Import Necessary Libraries

In [42]:
```python
# Import Libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.cluster import KMeans
import scipy.cluster.hierarchy as sch
from sklearn.preprocessing import normalize
from sklearn.cluster import AgglomerativeClustering
```

Data Understanding

In [52]:
```python
# Import Dataset
airline=pd.read_csv('EastWestAirlines.csv')
airline
```

Out[52]:

	ID#	Balance	Qual_miles	cc1_miles	cc2_miles	cc3_miles	Bonus_miles	Bonus_trans	Flight_miles_12mo	Flight_trans_12	Days_since_enroll	Award?
0	1	28143	0	1	1	1	174	1	0	0	7000	0
1	2	19244	0	1	1	1	215	2	0	0	6968	0
2	3	41354	0	1	1	1	4123	4	0	0	7034	0
3	4	14776	0	1	1	1	500	1	0	0	6952	0
4	5	97752	0	4	1	1	43300	26	2077	4	6935	1
...	...	...	...	...	...	...	...	...	...	...	...	...
3994	4017	18476	0	1	1	1	8525	4	200	1	1403	1
3995	4018	64385	0	1	1	1	981	5	0	0	1395	1
3996	4019	73597	0	3	1	1	25447	8	0	0	1402	1
3997	4020	54899	0	1	1	1	500	1	500	1	1401	0
3998	4021	3016	0	1	1	1	0	0	0	0	1398	0

3999 rows × 12 columns

In [53]:
```python
airline2=airline.drop(['ID#'],axis=1)
airline2
```

Out[53]:

	Balance	Qual_miles	cc1_miles	cc2_miles	cc3_miles	Bonus_miles	Bonus_trans	Flight_miles_12mo	Flight_trans_12	Days_since_enroll	Award?
0	28143	0	1	1	1	174	1	0	0	7000	0
1	19244	0	1	1	1	215	2	0	0	6968	0
2	41354	0	1	1	1	4123	4	0	0	7034	0
3	14776	0	1	1	1	500	1	0	0	6952	0
4	97752	0	4	1	1	43300	26	2077	4	6935	1
...	...	...	...	...	...	...	...	...	...	...	...
3994	18476	0	1	1	1	8525	4	200	1	1403	1
3995	64385	0	1	1	1	981	5	0	0	1395	1
3996	73597	0	3	1	1	25447	8	0	0	1402	1
3997	54899	0	1	1	1	500	1	500	1	1401	0
3998	3016	0	1	1	1	0	0	0	0	1398	0

3999 rows × 11 columns

In [54]:
```python
airline2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3999 entries, 0 to 3998
Data columns (total 11 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   Balance            3999 non-null   int64
 1   Qual_miles         3999 non-null   int64
 2   cc1_miles          3999 non-null   int64
 3   cc2_miles          3999 non-null   int64
 4   cc3_miles          3999 non-null   int64
 5   Bonus_miles        3999 non-null   int64
 6   Bonus_trans        3999 non-null   int64
 7   Flight_miles_12mo  3999 non-null   int64
 8   Flight_trans_12    3999 non-null   int64
 9   Days_since_enroll  3999 non-null   int64
 10  Award?             3999 non-null   int64
dtypes: int64(11)
memory usage: 343.8 KB
```

In [5]:
```python
# Normalize heterogenous numerical data
airline2_norm=pd.DataFrame(normalize(airline2),columns=airline2.columns)
airline2_norm
```

Out[5]:

