlate with the target variable (attack_detected), making them important signals for modeling.

- Not erroneous – There is no evidence suggesting these values are the result of logging errors or noise.

Therefore, the outliers will be retained for further analysis and modeling, since they may provide valuable insights into anomalous activities.

3. Univariate Analysis

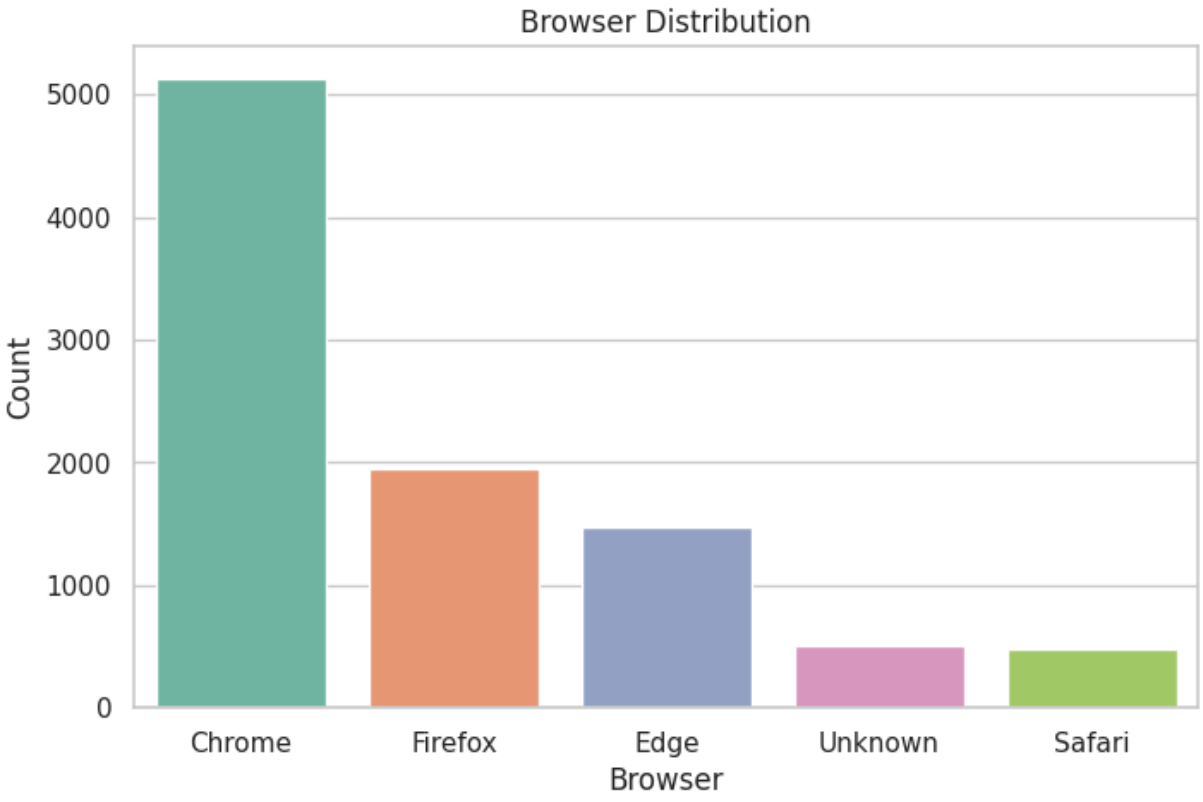
Univariate analysis is a statistical method to describe or summarize a single variable at a time, without considering any other variables.

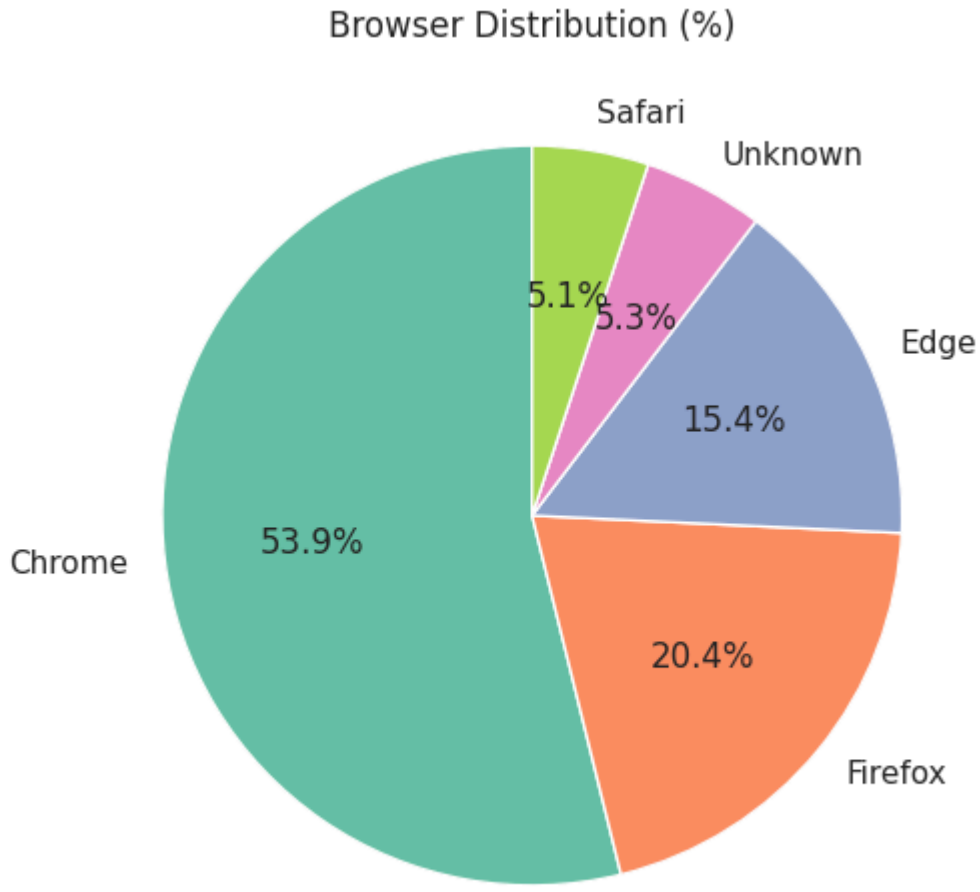
```
# Frequency counts
print("Browser Mapping: ", mapping_browser)

browser_counts = df_clean['browser_type'].value_counts()
print("Browser Frequency:\n", browser_counts)

# Percentage
browser_percentage = df_clean['browser_type'].value_counts(normalize=True) * 10
print("\nBrowser Percentage (%):\n", browser_percentage)
```

```
Browser Mapping:  {'Edge': 0, 'Firefox': 1, 'Chrome': 2, 'Safari': 3, 'Unknown':
Browser Frequency:
 browser_type
2    5137
1    1944
0    1469
4     502
3     485
Name: count, dtype: int64

Browser Percentage (%):
 browser_type
2    53.863899
1    20.383768
0    15.403167
4     5.263710
3     5.085457
Name: proportion, dtype: float64
```

```
reverse_mapping_browser = {v: k for k, v in mapping_browser.items()}

browser_labels = [reverse_mapping_browser[idx] for idx in browser_counts.index]

browser_df = pd.DataFrame({
    "Browser": browser_labels,
    "Count": browser_counts.values
})

plt.figure(figsize=(8,5))
sns.barplot(data=browser_df, x="Browser", y="Count", palette="Set2", hue="Brows
plt.title("Browser Distribution")
```

```
plt.xlabel("Browser")
plt.ylabel("Count")
plt.show()

# Visualization - Pie Chart
plt.figure(figsize=(6,6))
plt.pie(browser_counts.values, labels=browser_labels, autopct='%1.1f%%', starta
plt.title("Browser Distribution (%)")
plt.show()
```

