In [1]:
```python
import pandas as pd
import numpy as np
from sklearn import preprocessing
from IPython.display import display, HTML
```

In [2]:
```python
import warnings
warnings.filterwarnings("ignore")
```

In [14]:
```python
# reading the data
df = pd.read_csv('C:/Users/nayak/Downloads/malware_multiclass.csv')
print(df.shape)
df=df.rename(columns=lambda x: x.strip())
cols=df.columns
display(HTML(df.head(10).to_html()))
```

```
(100000, 36)
```

	hash	millisecond	classification	os	state	usage_counter	prio	static_prio	normal_prio	policy	vm_pgoff	vm_truncate_count	task_size	cached_hole
0	42fb5e2ec009a05ff5143227297074f1e9c6c3ebb9c914e223349672eca79ad0	0	malware	CentOS	0	0	3069378560	14274	0	0	0	13173	0	
1	42fb5e2ec009a05ff5143227297074f1e9c6c3ebb9c914e223349672eca79ad0	1	malware	Windows	0	0	3069378560	14274	0	0	0	13173	0	
2	42fb5e2ec009a05ff5143227297074f1e9c6c3ebb9c914e223349672eca79ad0	2	malware	Mac	0	0	3069378560	14274	0	0	0	13173	0	
3	42fb5e2ec009a05ff5143227297074f1e9c6c3ebb9c914e223349672eca79ad0	3	malware	Ubuntu	0	0	3069378560	14274	0	0	0	13173	0	
4	42fb5e2ec009a05ff5143227297074f1e9c6c3ebb9c914e223349672eca79ad0	4	malware	Mac	0	0	3069378560	14274	0	0	0	13173	0	
5	42fb5e2ec009a05ff5143227297074f1e9c6c3ebb9c914e223349672eca79ad0	5	malware	Windows	0	0	3069378560	14274	0	0	0	13173	0	
6	42fb5e2ec009a05ff5143227297074f1e9c6c3ebb9c914e223349672eca79ad0	6	malware	Ubuntu	0	0	3069378560	14274	0	0	0	13173	0	
7	42fb5e2ec009a05ff5143227297074f1e9c6c3ebb9c914e223349672eca79ad0	7	malware	Mac	0	0	3069378560	14274	0	0	0	13173	0	
8	42fb5e2ec009a05ff5143227297074f1e9c6c3ebb9c914e223349672eca79ad0	8	malware	CentOS	0	0	3069378560	14274	0	0	0	13173	0	
9	42fb5e2ec009a05ff5143227297074f1e9c6c3ebb9c914e223349672eca79ad0	9	malware	Mac	0	0	3069378560	14274	0	0	0	13173	0	

In [15]:
```python
# selecting columns specified in readme file
df = df.loc[:, ['classification', 'os', 'usage_counter', 'prio', 'static_prio', 'normal_prio', 'vm_pgoff', 'vm_truncate_count', 'task_size', 'map_count', 'hiwater_rss', 'total_vm',
display(HTML(df.head(10).to_html()))
```

	classification	os	usage_counter	prio	static_prio	normal_prio	vm_pgoff	vm_truncate_count	task_size	map_count	hiwater_rss	total_vm	shared_vm	exec_vm	reserved_vm	nr_ptes	nvcsw	nivcsw	signal_nv
0	malware	CentOS	0	3069378560	14274	0	0	13173	0	6850	0	150	120	124	210	0	341974	0	
1	malware	Windows	0	3069378560	14274	0	0	13173	0	6850	0	150	120	124	210	0	341974	0	
2	malware	Mac	0	3069378560	14274	0	0	13173	0	6850	0	150	120	124	210	0	341974	0	
3	malware	Ubuntu	0	3069378560	14274	0	0	13173	0	6850	0	150	120	124	210	0	341974	0	
4	malware	Mac	0	3069378560	14274	0	0	13173	0	6850	0	150	120	124	210	0	341974	0	
5	malware	Windows	0	3069378560	14274	0	0	13173	0	6850	0	150	120	124	210	0	341974	0	
6	malware	Ubuntu	0	3069378560	14274	0	0	13173	0	6850	0	150	120	124	210	0	341974	0	
7	malware	Mac	0	3069378560	14274	0	0	13173	0	6850	0	150	120	124	210	0	341974	0	
8	malware	CentOS	0	3069378560	14274	0	0	13173	0	6850	0	150	120	124	210	0	341974	0	
9	malware	Mac	0	3069378560	14274	0	0	13173	0	6852	0	150	120	124	211	0	341974	0	

