In [1]:
```
pip install pygad
```

```
Defaulting to user installation because normal site-packages is not writeableNote: you may need to restart the kernel to use up
dated packages.

Collecting pygad
  Downloading pygad-3.0.1-py3-none-any.whl (67 kB)
                                              0.0/68.0 kB ? eta -:--:--
     ------------------                       30.7/68.0 kB ? eta -:--:--
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     ------------------                       30.7/68.0 kB ? eta -:--:--
     ---------------------------------     61.4/68.0 kB 163.6 kB/s eta 0:00:01
     ---------------------------------------- 68.0/68.0 kB 167.8 kB/s eta 0:00:00
Collecting cloudpickle (from pygad)
  Downloading cloudpickle-2.2.1-py3-none-any.whl (25 kB)
Requirement already satisfied: matplotlib in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages (from pyga
d) (3.7.1)
Requirement already satisfied: numpy in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages (from pygad) (1.
24.3)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages (from
matplotlib->pygad) (1.0.7)
Requirement already satisfied: cycler>=0.10 in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages (from mat
plotlib->pygad) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages (fro
m matplotlib->pygad) (4.39.4)
Requirement already satisfied: kiwisolver>=1.0.1 in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages (fro
m matplotlib->pygad) (1.4.4)
Requirement already satisfied: packaging>=20.0 in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages (from
matplotlib->pygad) (23.1)
Requirement already satisfied: pillow>=6.2.0 in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages (from ma
tplotlib->pygad) (9.5.0)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages (from
matplotlib->pygad) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages
(from matplotlib->pygad) (2.8.2)
Requirement already satisfied: six>=1.5 in c:\users\p. vijay kumar\appdata\roaming\python\python310\site-packages (from python-
dateutil>=2.7->matplotlib->pygad) (1.16.0)
Installing collected packages: cloudpickle, pygad
Successfully installed cloudpickle-2.2.1 pygad-3.0.1
```
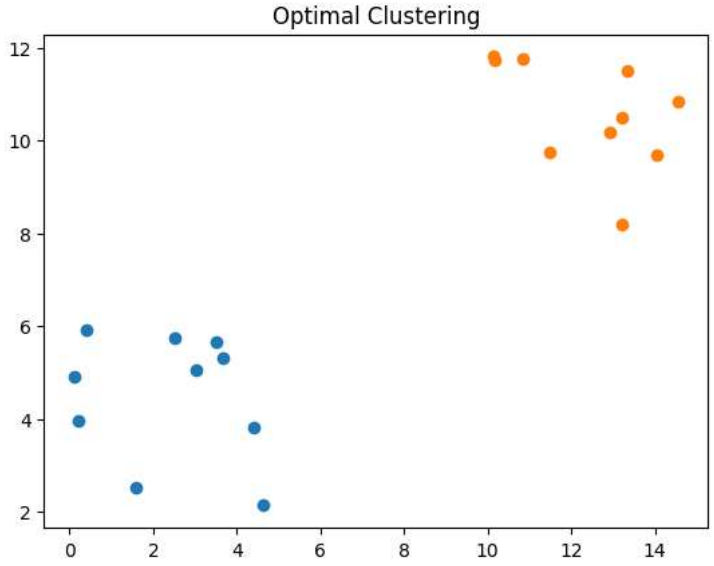

In [2]:
```
import numpy
import matplotlib.pyplot
import pygad

```

In [3]:
```
 cluster1_num_samples = 10
cluster1_x1_start = 0
cluster1_x1_end = 5
cluster1_x2_start = 2
cluster1_x2_end = 6
cluster1_x1 = numpy.random.random(size=(cluster1_num_samples))
cluster1_x1 = cluster1_x1 * (cluster1_x1_end - cluster1_x1_start) + cluster1_x1_start
cluster1_x2 = numpy.random.random(size=(cluster1_num_samples))
cluster1_x2 = cluster1_x2 * (cluster1_x2_end - cluster1_x2_start) + cluster1_x2_start
cluster2_num_samples = 10
cluster2_x1_start = 10
cluster2_x1_end = 15
cluster2_x2_start = 8
cluster2_x2_end = 12
cluster2_x1 = numpy.random.random(size=(cluster2_num_samples))
cluster2_x1 = cluster2_x1 * (cluster2_x1_end - cluster2_x1_start) + cluster2_x1_start
cluster2_x2 = numpy.random.random(size=(cluster2_num_samples))
cluster2_x2 = cluster2_x2 * (cluster2_x2_end - cluster2_x2_start) + cluster2_x2_start
```

In [4]:
```
c1 = numpy.array([cluster1_x1, cluster1_x2]).T
c2 = numpy.array([cluster2_x1, cluster2_x2]).T
data = numpy.concatenate((c1, c2), axis=0)
data
```

Out[4]:
```
array([[ 3.67414028,  5.31354345],
       [ 2.50629552,  5.73283813],
       [ 0.19925081,  3.97079906],
       [ 1.58553877,  2.52061995],
       [ 3.01306715,  5.06534961],
       [ 0.109121  ,  4.9054157 ],
       [ 3.51978981,  5.6629299 ],
       [ 4.41043327,  3.81622891],
       [ 0.40499763,  5.91186134],
       [ 4.63732014,  2.13177086],
       [10.13011032, 11.80636927],
       [12.92822937, 10.18542153],
       [14.55117235, 10.83016935],
       [13.22479805,  8.19929457],
       [13.34697659, 11.5066323 ],
       [14.04866992,  9.69652389],
       [13.21864178, 10.48591281],
       [11.48268651,  9.74504236],
       [10.84244235, 11.75319828],
       [10.1604462 , 11.7411278 ]])
```

In [5]:
```
matplotlib.pyplot.scatter(cluster1_x1, cluster1_x2)
matplotlib.pyplot.scatter(cluster2_x1, cluster2_x2)
matplotlib.pyplot.title("Optimal Clustering")
matplotlib.pyplot.show()
```



In [8]:
```
def euclidean_distance(X, Y):
    return numpy.sqrt(numpy.sum(numpy.power(X - Y, 2), axis=1))
```

In [9]:
```
def cluster_data(solution, solution_idx):
    global num_cluster, data
    feature_vector_length = data.shape[1]
    cluster_centers = []
    all_clusters_dists = []
    clusters = []
    clusters_sum_dist = []

    for clust_idx in range(num_clusters):
        cluster_centers.append(solution[feature_vector_length*clust_idx:feature_vector_length*(clust_idx+1)])
        cluster_center_dists = euclidean_distance(data, cluster_centers[clust_idx])
        all_clusters_dists.append(numpy.array(cluster_center_dists))

    cluster_centers = numpy.array(cluster_centers)
    all_clusters_dists = numpy.array(all_clusters_dists)

    cluster_indices = numpy.argmin(all_clusters_dists, axis=0)
    for clust_idx in range(num_clusters):
        clusters.append(numpy.where(cluster_indices == clust_idx)[0])

        if len(clusters[clust_idx]) == 0:
           clusters_sum_dist.append(0)
        else:
            clusters_sum_dist.append(numpy.sum(all_clusters_dists[clust_idx, clusters[clust_idx]]))

    clusters_sum_dist = numpy.array(clusters_sum_dist)
    return cluster_centers, all_clusters_dists, cluster_indices, clusters, clusters_sum_dist
```

In [10]:
```
def fitness_func(ga_instance,solution, solution_idx):
    _, _, _, _, clusters_sum_dist = cluster_data(solution, solution_idx)
    fitness = 1.0 / (numpy.sum(clusters_sum_dist) + 0.00000001)
    return fitness
```

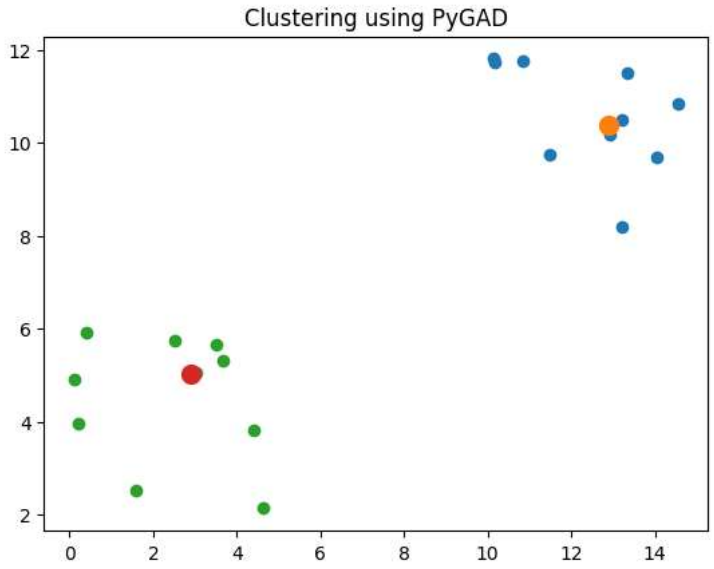
In [11]:
```
num_clusters = 2
num_genes = num_clusters * data.shape[1]
ga_instance = pygad.GA(num_generations=100,
 sol_per_pop=10,
num_parents_mating=5,
init_range_low=-6,
init_range_high=20,
keep_parents=2,
num_genes=num_genes,
fitness_func=fitness_func,
 suppress_warnings=True)
ga_instance.run()
```

In [12]:
```
best_solution, best_solution_fitness, best_solution_idx = ga_instance.best_solution()
print("Best solution is {bs}".format(bs=best_solution))
print("Fitness of the best solution is {bsf}".format(bsf=best_solution_fitness))
print("Best solution found after {gen} generations".format(gen=ga_instance.best_solution_generation))
```

```
Best solution is [12.90231033 10.38749219  2.89974809  5.01436296]
Fitness of the best solution is 0.02753202947702754
Best solution found after 67 generations
```

In [13]:
```
cluster_centers, all_clusters_dists, cluster_indices, clusters, clusters_sum_dist= cluster_data(best_solution, best_solution_idx)
```

In [14]:
```
for cluster_idx in range(num_clusters):
 cluster_x = data[clusters[cluster_idx], 0]
 cluster_y = data[clusters[cluster_idx], 1]
 matplotlib.pyplot.scatter(cluster_x, cluster_y)
 matplotlib.pyplot.scatter(cluster_centers[cluster_idx, 0], cluster_centers[cluster_idx, 1], linewidths=5)
matplotlib.pyplot.title("Clustering using PyGAD")
matplotlib.pyplot.show()
```



In [ ]:
```
1
```