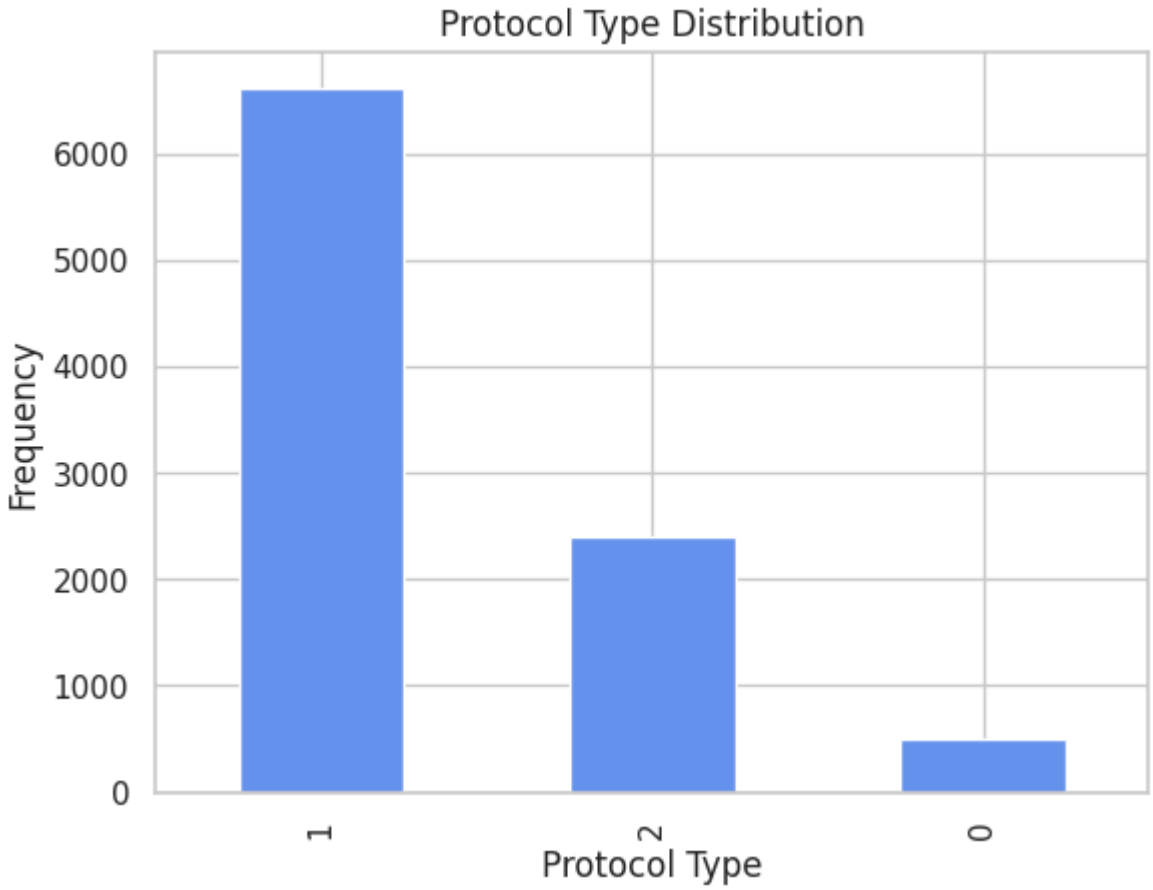





```
# Frequency Count
freq = df_clean['protocol_type'].value_counts()

# Percentage
perc = df_clean['protocol_type'].value_counts(normalize=True) * 100
```

```
# Gabungkan ke satu tabel
summary = pd.DataFrame({'Frequency': freq, 'Percentage': perc.round(2)})
print(summary)

# Visualization
summary['Frequency'].plot(kind='bar', color='cornflowerblue')
plt.title("Protocol Type Distribution")
plt.xlabel("Protocol Type")
plt.ylabel("Frequency")
plt.show()
```