	Balance	Qual_miles	cc1_miles	cc2_miles	cc3_miles	Bonus_miles	Bonus_trans	Flight_miles_12mo	Flight_trans_12	Days_since_enroll	Award?
0	0.970414	0.0	0.000034	0.000034	0.000034	0.006000	0.000034	0.000000	0.000000	0.241371	0.000000
1	0.940209	0.0	0.000049	0.000049	0.000049	0.010504	0.000098	0.000000	0.000000	0.340437	0.000000
2	0.981113	0.0	0.000024	0.000024	0.000024	0.097817	0.000095	0.000000	0.000000	0.166880	0.000000
3	0.904428	0.0	0.000061	0.000061	0.000061	0.030605	0.000061	0.000000	0.000000	0.425527	0.000000
4	0.912226	0.0	0.000037	0.000009	0.000009	0.404078	0.000243	0.019383	0.000037	0.064718	0.000009
...	...	...	...	...	...	...	...	...	...	...	...
3994	0.905810	0.0	0.000049	0.000049	0.000049	0.417949	0.000196	0.009805	0.000049	0.068784	0.000049
3995	0.999649	0.0	0.000016	0.000016	0.000016	0.015231	0.000078	0.000000	0.000000	0.021659	0.000016
3996	0.944948	0.0	0.000039	0.000013	0.000013	0.326726	0.000103	0.000000	0.000000	0.018001	0.000013
3997	0.999592	0.0	0.000018	0.000018	0.000018	0.009104	0.000018	0.009104	0.000018	0.025509	0.000000
3998	0.907271	0.0	0.000301	0.000301	0.000301	0.000000	0.000000	0.000000	0.000000	0.420546	0.000000

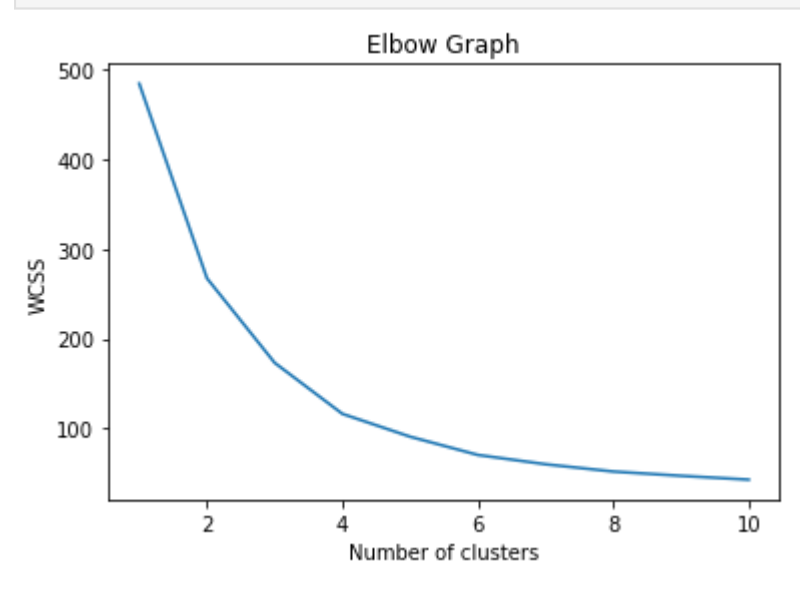
3999 rows × 11 columns

K-Means Clustering

In [27]:
```python
# Use Elbow Graph to find optimum number of  clusters (K value) from K values range
# The K-means algorithm aims to choose centroids that minimise the inertia, or within-cluster sum-of-squares criterion WCSS
# random state can be anything from 0 to 42, but the same number to be used everytime,so that the results don't change.
```

In [55]:
```python
# within-cluster sum-of-squares criterion
wcss=[]
for i in range (1,11):
    kmeans=KMeans(n_clusters=i,random_state=2)
    kmeans.fit(airline2_norm)
    wcss.append(kmeans.inertia_)
```

In [45]:
```python
# Plot K values range vs WCSS to get Elbow graph for choosing K (no. of clusters)
plt.plot(range(1,11),wcss)
plt.title('Elbow Graph')
plt.xlabel('Number of clusters')
plt.ylabel('WCSS')
plt.show()
```



Build Cluster algorithm using K=4

In [56]:
```python
# Cluster algorithm using K=4
clusters4=KMeans(4,random_state=30).fit(airline2_norm)
clusters4
```

Out[56]: KMeans(n_clusters=4, random_state=30)