In [16]:
```python
# checking if the data has null values
df.isna().sum()
```

Out[16]:
```
classification       0
os                   0
usage_counter        0
prio                 0
static_prio          0
normal_prio          0
vm_pgoff             0
vm_truncate_count    0
task_size            0
map_count            0
hiwater_rss          0
total_vm             0
shared_vm            0
exec_vm              0
reserved_vm          0
nr_ptes              0
nvcsw                0
nivcsw               0
signal_nvcsw         0
dtype: int64
```

In [17]:
```python
# convert all nominal variables to binary variables
df_num=df.copy(deep=True)
df_dummies=pd.get_dummies(df_num['os'],dtype=float)
df_num=df_num.join(df_dummies)
# drop original columns
df_num=df_num.drop('os',axis=1)
df_num.head()
```

Out[17]:

	classification	usage_counter	prio	static_prio	normal_prio	vm_pgoff	vm_truncate_count	task_size	map_count	hiwater_rss	...	reserved_vm	nr_ptes	nvcsw	nivcsw	signal_nvcsw	CentOS	Debian	Mac	Ubuntu	W
0	malware	0	3069378560	14274	0	0	13173	0	6850	0	...	210	0	341974	0	0	1.0	0.0	0.0	0.0	
1	malware	0	3069378560	14274	0	0	13173	0	6850	0	...	210	0	341974	0	0	0.0	0.0	0.0	0.0	
2	malware	0	3069378560	14274	0	0	13173	0	6850	0	...	210	0	341974	0	0	0.0	0.0	1.0	0.0	
3	malware	0	3069378560	14274	0	0	13173	0	6850	0	...	210	0	341974	0	0	0.0	0.0	0.0	1.0	
4	malware	0	3069378560	14274	0	0	13173	0	6850	0	...	210	0	341974	0	0	0.0	0.0	1.0	0.0	

5 rows × 23 columns

In [18]:
```python
# dropping the extra column
df_num.drop('CentOS', axis=1, inplace=True)
df_num.head()
```

Out[18]:

	classification	usage_counter	prio	static_prio	normal_prio	vm_pgoff	vm_truncate_count	task_size	map_count	hiwater_rss	...	exec_vm	reserved_vm	nr_ptes	nvcsw	nivcsw	signal_nvcsw	Debian	Mac	Ubuntu
0	malware	0	3069378560	14274	0	0	13173	0	6850	0	...	124	210	0	341974	0	0	0.0	0.0	0.0
1	malware	0	3069378560	14274	0	0	13173	0	6850	0	...	124	210	0	341974	0	0	0.0	0.0	0.0
2	malware	0	3069378560	14274	0	0	13173	0	6850	0	...	124	210	0	341974	0	0	0.0	1.0	0.0
3	malware	0	3069378560	14274	0	0	13173	0	6850	0	...	124	210	0	341974	0	0	0.0	0.0	1.0
4	malware	0	3069378560	14274	0	0	13173	0	6850	0	...	124	210	0	341974	0	0	0.0	1.0	0.0

5 rows × 22 columns

In [21]:
```python
df_num.drop('classification', axis=1, inplace=True)
cols_to_norm = df_num.columns.to_list()
df_num[cols_to_norm] = df_num[cols_to_norm].apply(lambda x: (x - x.min()) / (x.max() - x.min()))
```

In [22]:
```python
df_num.head()
```

Out[22]:

	usage_counter	prio	static_prio	normal_prio	vm_pgoff	vm_truncate_count	task_size	map_count	hiwater_rss	total_vm	...	exec_vm	reserved_vm	nr_ptes	nvcsw	nivcsw	signal_nvcsw	Debian	Mac	Ubuntu	Windo
0	NaN	0.18254	0.016007	NaN	NaN	0.199175	NaN	0.16651	NaN	0.052031	...	0.307692	0.249311	NaN	0.091519	0.0	NaN	0.0	0.0	0.0	0
1	NaN	0.18254	0.016007	NaN	NaN	0.199175	NaN	0.16651	NaN	0.052031	...	0.307692	0.249311	NaN	0.091519	0.0	NaN	0.0	0.0	0.0	1
2	NaN	0.18254	0.016007	NaN	NaN	0.199175	NaN	0.16651	NaN	0.052031	...	0.307692	0.249311	NaN	0.091519	0.0	NaN	0.0	1.0	0.0	0
3	NaN	0.18254	0.016007	NaN	NaN	0.199175	NaN	0.16651	NaN	0.052031	...	0.307692	0.249311	NaN	0.091519	0.0	NaN	0.0	0.0	1.0	0
4	NaN	0.18254	0.016007	NaN	NaN	0.199175	NaN	0.16651	NaN	0.052031	...	0.307692	0.249311	NaN	0.091519	0.0	NaN	0.0	1.0	0.0	0