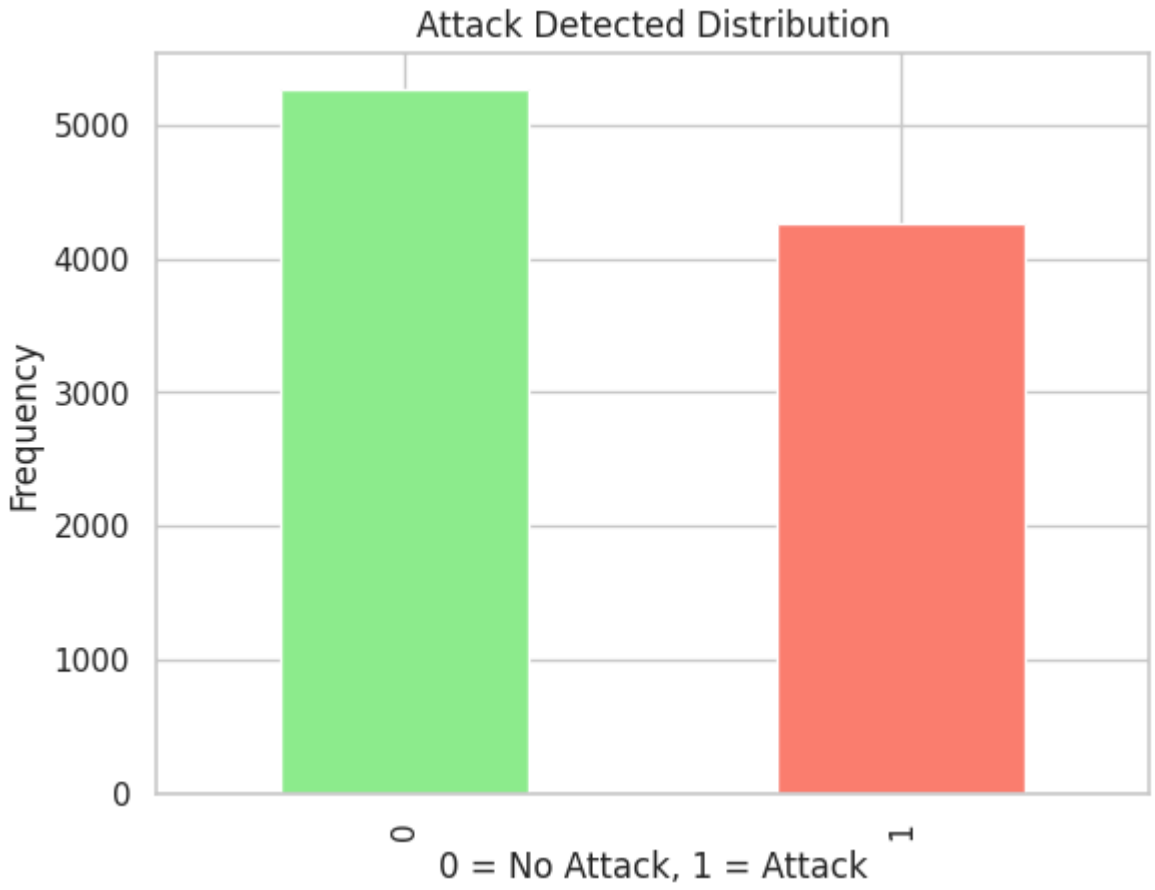
```
               Frequency  Percentage
protocol_type
1                   6624       69.46
2                   2406       25.23
0                    507        5.32
```



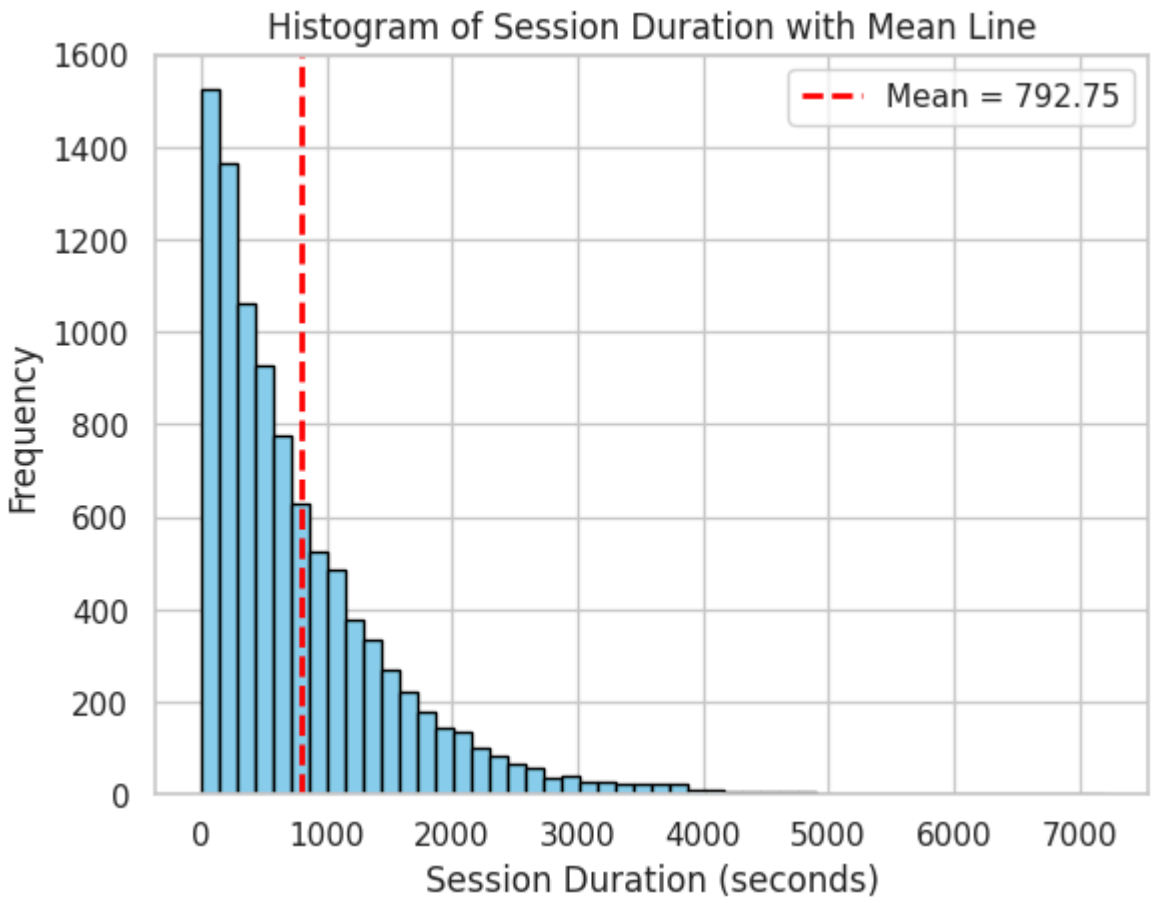

```
# Frequency Count
freq = df_clean['attack_detected'].value_counts()

# Percentage
perc = df_clean['attack_detected'].value_counts(normalize=True) * 100

# Gabungkan ke tabel
summary = pd.DataFrame({'Frequency': freq, 'Percentage': perc.round(2)})
print(summary)

# Visualization (Bar Chart)
```

```
summary['Frequency'].plot(kind='bar', color=['lightgreen','salmon'])
plt.title("Attack Detected Distribution")
plt.xlabel("0 = No Attack, 1 = Attack")
plt.ylabel("Frequency")
plt.show()
```

```
                  Frequency  Percentage
attack_detected
0                      5273       55.29
1                      4264       44.71
```




```
session_time = df_clean['session_duration']

# Hitung mean
mean_val = session_time.mean()

# Plot histogram + garis mean
plt.hist(session_time, bins=50, color="skyblue", edgecolor="black")
plt.axvline(mean_val, color='red', linestyle='--', linewidth=2, label=f"Mean =
plt.title("Histogram of Session Duration with Mean Line")
plt.xlabel("Session Duration (seconds)")
plt.ylabel("Frequency")
plt.legend()
plt.show()
```