In [57]:
```python
clusters4.labels_
```

Out[57]: array([0, 0, 0, ..., 3, 0, 0])

In [58]:
```python
# Assign clusters to the data set
airline4=airline2.copy()
airline4['clusters4id']=clusters4.labels_
airline4
```

Out[58]:

	Balance	Qual_miles	cc1_miles	cc2_miles	cc3_miles	Bonus_miles	Bonus_trans	Flight_miles_12mo	Flight_trans_12	Days_since_enroll	Award?	clusters4id
0	28143	0	1	1	1	174	1	0	0	7000	0	0
1	19244	0	1	1	1	215	2	0	0	6968	0	0
2	41354	0	1	1	1	4123	4	0	0	7034	0	0
3	14776	0	1	1	1	500	1	0	0	6952	0	0
4	97752	0	4	1	1	43300	26	2077	4	6935	1	3
...	...	...	...	...	...	...	...	...	...	...	...	...
3994	18476	0	1	1	1	8525	4	200	1	1403	1	3
3995	64385	0	1	1	1	981	5	0	0	1395	1	0
3996	73597	0	3	1	1	25447	8	0	0	1402	1	3
3997	54899	0	1	1	1	500	1	500	1	1401	0	0
3998	3016	0	1	1	1	0	0	0	0	1398	0	0

3999 rows × 12 columns

In [59]:
```python
# Compute the centroids for K=4 clusters with 11 variables
clusters4.cluster_centers_
```

Out[59]:
```
array([[9.82878899e-01, 3.71612347e-03, 4.15057209e-05, 3.77179195e-05,
        3.76205578e-05, 8.06914054e-02, 1.57453088e-04, 6.65079627e-03,
        2.12921781e-05, 1.03324885e-01, 4.81770304e-06],
       [5.23653977e-01, 2.37603195e-03, 9.13653056e-05, 4.56081254e-05,
        4.45095230e-05, 7.97866700e-01, 5.07019477e-04, 1.75075997e-02,
        5.89123100e-05, 1.31443994e-01, 3.00837174e-05],
       [6.28081328e-01, 9.30359261e-04, 2.06331617e-04, 2.06128767e-04,
        2.05879951e-04, 1.23980626e-01, 4.76413717e-04, 6.66146530e-03,
        2.24385615e-05, 6.89106611e-01, 2.58980762e-05],
       [8.99048678e-01, 2.03403471e-03, 5.68074076e-05, 3.01913199e-05,
        2.95156437e-05, 4.03089039e-01, 4.02398112e-04, 7.62262675e-03,
        2.24052643e-05, 8.50654942e-02, 9.73901648e-06]])
```