5 rows × 21 columns

In [23]:
```python
df_num.describe()
```

Out[23]:

	usage_counter	prio	static_prio	normal_prio	vm_pgoff	vm_truncate_count	task_size	map_count	hiwater_rss	total_vm	...	exec_vm	reserved_vm	nr_ptes	nvcsw	nivcsw
count	0.0	100000.000000	100000.000000	0.0	0.0	100000.000000	0.0	100000.000000	0.0	100000.000000	...	100000.000000	100000.000000	0.0	100000.000000	100000.000000
mean	NaN	0.499762	0.234841	NaN	NaN	0.321712	NaN	0.241567	NaN	0.093546	...	0.343059	0.242872	NaN	0.226876	0.090387
std	NaN	0.287065	0.258006	NaN	NaN	0.186489	NaN	0.147887	NaN	0.111189	...	0.214211	0.155259	NaN	0.194690	0.144466
min	NaN	0.000000	0.000000	NaN	NaN	0.000000	NaN	0.000000	NaN	0.000000	...	0.000000	0.000000	NaN	0.000000	0.000000
25%	NaN	0.248016	0.020373	NaN	NaN	0.169110	NaN	0.150023	NaN	0.033856	...	0.192308	0.114325	NaN	0.091519	0.002740
50%	NaN	0.492063	0.121509	NaN	NaN	0.317833	NaN	0.206165	NaN	0.061654	...	0.336538	0.225895	NaN	0.204049	0.024658
75%	NaN	0.743056	0.458611	NaN	NaN	0.456305	NaN	0.316299	NaN	0.115110	...	0.442308	0.336088	NaN	0.298492	0.126027
max	NaN	1.000000	1.000000	NaN	NaN	1.000000	NaN	1.000000	NaN	1.000000	...	1.000000	1.000000	NaN	1.000000	1.000000

8 rows × 21 columns

In [25]:
```python
# dropping the Nan as all values of it are zeroes
df_num.drop(['usage_counter', 'normal_prio', 'vm_pgoff', 'task_size', 'hiwater_rss', 'nr_ptes', 'signal_nvcsw'], axis=1, inplace=True)
df_num.head()
```

Out[25]:

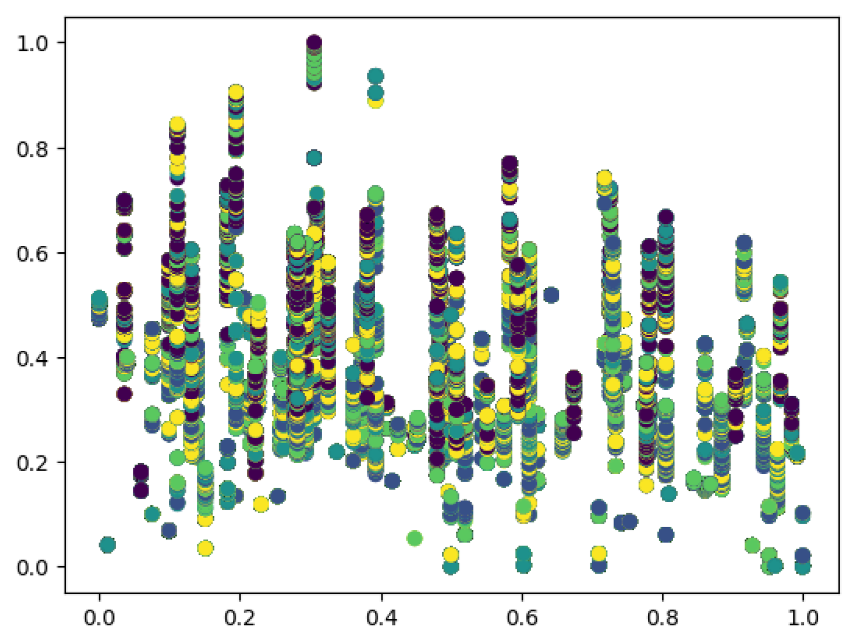
	prio	static_prio	vm_truncate_count	map_count	total_vm	shared_vm	exec_vm	reserved_vm	nvcsw	nivcsw	Debian	Mac	Ubuntu	Windows
0	0.18254	0.016007	0.199175	0.16651	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	0.0	0.0	0.0
1	0.18254	0.016007	0.199175	0.16651	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	0.0	0.0	1.0
2	0.18254	0.016007	0.199175	0.16651	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	1.0	0.0	0.0
3	0.18254	0.016007	0.199175	0.16651	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	0.0	1.0	0.0
4	0.18254	0.016007	0.199175	0.16651	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	1.0	0.0	0.0

In [27]:
```python
df_kmeans = df_num.copy(deep=True)
df_knn = df_num.copy(deep=True)
```

In [32]:
```python
import matplotlib.pyplot as plt
from matplotlib.colors import ListedColormap
from sklearn.cluster import KMeans

kmeans=KMeans(n_clusters=5, random_state=1,max_iter=500)
kmeans.fit(df_kmeans)
y_pred=kmeans.predict(df_kmeans)

plt.scatter(df_kmeans['prio'],df_kmeans['vm_truncate_count'],c=y_pred,cmap='viridis')

# get the cluster labels and add it back to the original data
opt=kmeans.labels_
df_knn['Cluster']=opt
display('Data:',HTML(df_knn.head(10).to_html()))
```

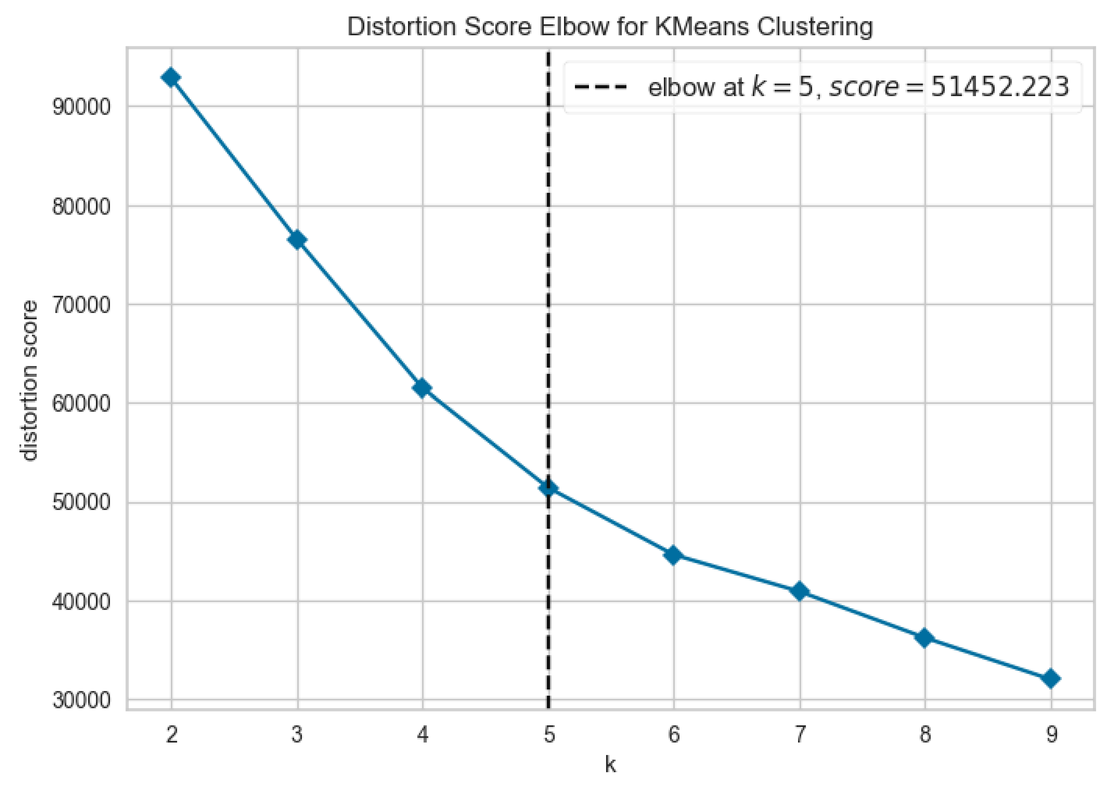
'Data:'