4. Bivariate Analysis

Bivariate analysis is a statistical method to study the relationship between exactly two variables, aiming to determine if they are related, and if so, to describe the nature, strength, and direction of that relationship

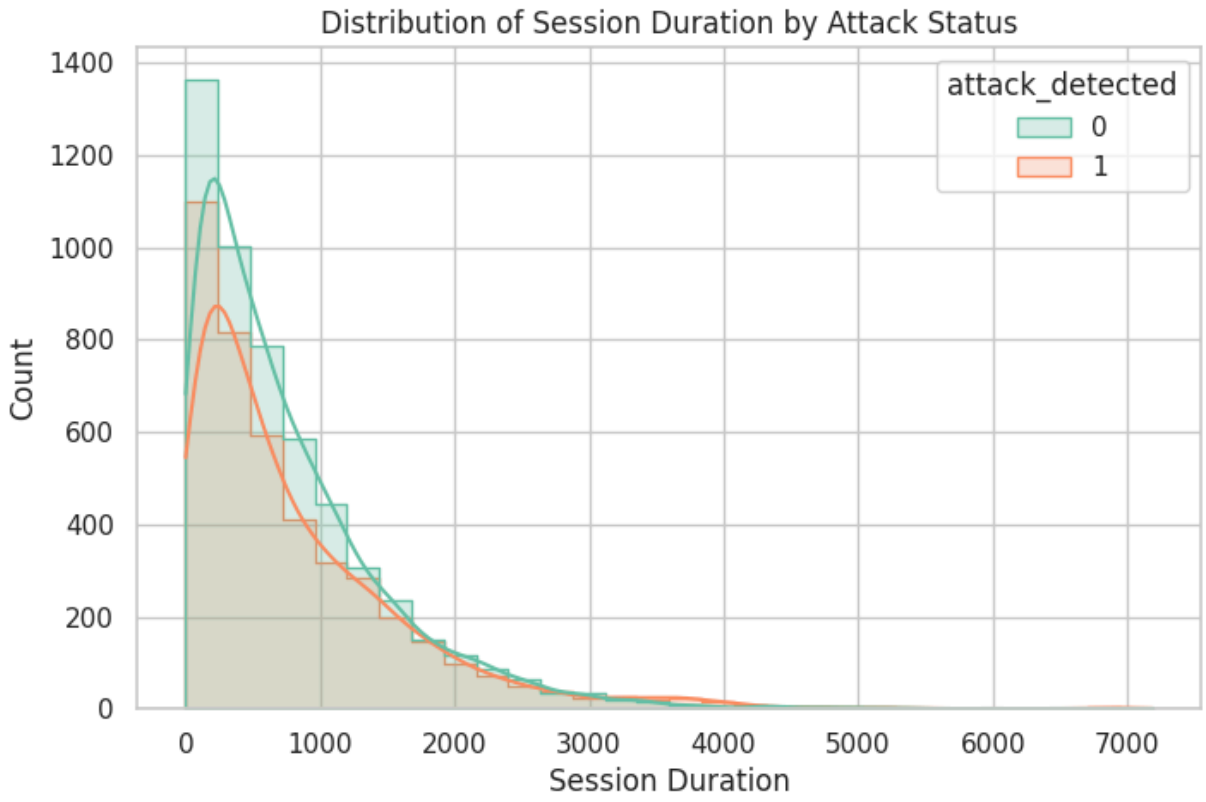
Session Duration vs Attack Detected (Numerical vs Categorical)

```
print("Session Duration Statistics by Attack Detected:")
print(df_clean.groupby("attack_detected")["session_duration"].describe())
```

```
Session Duration Statistics by Attack Detected:
                  count        mean         std  min         25%         50%  \
attack_detected
0                5273.0  763.321311  728.250219  0.5  232.042818  554.069552
1                4264.0  829.131980  851.857703  0.5  231.664142  559.358924

                        75%          max
attack_detected
0                1066.236472  7190.392213
1                1166.808449  7141.336086
```

```
# Histogram with hue
plt.figure(figsize=(8,5))
sns.histplot(data=df_clean, x="session_duration", hue="attack_detected", bin
```

```
plt.title("Distribution of Session Duration by Attack Status")
plt.xlabel("Session Duration")
plt.ylabel("Count")
plt.show()
```

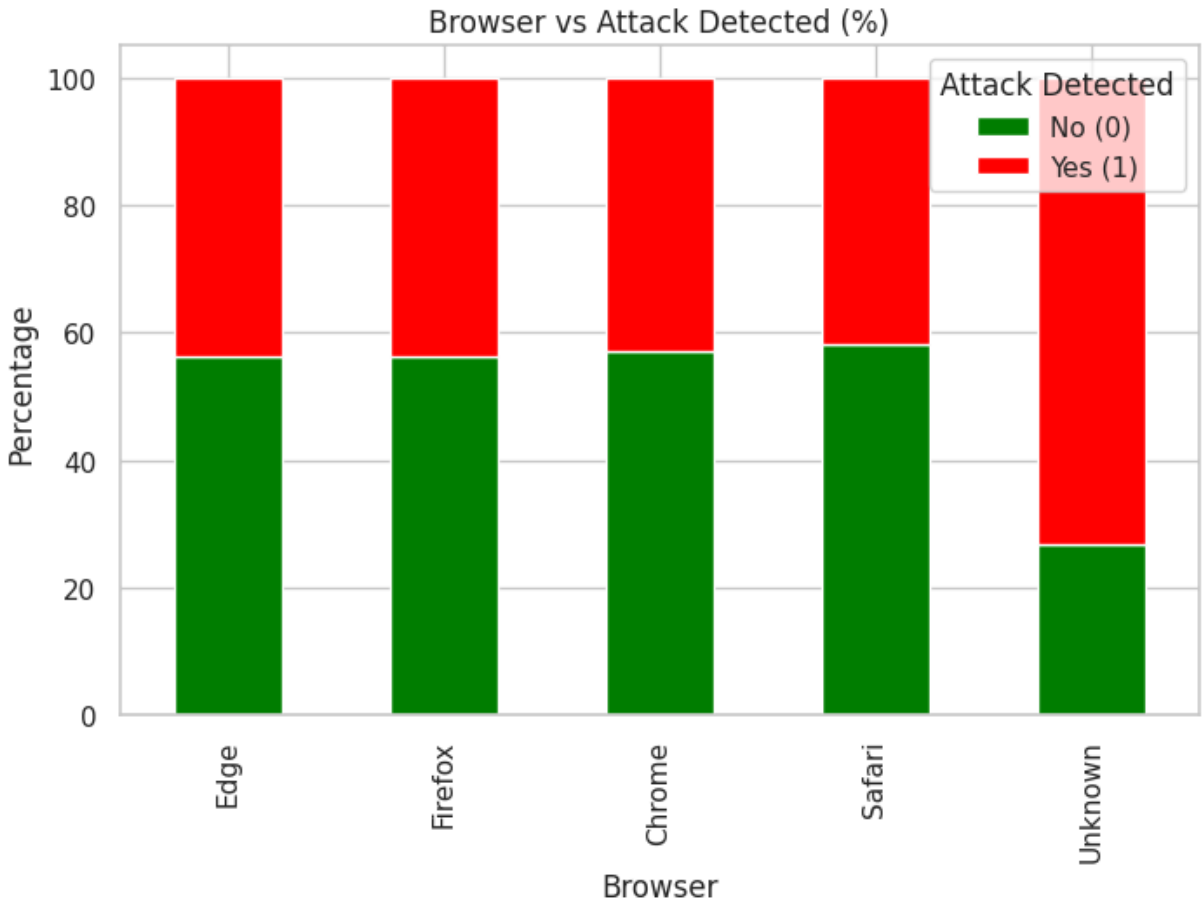


Browser Type vs Attack Detected (Categorical vs Categorical)

```
crosstab_browser = pd.crosstab(df_clean['browser_type'], df_clean['attack_detec
print("\nBrowser vs Attack Detected:\n", crosstab_browser)

# Normalized crosstab (percentage per browser)
crosstab_browser_pct = pd.crosstab(df_clean['browser_type'], df_clean['attack_c
print("\nBrowser vs Attack Detected (%)\n", crosstab_browser_pct)
```

```
Browser vs Attack Detected:
 attack_detected     0     1
browser_type
0                  826   643
1                 1095   849
2                 2935  2202
3                  282   203
4                  135   367

Browser vs Attack Detected (%)
 attack_detected          0          1
browser_type
0                56.228727  43.771273
1                56.327160  43.672840
2                57.134514  42.865486
3                58.144330  41.855670
4                26.892430  73.107570
```

```
# Crosstab (persentase per browser)
crosstab_browser_pct = pd.crosstab(
    df_clean['browser_type'],
    df_clean['attack_detected'],
    normalize='index'
) * 100

# Ganti index angka dengan label teks
crosstab_browser_pct.index = crosstab_browser_pct.index.map(reverse_mapping_brc

# Warna sesuai label (0 -> hijau, 1 -> merah)
colors = ["green", "red"]

# Plot
crosstab_browser_pct.plot(
    kind="bar",
    stacked=True,
    figsize=(8,5),
    color=colors
)

plt.title("Browser vs Attack Detected (%)")
plt.xlabel("Browser")
plt.ylabel("Percentage")
plt.legend(title="Attack Detected", labels=["No (0)", "Yes (1)"])
plt.show()
```



IP Reputation vs Attack Detected (continous vs categorical)

```
df.groupby("attack_detected")["ip_reputation_score"].describe()
```

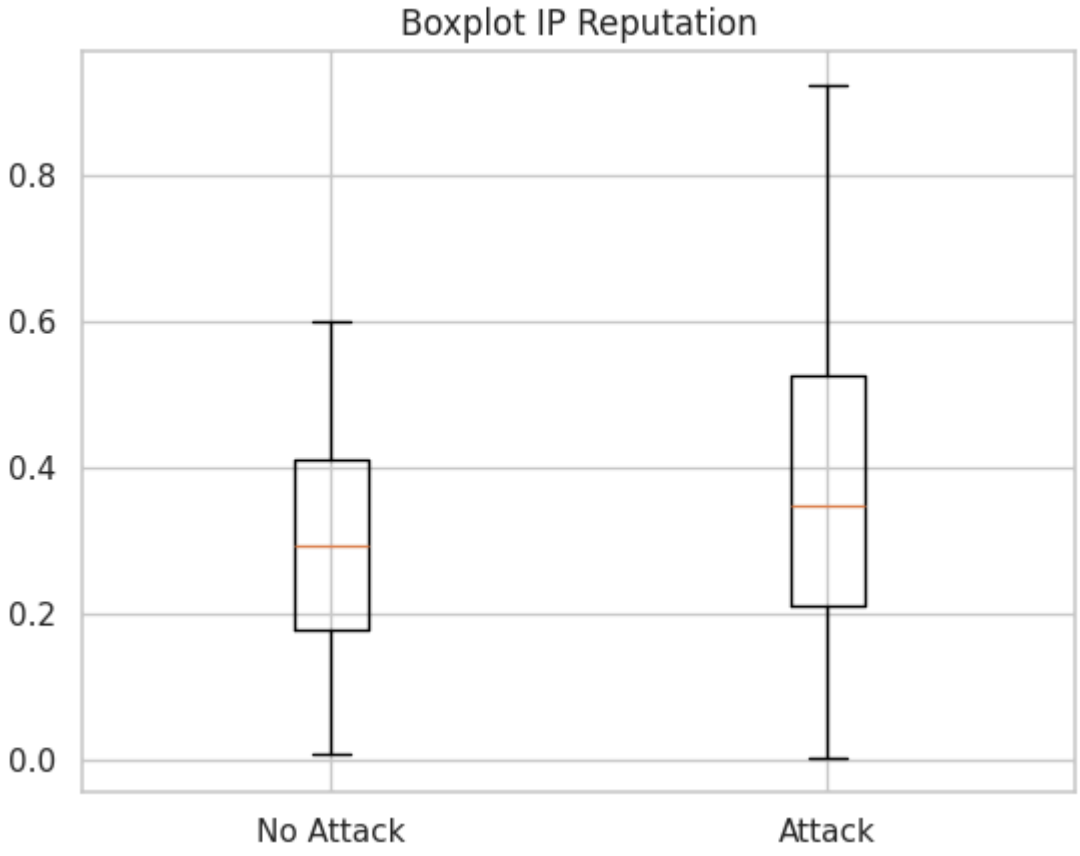
attack_detected	count	mean	std	min	25%	50%	75%
0	5273.0	0.297636	0.147434	0.007030	0.177466	0.293780	0.412074
1	4264.0	0.373015	0.200488	0.002497	0.211048	0.347314	0.525693

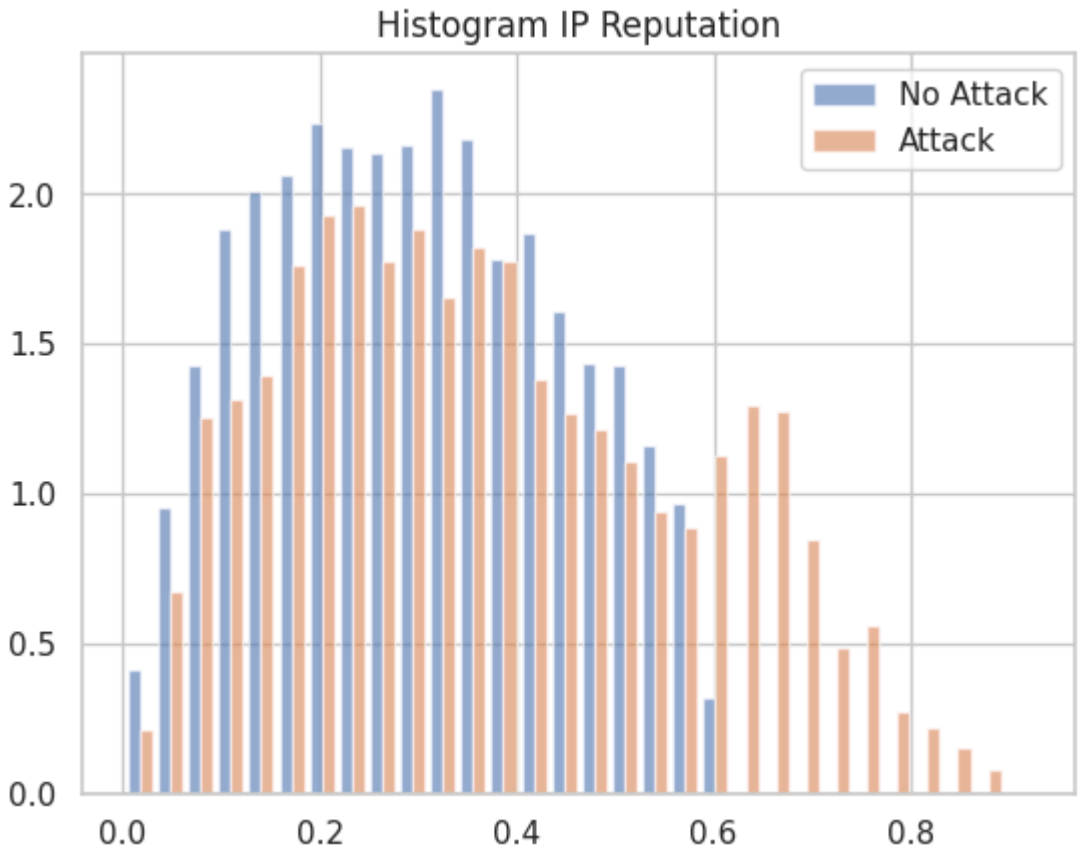
```
g0 = df[df["attack_detected"]==0]["ip_reputation_score"]
g1 = df[df["attack_detected"]==1]["ip_reputation_score"]

t, p = stats.ttest_ind(g0, g1, equal_var=False)
print(f"T-test: t={t:.3f}, p={p:.4f}")
```

```
T-test: t=-20.478, p=0.0000
```

```
plt.boxplot([g0,g1], labels=["No Attack","Attack"])
plt.title("Boxplot IP Reputation"); plt.show()

plt.hist([g0,g1], bins=30, alpha=0.6, label=["No Attack","Attack"], density=Tru
plt.legend(); plt.title("Histogram IP Reputation"); plt.show()
```

```
/tmp/ipython-input-2409333100.py:1: MatplotlibDeprecationWarning: The 'labels' p
  plt.boxplot([g0,g1], labels=["No Attack","Attack"])
```

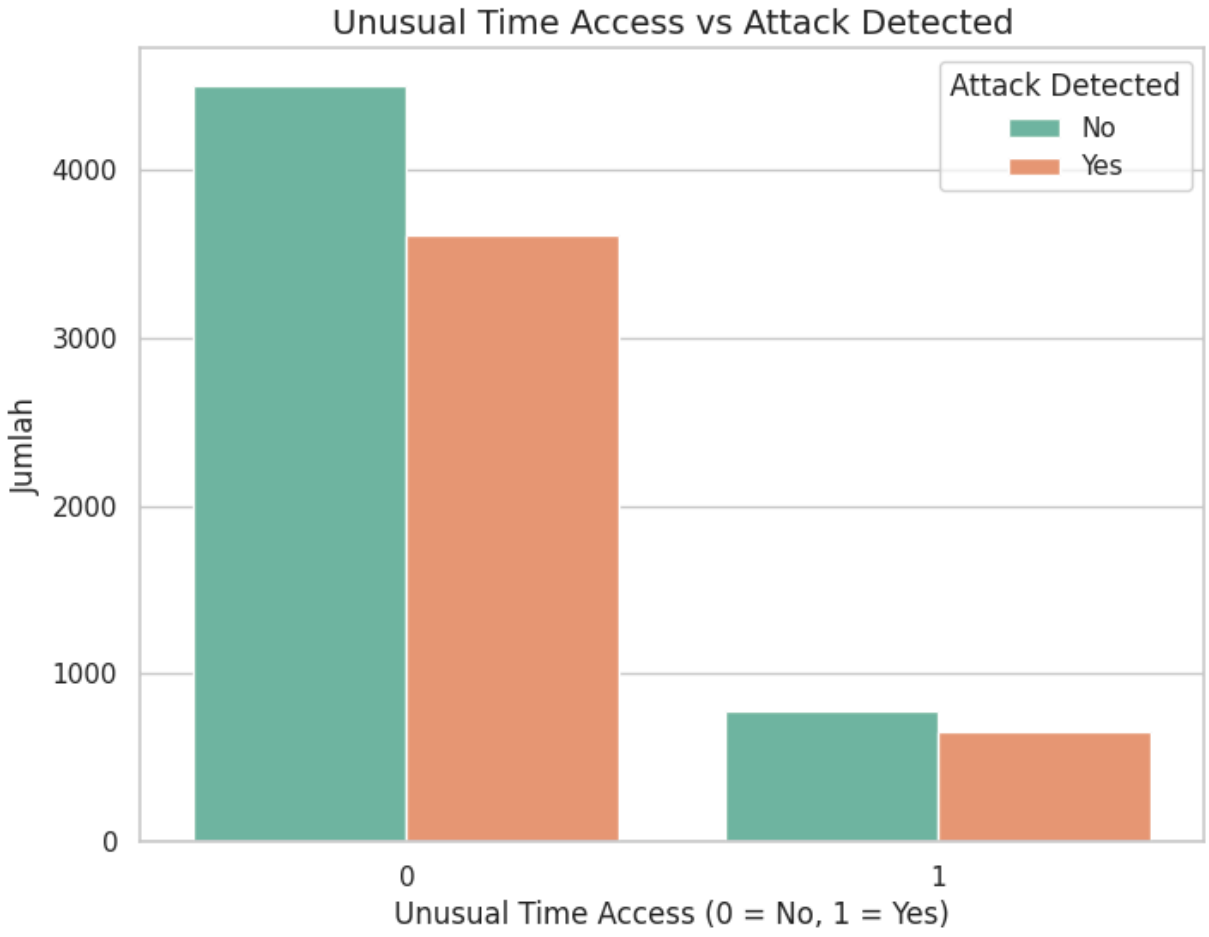


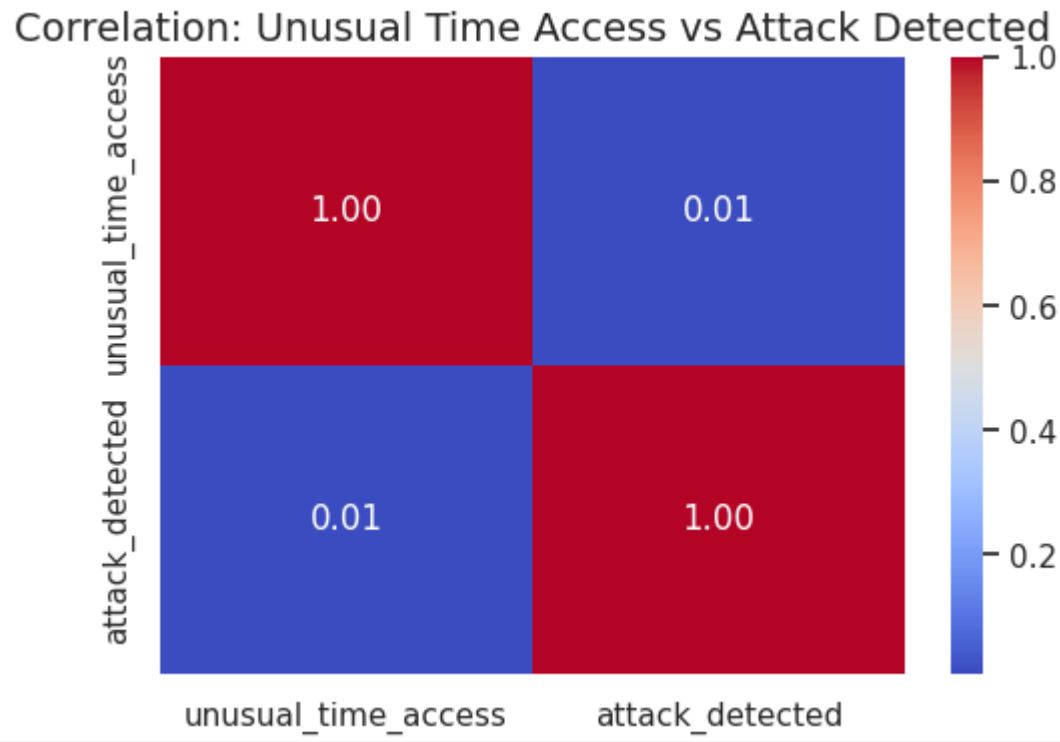


Unusual Time Access VS Attack Detected (Bivariate)

Double-click (or enter) to edit

```
plt.figure(figsize=(8,6))
sns.countplot(data=df_clean, x="unusual_time_access", hue="attack_detected", pa

plt.title("Unusual Time Access vs Attack Detected", fontsize=14)
plt.xlabel("Unusual Time Access (0 = No, 1 = Yes)")
plt.ylabel("Jumlah")
plt.legend(title="Attack Detected", labels=["No", "Yes"])
plt.show()

# --- Heatmap (korelasi) ---
plt.figure(figsize=(6,4))
corr = df_clean[["unusual_time_access", "attack_detected"]].corr()
sns.heatmap(corr, annot=True, cmap="coolwarm", cbar=True, fmt=".2f")

plt.title("Correlation: Unusual Time Access vs Attack Detected", fontsize=14)
plt.show()
```

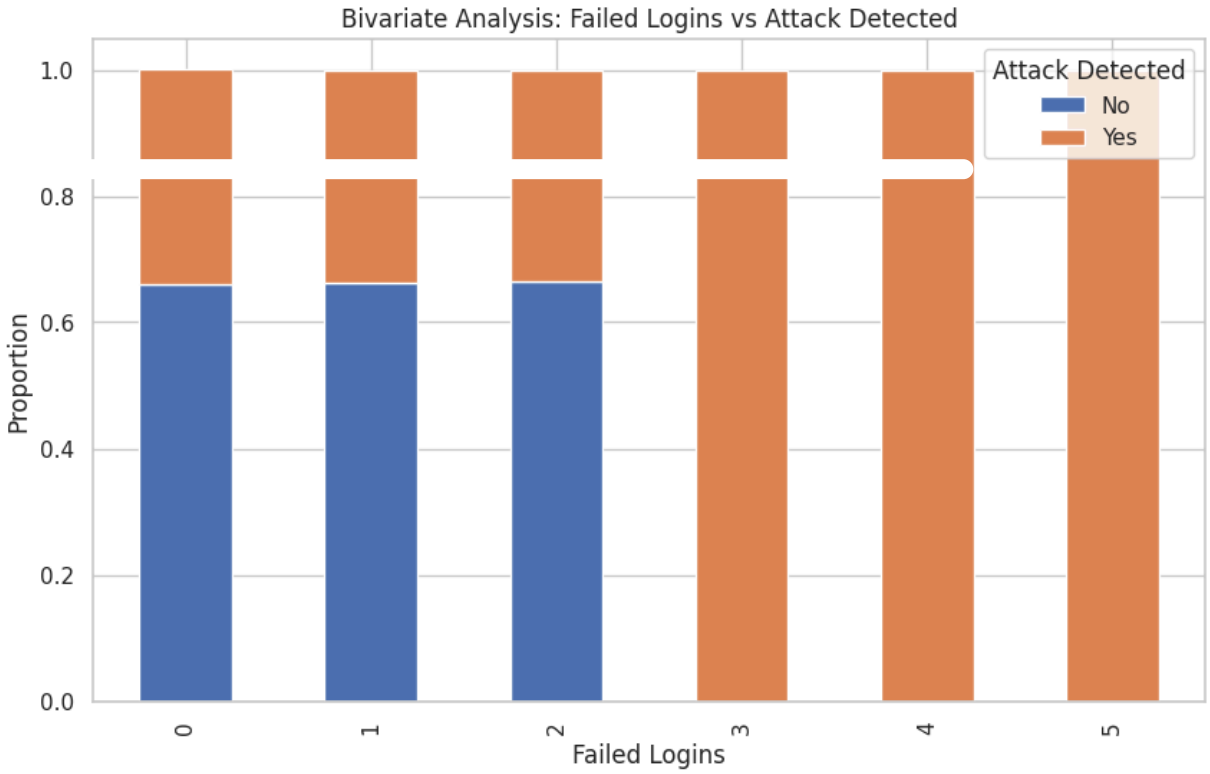




Login Failed vs Attack Detected

```
# Crosstab antara failed_logins dan attack_detected
crosstab = pd.crosstab(df_clean["failed_logins"], df_clean["attack_detected"],

# Plot stacked bar chart
crosstab.plot(kind="bar", stacked=True, figsize=(10,6))
```

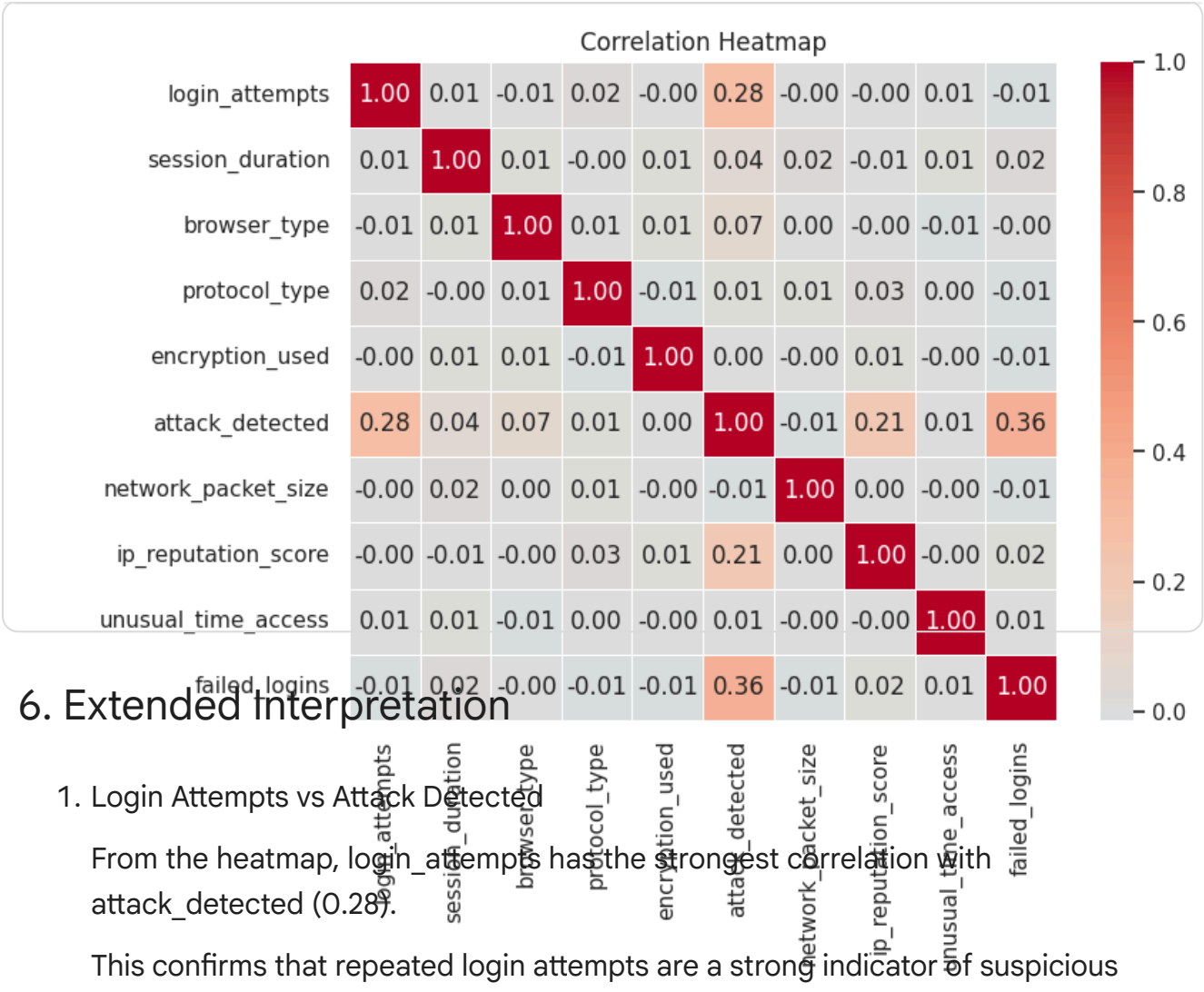
```
plt.title("Bivariate Analysis: Failed Logins vs Attack Detected")
plt.xlabel("Failed Logins")
plt.ylabel("Proportion")
plt.legend(title="Attack Detected", labels=["No", "Yes"])
plt.show()
```



5. Multivariate Analysis

Multivariate analysis (MVA) is a statistical technique that simultaneously examines more than two variables in a dataset to uncover patterns, correlations, and relationships among them, providing a deeper and more comprehensive understanding than analyzing variables one by one.

```
features = ["login_attempts", "session_duration", "browser_type", "protocol_
corr_matrix = df_clean[features].corr(method='pearson')

plt.figure(figsize=(8,6))
sns.heatmap(corr_matrix, annot=True, fmt=".2f", cmap="coolwarm", center=0, l
plt.title("Correlation Heatmap")
plt.show()
```



6. Extended Interpretation

1. Login Attempts vs Attack Detected

   From the heatmap, login_attempts has the strongest correlation with attack_detected (0.28).

   This confirms that repeated login attempts are a strong indicator of suspicious activity or brute-force style attacks.

2. Session Duration vs Attack Detected

   Correlation is weak (0.04), but looking at the descriptive statistics:

   - Mean session duration is slightly higher for attack sessions (829s) than normal sessions (763s).
   - Both groups have high variability (std ~ 728–851).
   - Maximum session durations are extremely long in both cases (~7,100s), which may represent outliers or special cases worth investigating.
   - Although correlation is low, the longer average duration in attack sessions suggests that attackers may maintain longer connections once inside.

3. Browser Type vs Attack Detected

   Overall correlation with attack detection is weak (0.07).

   But looking at the breakdown:

   - Most browsers (Edge, Firefox, Chrome, Safari) have around 56–58% no attack vs 42–44% attack.

- However, the “Unknown” browser shows a very different distribution: 73% of sessions flagged as attacks.
- This indicates that while mainstream browsers don’t show much difference, unrecognized or uncommon browsers are a strong red flag.

4. Protocol Type & Encryption Used

   Both show almost no correlation with attack detection.

   In this dataset, the protocol (ICMP, TCP, UDP) or encryption method (AES, DES) do