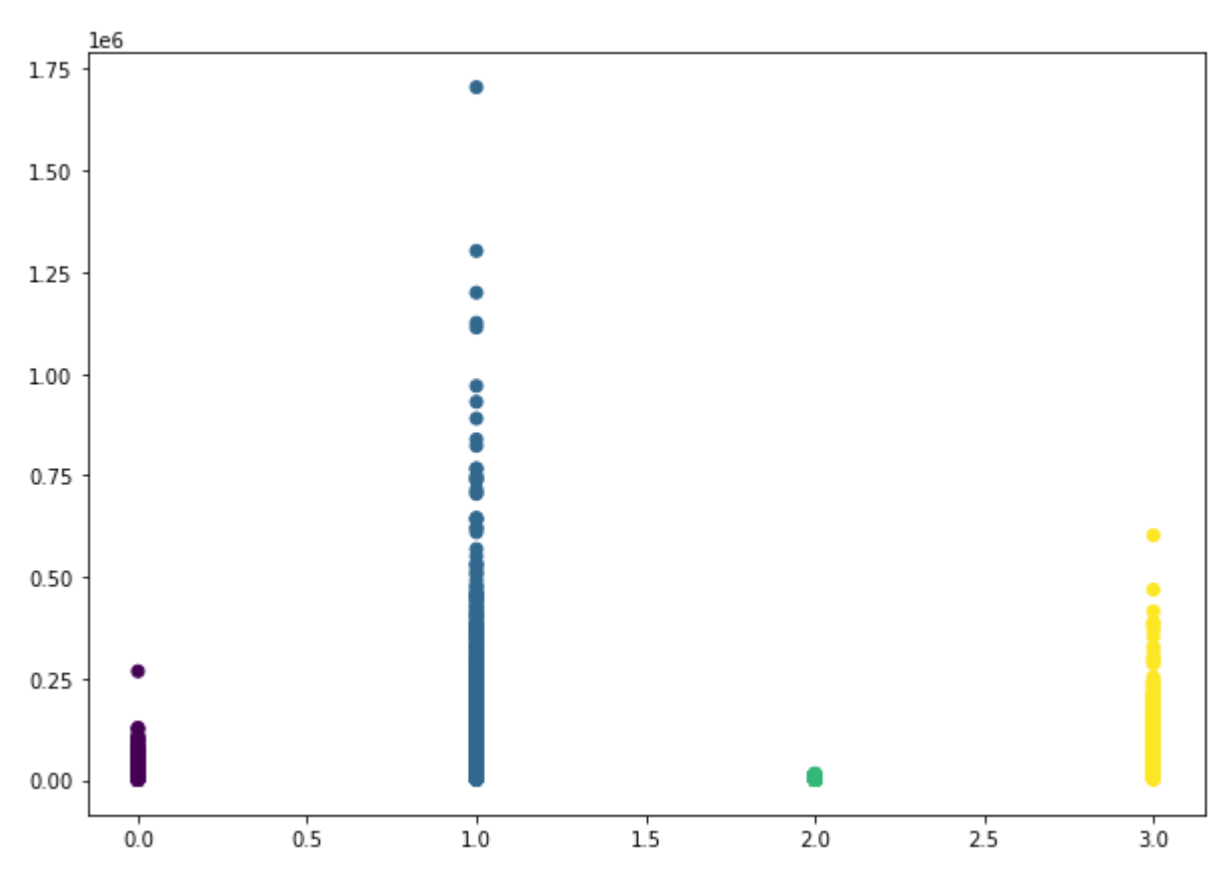
In [60]:
```python
# Group data by Clusters (K=4)
airline4.groupby('clusters4id').agg(['mean']).reset_index()
```

Out[60]:

	clusters4id	Balance	Qual_miles	cc1_miles	cc2_miles	cc3_miles	Bonus_miles	Bonus_trans	Flight_miles_12mo	Flight_trans_12	Days_since_enroll	Award?
		mean	mean	mean	mean	mean	mean	mean	mean	mean	mean	mean
0	0	88484.857577	175.062961	1.495441	1.008250	1.001737	8110.131568	8.770734	476.973079	1.439427	4060.013895	0.255319
1	1	28617.579670	112.000000	3.280220	1.030220	1.068681	42166.565934	17.634615	659.725275	1.909341	4229.689560	0.901099
2	2	5129.247934	8.285124	1.004132	1.004132	1.000000	891.388430	3.012397	66.466942	0.194215	4843.239669	0.185950
3	3	72378.903670	119.606422	3.077982	1.024771	1.018349	31486.477982	17.476147	445.017431	1.317431	4044.253211	0.477064

In [13]:
```python
# Plot Clusters
plt.figure(figsize=(10, 7))
plt.scatter(airline4['clusters4id'],airline4['Balance'], c=clusters4.labels_)
```

Out[13]: <matplotlib.collections.PathCollection at 0x200a24804c0>



Build Cluster algorithm using K=5

In [61]:
```python
# Cluster algorithm using K=5
clusters5=KMeans(5,random_state=30).fit(airline2_norm)
clusters5
```

Out[61]: KMeans(n_clusters=5, random_state=30)

In [62]:
```python
clusters5.labels_
```

Out[62]: array([0, 3, 0, ..., 4, 0, 3])