	prio	static_prio	vm_truncate_count	map_count	total_vm	shared_vm	exec_vm	reserved_vm	nvcsw	nivcsw	Debian	Mac	Ubuntu	Windows	Cluster
0	0.18254	0.016007	0.199175	0.166510	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	0.0	0.0	0.0	1
1	0.18254	0.016007	0.199175	0.166510	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	0.0	0.0	1.0	1
2	0.18254	0.016007	0.199175	0.166510	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	1.0	0.0	0.0	3
3	0.18254	0.016007	0.199175	0.166510	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	0.0	1.0	0.0	4
4	0.18254	0.016007	0.199175	0.166510	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	1.0	0.0	0.0	3
5	0.18254	0.016007	0.199175	0.166510	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	0.0	0.0	1.0	1
6	0.18254	0.016007	0.199175	0.166510	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	0.0	1.0	0.0	4
7	0.18254	0.016007	0.199175	0.166510	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	1.0	0.0	0.0	3
8	0.18254	0.016007	0.199175	0.166510	0.052031	1.0	0.307692	0.249311	0.091519	0.0	0.0	0.0	0.0	0.0	1
9	0.18254	0.016007	0.199175	0.166589	0.052031	1.0	0.307692	0.250689	0.091519	0.0	0.0	1.0	0.0	0.0	3



In [34]:
```python
import yellowbrick
from yellowbrick.cluster import KElbowVisualizer
print(yellowbrick.__version__)

km = KMeans(random_state=42,max_iter=500, algorithm='elkan')
visualizer = KElbowVisualizer(km, k=(2,10), timings=False, distance_metric='euclidean', metric='distortion')
visualizer.fit(df_kmeans)        # Fit the data to the visualizer
visualizer.show()        # Finalize and render the figure
```

```
1.5
```



Out[34]:
```
<Axes: title={'center': 'Distortion Score Elbow for KMeans Clustering'}, xlabel='k', ylabel='distortion score'>
```

In [35]:
```python
# dividing into clustering
km = KMeans(n_clusters=5)
km = km.fit(df_kmeans)

opt=km.labels_
df_knn['Cluster']=opt
display('Data:',HTML(df_knn.tail(10).to_html()))
```

'Data:'

	prio	static_prio	vm_truncate_count	map_count	total_vm	shared_vm	exec_vm	reserved_vm	nvcsw	nivcsw	Debian	Mac	Ubuntu	Windows	Cluster
99990	0.928571	0.0	0.040717	0.04153	0.01283	1.0	0.048077	0.084022	0.0	0.005479	1.0	0.0	0.0	0.0	3
99991	0.928571	0.0	0.040717	0.04153	0.01283	1.0	0.048077	0.084022	0.0	0.005479	0.0	0.0	1.0	0.0	0
99992	0.928571	0.0	0.040717	0.04153	0.01283	1.0	0.048077	0.084022	0.0	0.005479	0.0	0.0	0.0	0.0	3
99993	0.928571	0.0	0.040717	0.04153	0.01283	1.0	0.048077	0.084022	0.0	0.005479	1.0	0.0	0.0	0.0	3
99994	0.928571	0.0	0.040717	0.04153	0.01283	1.0	0.048077	0.084022	0.0	0.005479	1.0	0.0	0.0	0.0	3
99995	0.928571	0.0	0.040717	0.04153	0.01283	1.0	0.048077	0.084022	0.0	0.005479	0.0	0.0	0.0	0.0	3
99996	0.928571	0.0	0.040717	0.04153	0.01283	1.0	0.048077	0.084022	0.0	0.005479	0.0	0.0	0.0	1.0	2
99997	0.928571	0.0	0.040717	0.04153	0.01283	1.0	0.048077	0.084022	0.0	0.005479	0.0	0.0	0.0	0.0	3
99998	0.928571	0.0	0.040717	0.04153	0.01283	1.0	0.048077	0.084022	0.0	0.005479	0.0	0.0	1.0	0.0	0
99999	0.928571	0.0	0.040717	0.04153	0.01283	1.0	0.048077	0.084022	0.0	0.005479	0.0	1.0	0.0	0.0	1

In [45]:
```python
# Evaluating the clustering
from sklearn.metrics import silhouette_score

silhouette = silhouette_score(df_num, opt)

print("Silhouette Score:", silhouette)
```

```
Silhouette Score: 0.33248212708731995
```

In [46]:
```python
from sklearn.metrics import davies_bouldin_score
db_index = davies_bouldin_score(df_num, opt)

print("Davies Bouldin Score:", db_index)
```

```
Davies Bouldin Score: 1.3053753158670591
```