In [63]:
```python
# Assign clusters to the data set
airline5=airline2.copy()
airline5['clusters5id']=clusters5.labels_
airline5
```

Out[63]:

	Balance	Qual_miles	cc1_miles	cc2_miles	cc3_miles	Bonus_miles	Bonus_trans	Flight_miles_12mo	Flight_trans_12	Days_since_enroll	Award?	clusters5id
0	28143	0	1	1	1	174	1	0	0	7000	0	0
1	19244	0	1	1	1	215	2	0	0	6968	0	3
2	41354	0	1	1	1	4123	4	0	0	7034	0	0
3	14776	0	1	1	1	500	1	0	0	6952	0	3
4	97752	0	4	1	1	43300	26	2077	4	6935	1	4
...	...	...	...	...	...	...	...	...	...	...	...	...
3994	18476	0	1	1	1	8525	4	200	1	1403	1	4
3995	64385	0	1	1	1	981	5	0	0	1395	1	0
3996	73597	0	3	1	1	25447	8	0	0	1402	1	4
3997	54899	0	1	1	1	500	1	500	1	1401	0	0
3998	3016	0	1	1	1	0	0	0	0	1398	0	3

3999 rows × 12 columns

In [64]:
```python
# Compute the centroids for K=5 clusters with 11 variables
clusters5.cluster_centers_
```

Out[64]:
```
array([[9.87581993e-01, 3.39051837e-03, 3.51053916e-05, 3.03791237e-05,
        3.02652033e-05, 9.01709733e-02, 1.53701634e-04, 6.66013521e-03,
        2.09767345e-05, 7.53291184e-02, 3.94536689e-06],
       [5.14758999e-01, 2.45703304e-03, 9.55752981e-05, 5.00781670e-05,
        4.87710513e-05, 8.02358706e-01, 5.20472068e-04, 1.80244812e-02,
        6.06430623e-05, 1.36539353e-01, 3.06234744e-05],
       [4.14644791e-01, 1.30104261e-18, 2.28611980e-04, 2.27627266e-04,
        2.27627266e-04, 1.50766683e-01, 5.97513433e-04, 7.35401490e-03,
        2.84888383e-05, 8.48268382e-01, 3.91049405e-05],
       [8.93103634e-01, 4.45303855e-03, 1.23796982e-04, 1.23612826e-04,
        1.23612826e-04, 7.60122618e-02, 2.95169039e-04, 6.30476783e-03,
        2.07480658e-05, 4.07515394e-01, 1.35161631e-05],
       [8.91833807e-01, 2.00098101e-03, 5.80553278e-05, 3.01489923e-05,
        2.94377607e-05, 4.20637046e-01, 4.04859493e-04, 7.68892416e-03,
        2.27011475e-05, 8.30834166e-02, 1.00407121e-05]])
```

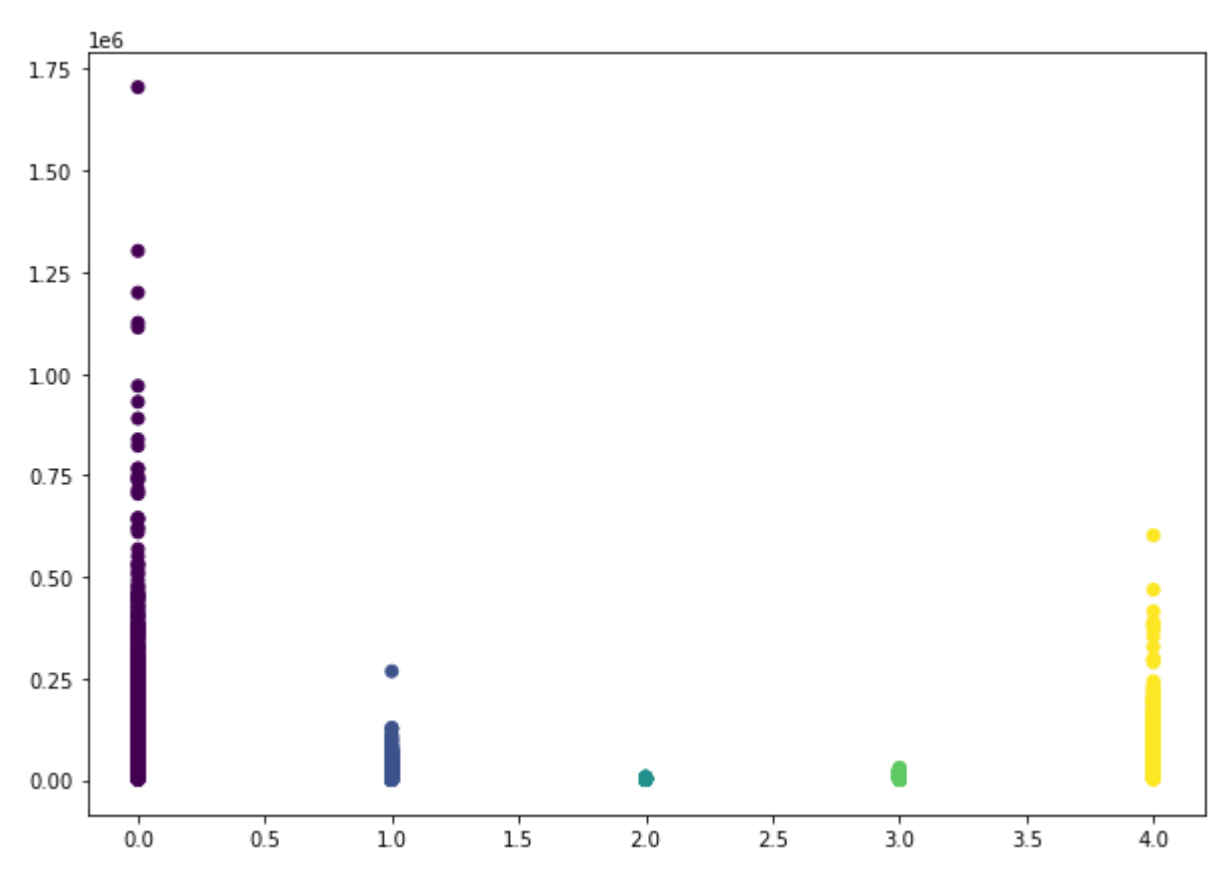
In [65]:
```python
# Group data by Clusters (K=5)
airline5.groupby('clusters5id').agg(['mean']).reset_index()
```

Out[65]:

	clusters5id	Balance	Qual_miles	cc1_miles	cc2_miles	cc3_miles	Bonus_miles	Bonus_trans	Flight_miles_12mo	Flight_trans_12	Days_since_enroll	Award?
		mean	mean	mean	mean	mean	mean	mean	mean	mean	mean	mean
0	0	97404.121382	185.499533	1.604575	1.009337	1.001867	9636.360411	9.704015	520.399627	1.565359	3960.816060	0.269374
1	1	27526.798295	115.818182	3.247159	1.034091	1.071023	41812.809659	17.599432	676.107955	1.951705	4226.252841	0.903409
2	2	2415.576577	0.000000	1.009009	1.000000	1.000000	850.189189	3.036036	48.612613	0.171171	4723.225225	0.225225
3	3	11768.858247	55.121134	1.005155	1.000000	1.000000	984.778351	3.469072	93.216495	0.293814	4908.760309	0.172680
4	4	70743.739563	116.122266	3.135189	1.025845	1.019881	32531.393638	17.626243	442.855865	1.312127	4045.261431	0.491054

In [19]:
```python
# Plot Clusters
plt.figure(figsize=(10, 7))
plt.scatter(airline5['clusters5id'],airline5['Balance'], c=clusters5.labels_)
```

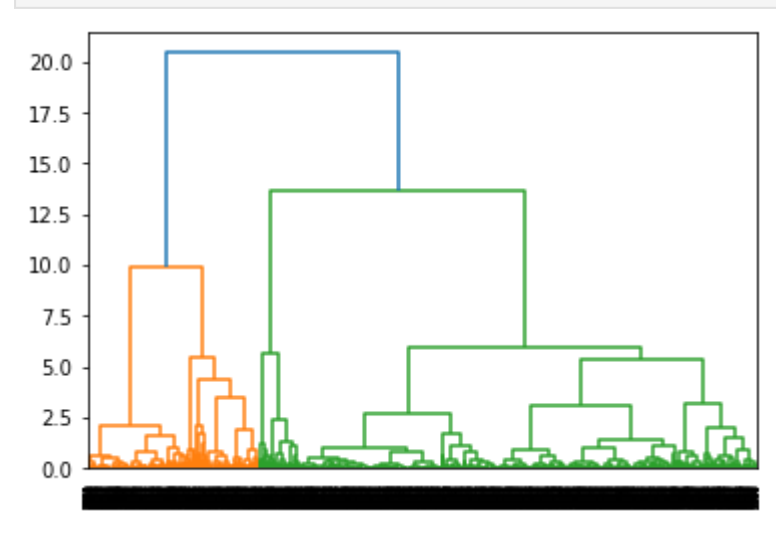
Out[19]: <matplotlib.collections.PathCollection at 0x200a24f7a00>



H- Clustering

Euclidean Distance, Ward

In [66]:
```python
dendrogram = sch.dendrogram(sch.linkage(airline2_norm, method='ward'))
```



From the Ward method, we see that as the height increases the clusters get grouped together

We decided to cut the tree at height 85 to obtain 3 clusters and then assigned each cluster with its respective observations

In [73]:
```python
X = airline2_norm.values
```

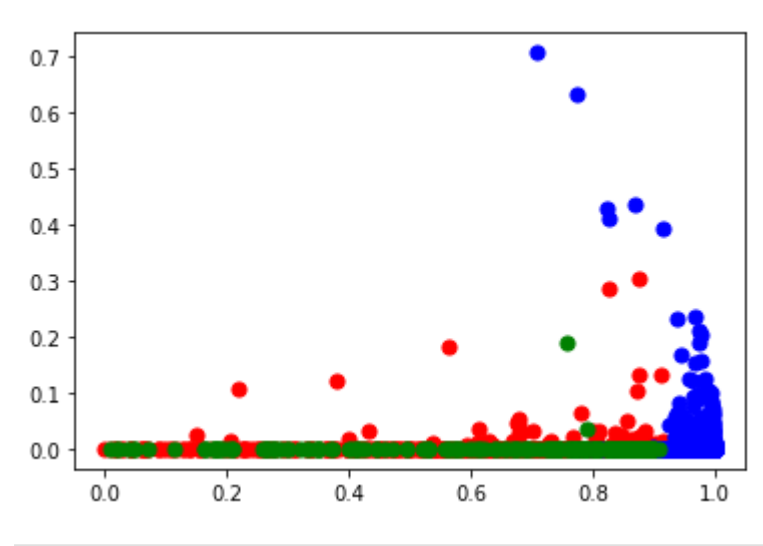
In [74]:
```python
model = AgglomerativeClustering(n_clusters=3, affinity='euclidean', linkage='ward')
```

In [75]:
```python
h_cluster = model.fit(X)
```

In [76]:
```python
labels = model.labels_
```

In [72]:
```python
plt.scatter(X[labels==0, 0], X[labels==0, 1], s=50, marker='o', color='red')
plt.scatter(X[labels==1, 0], X[labels==1, 1], s=50, marker='o', color='blue')
plt.scatter(X[labels==2, 0], X[labels==2, 1], s=50, marker='o', color='green')
```

Out[72]: <matplotlib.collections.PathCollection at 0x200a260ec40>



In [ ]: