# Applying K-Means Clustering on Hotness Classification

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# Contents

1. **Goal**

2. **Data Classification**

3. **K-means Clustering Algorithm**

4. **Review & Future Plan**

Details exist in each Chapters !

# 1. Goal

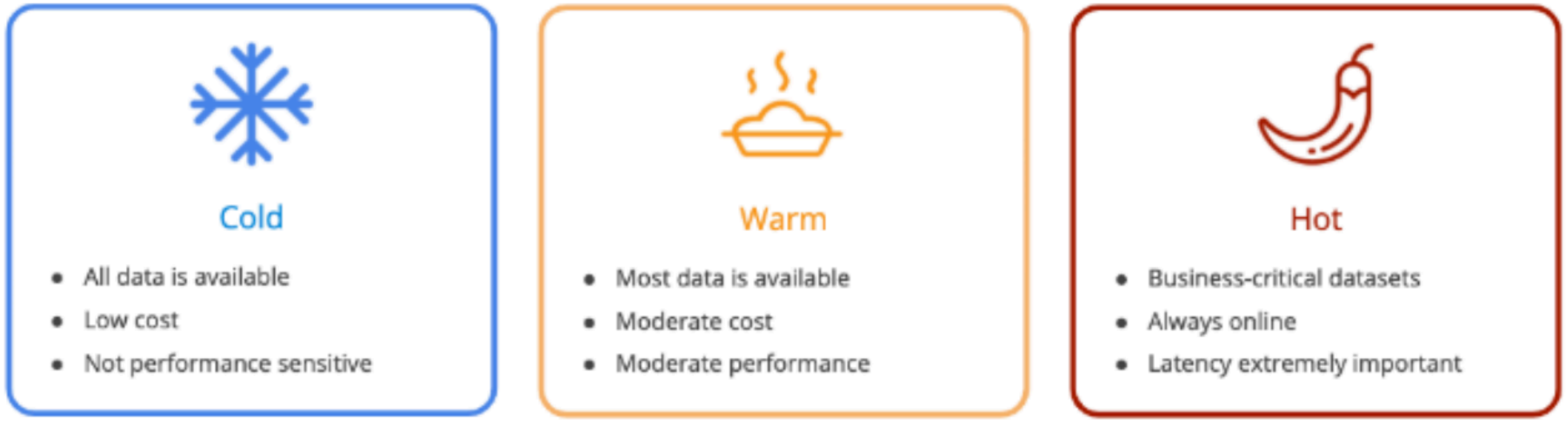
- Demand of SSD is improving nowadays, and it has a particular feature, which is called ‘garbage collection’. It occurs ‘write amplification’, and it makes life-cycle to down.

- Many researchers go ahead the study(classify data according to I/O access pattern) to reduce GC overhead.

- And we expect to find more sophisticated method.

# 2. Data Classification

## 2-1. Hot & Cold & Warm



Cold

- All data is available
- Low cost
- Not performance sensitive

Warm

- Most data is available
- Moderate cost
- Moderate performance

Hot

- Business-critical datasets
- Always online
- Latency extremely important

# 2. Data Classification

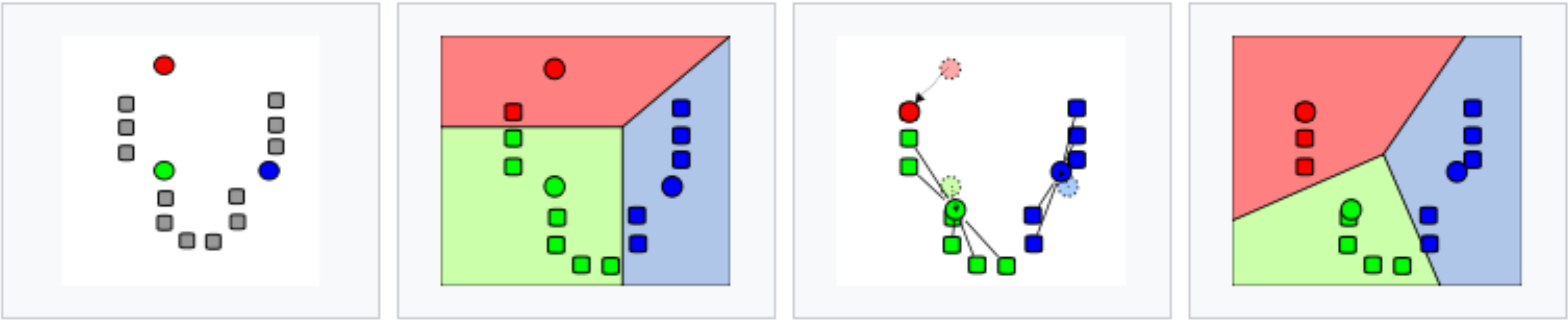
## 2-2. Purpose of Data Classification

- The arrangement of similar-state data helps to avoid the write amplification.
- Criteria of classification is ‘Hotness’

# 3. K-means Clustering Algorithm

## 3-1. Concepts

Demonstration of the standard algorithm

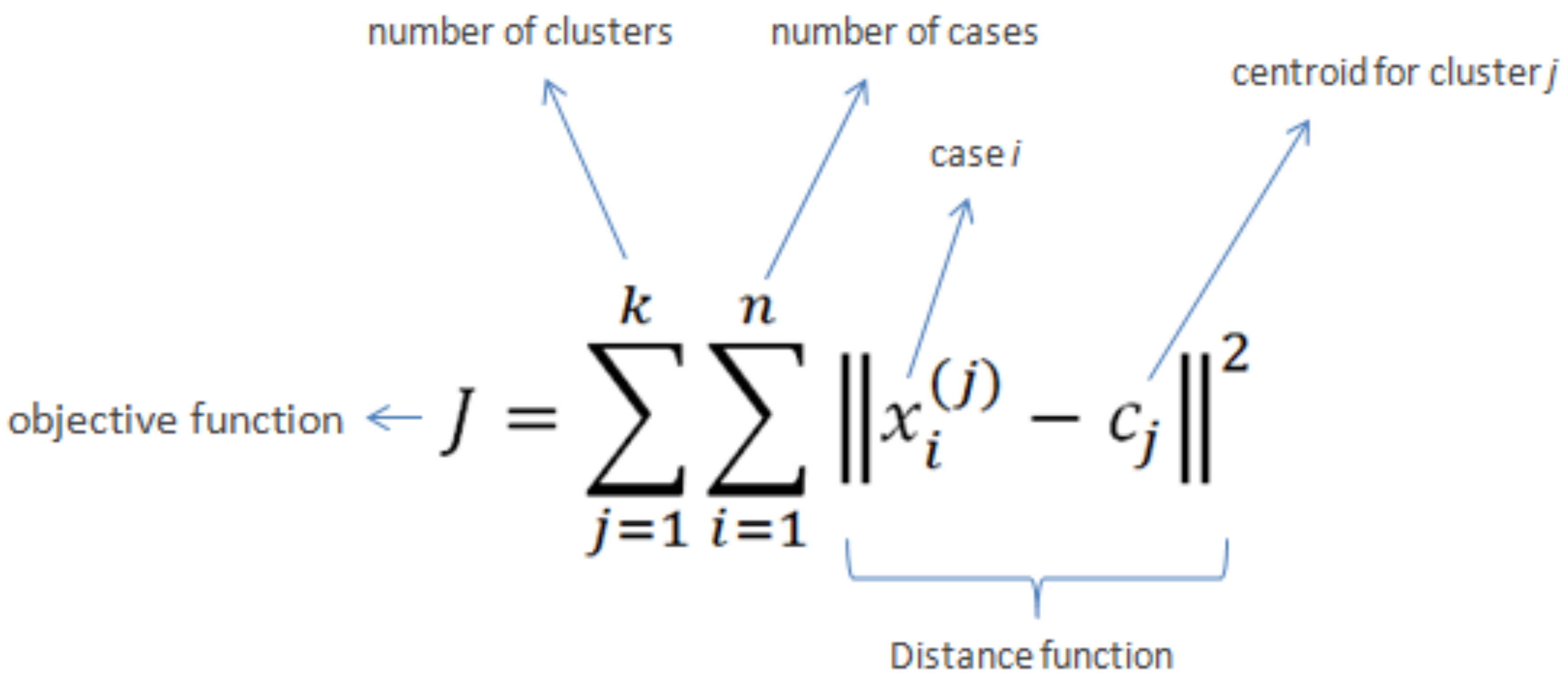


1. *k* initial "means" (in this case *k*=3) are randomly generated within the data domain (shown in color).

2. *k* clusters are created by associating every observation with the nearest mean. The partitions here represent the Voronoi diagram generated by the means.

3. The centroid of each of the *k* clusters becomes the new mean.

4. Steps 2 and 3 are repeated until convergence has been reached.

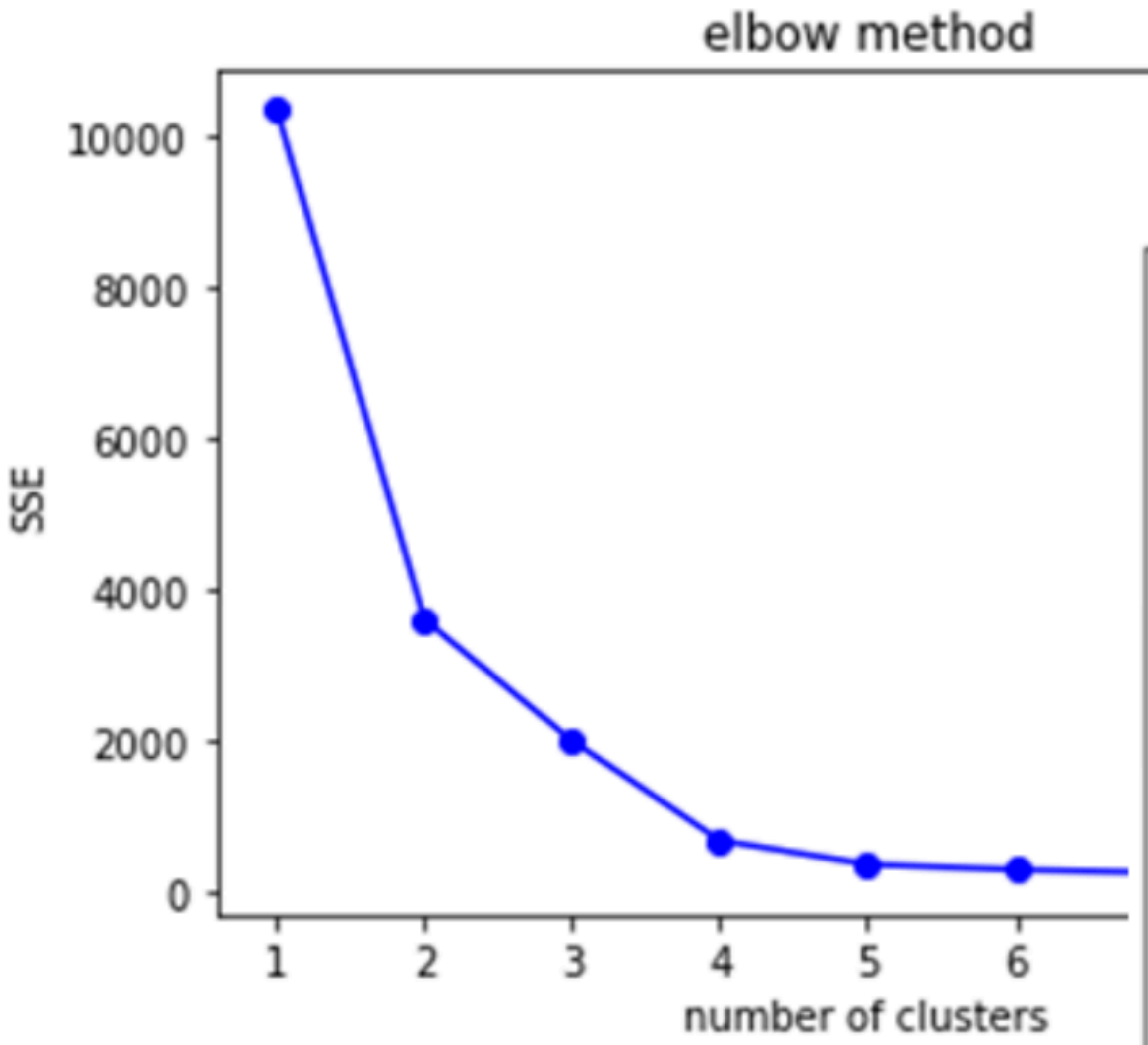


$$\text{objective function} \leftarrow J = \sum_{j=1}^{k}\sum_{i=1}^{n} \underbrace{\left\| x_i^{(j)} - c_j \right\|^2}_{\text{Distance function}}$$

Core goal : Maximize the cohesion of data within each cluster & maximize the separation of clusters.

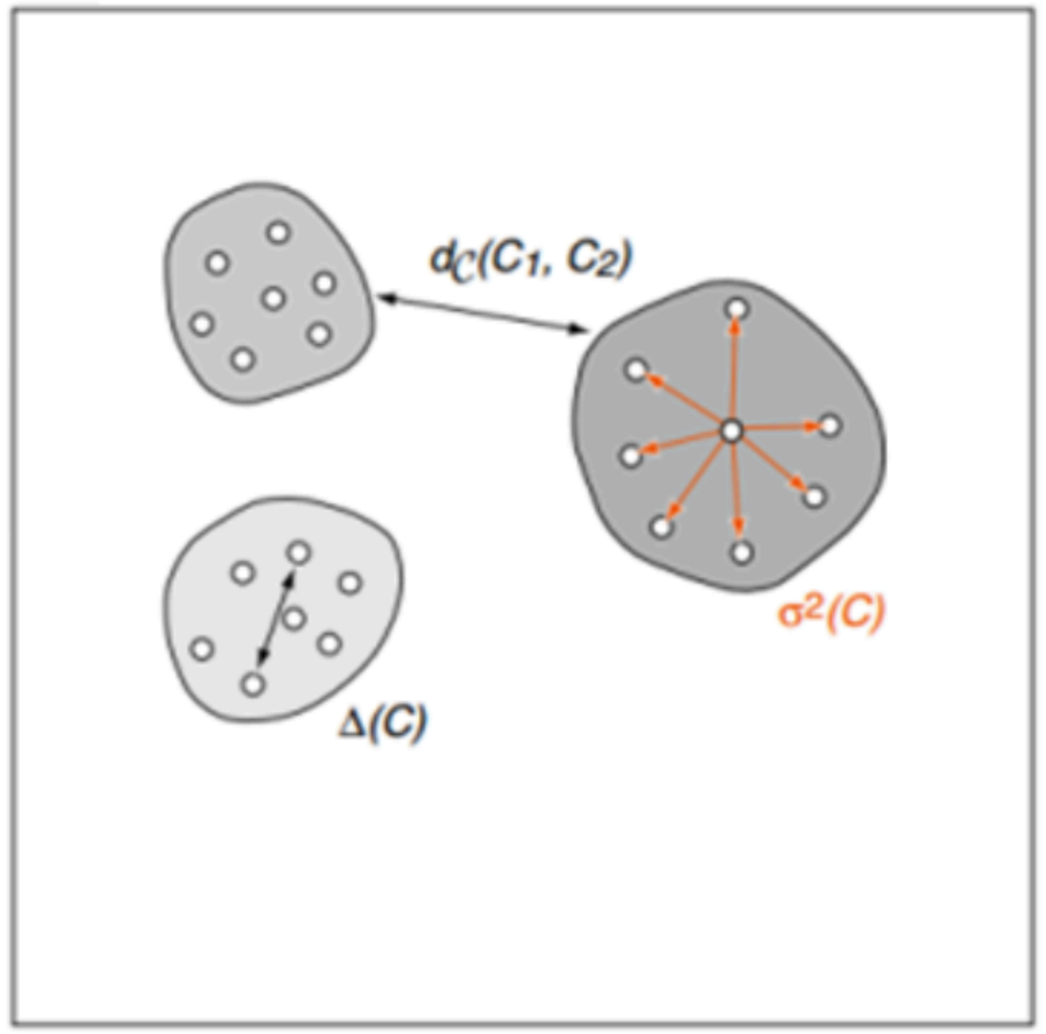
# 3. K-means Clustering Algorithm

## 3-2. Elbow Method : Find the optimized number(k) of Clusters



$$SSE = \sum_{i=1}^{k}\sum_{x\in c_i} dist(x,c_i)^2$$

SSE 공식

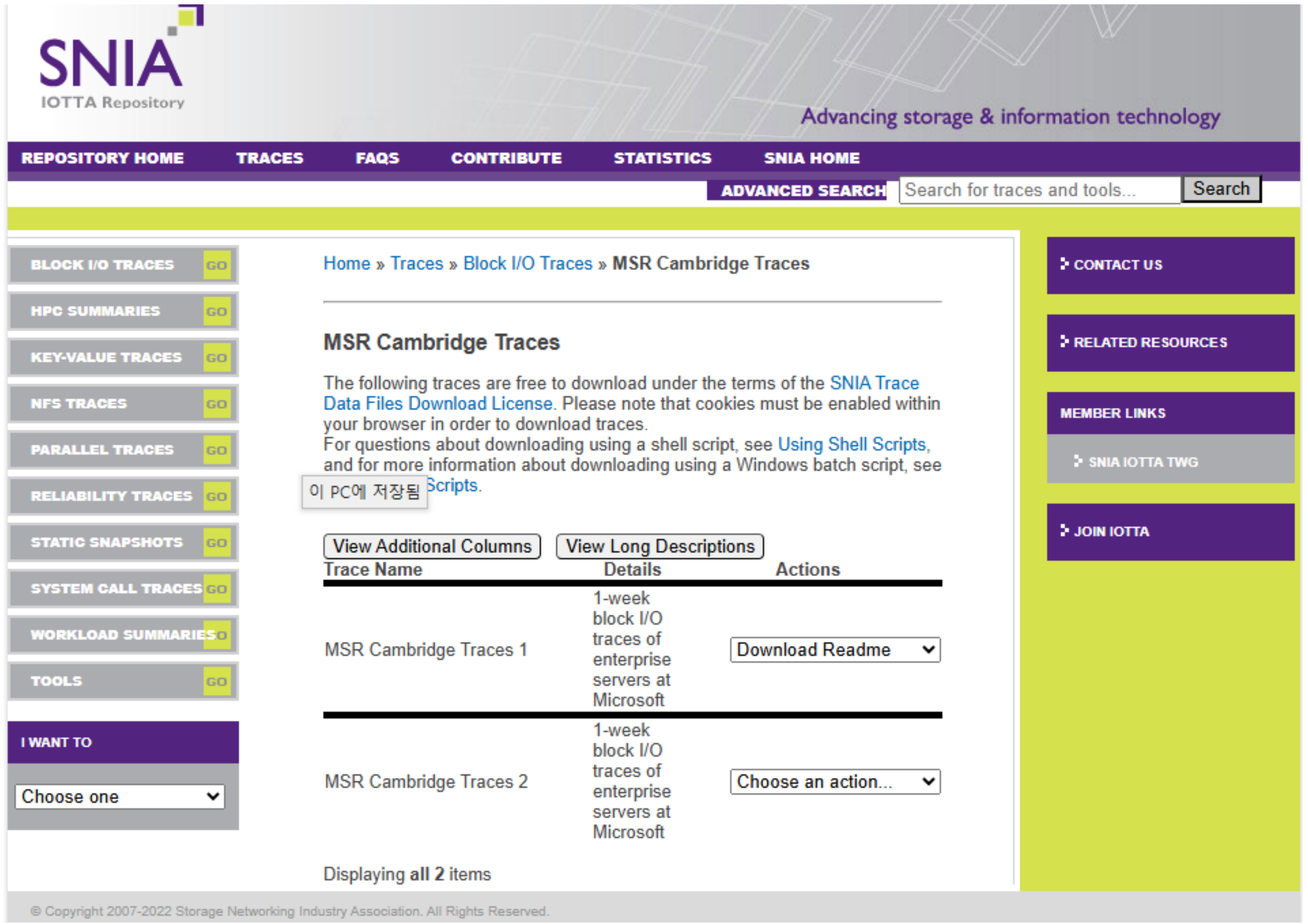


- Find the moment When SSE decreases the most

- Easy to implement

# 3. K-means Clustering Algorithm

## 3-3. Prepare files and Example implementation



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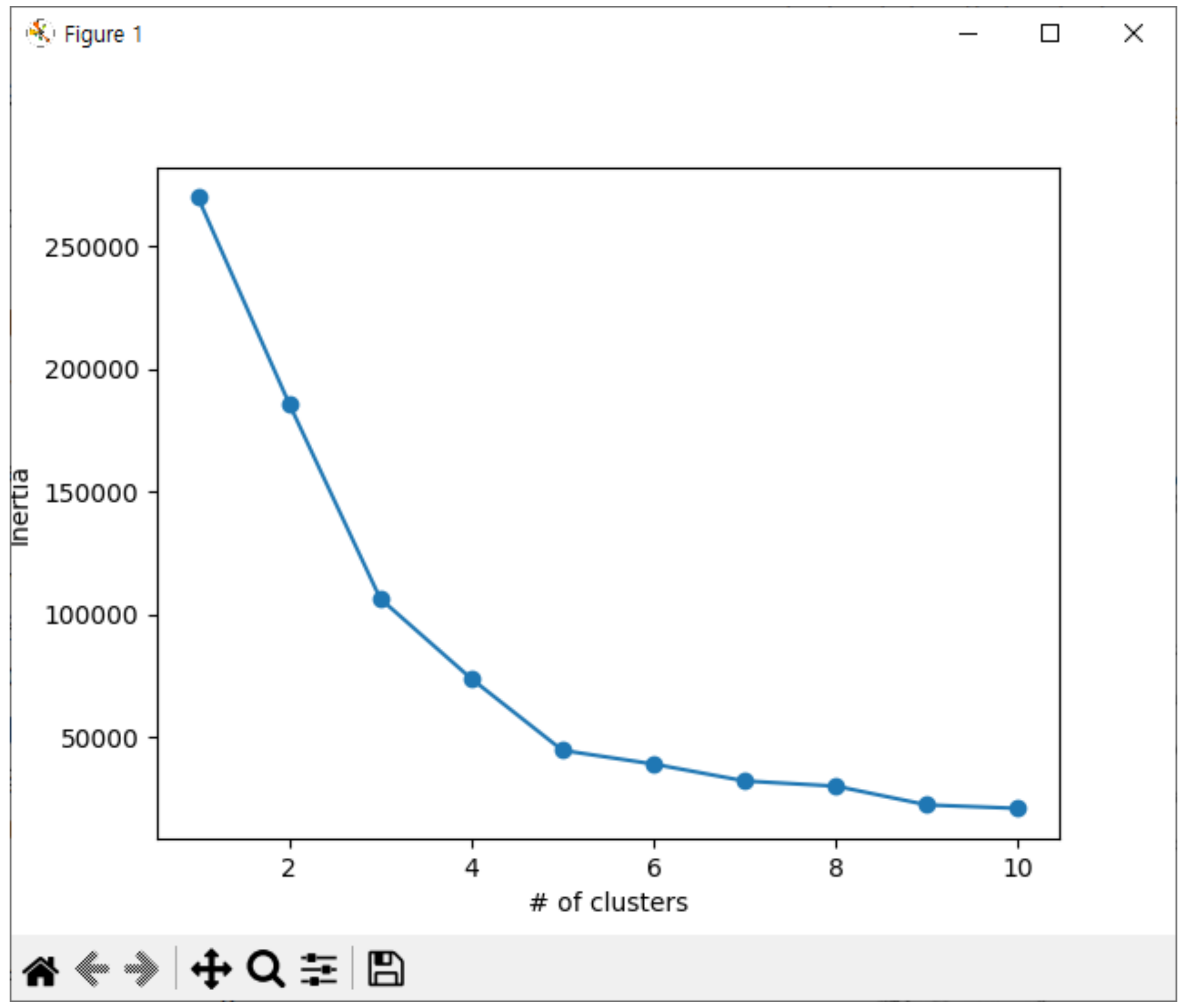
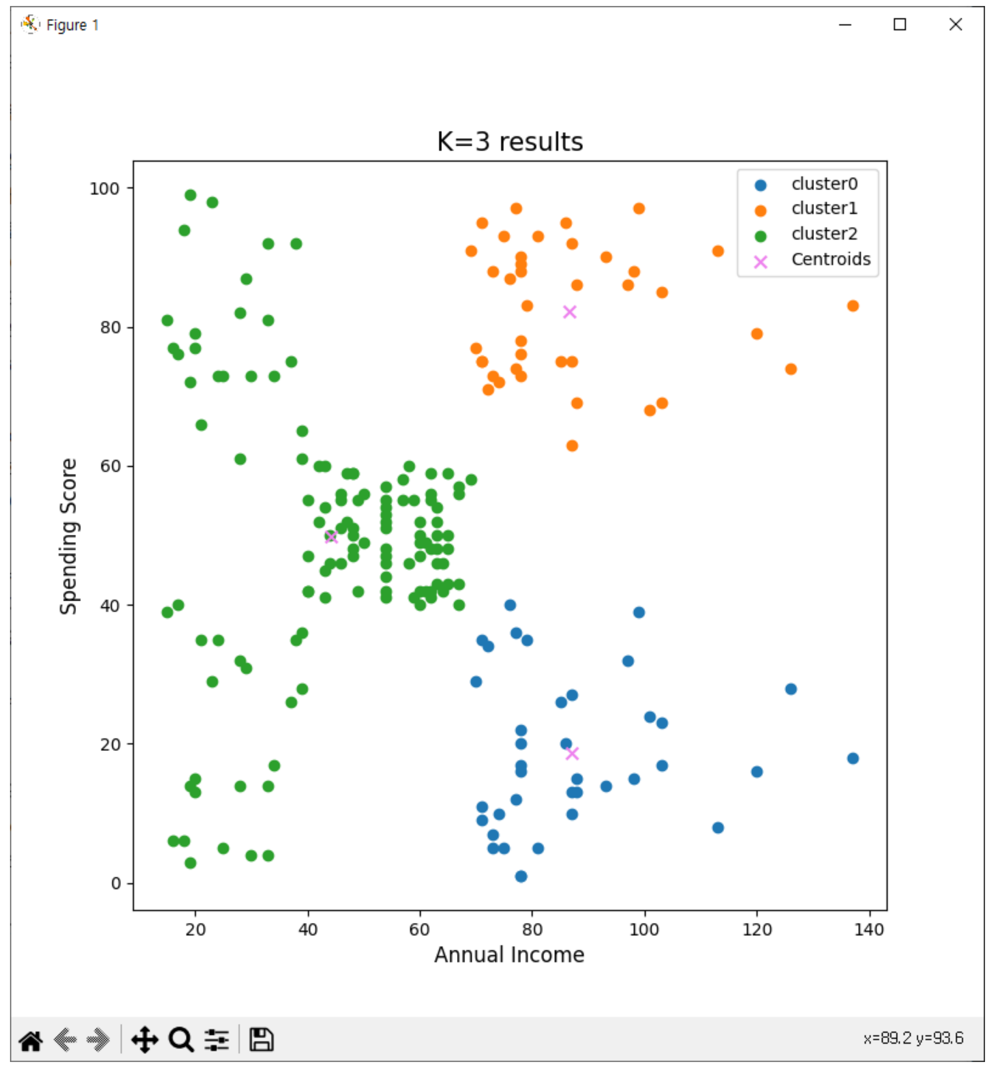
mscambridge trace

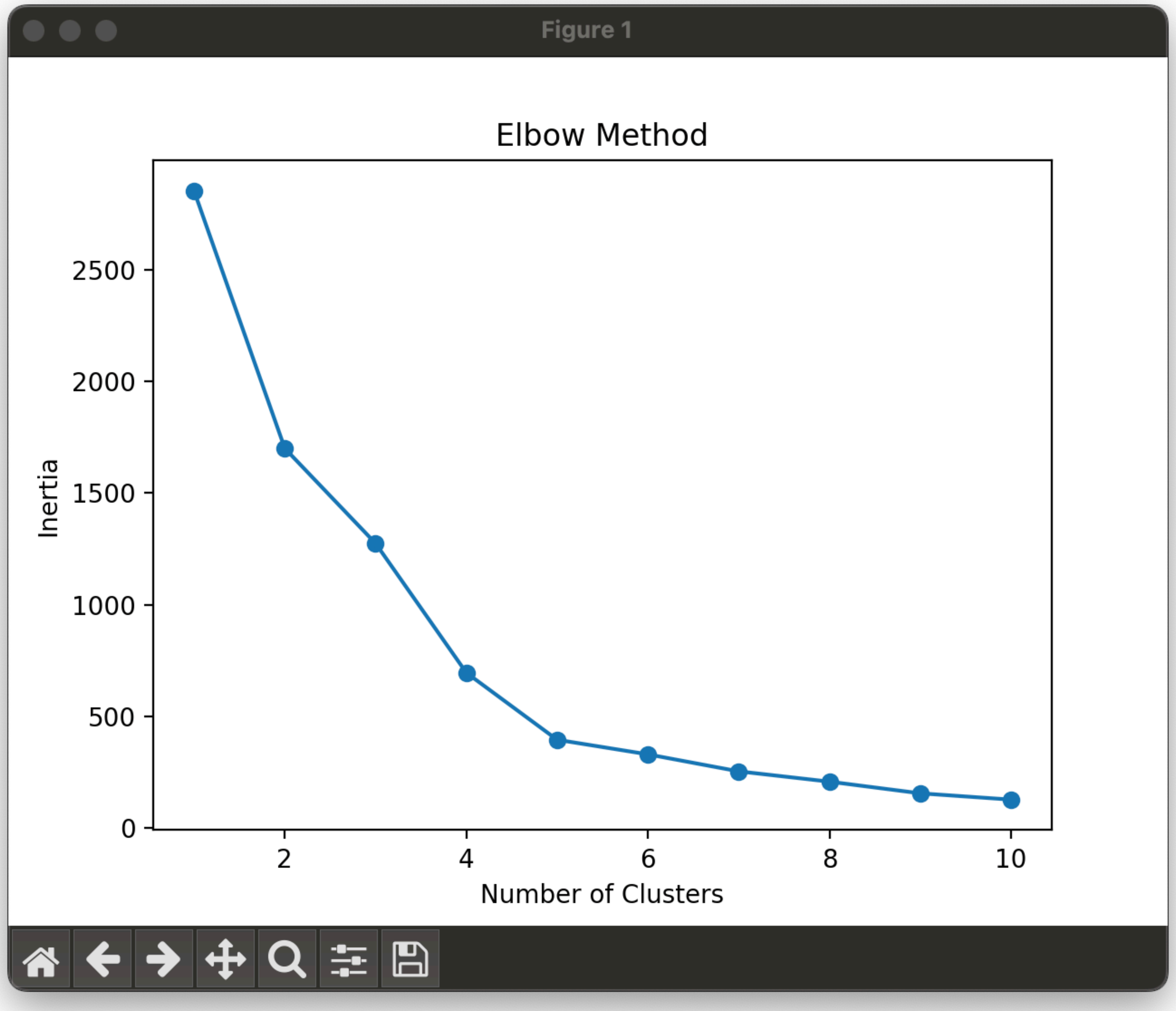


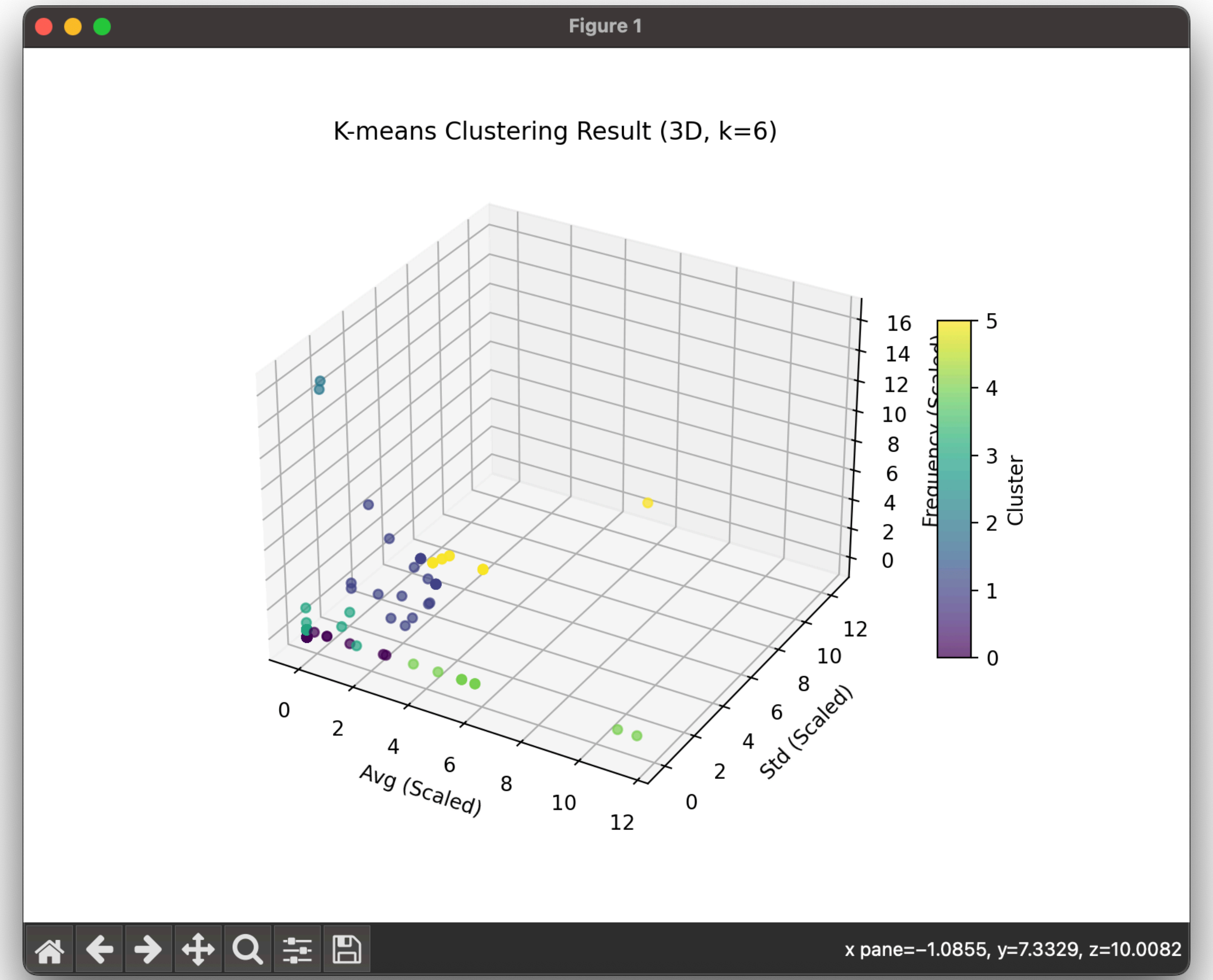


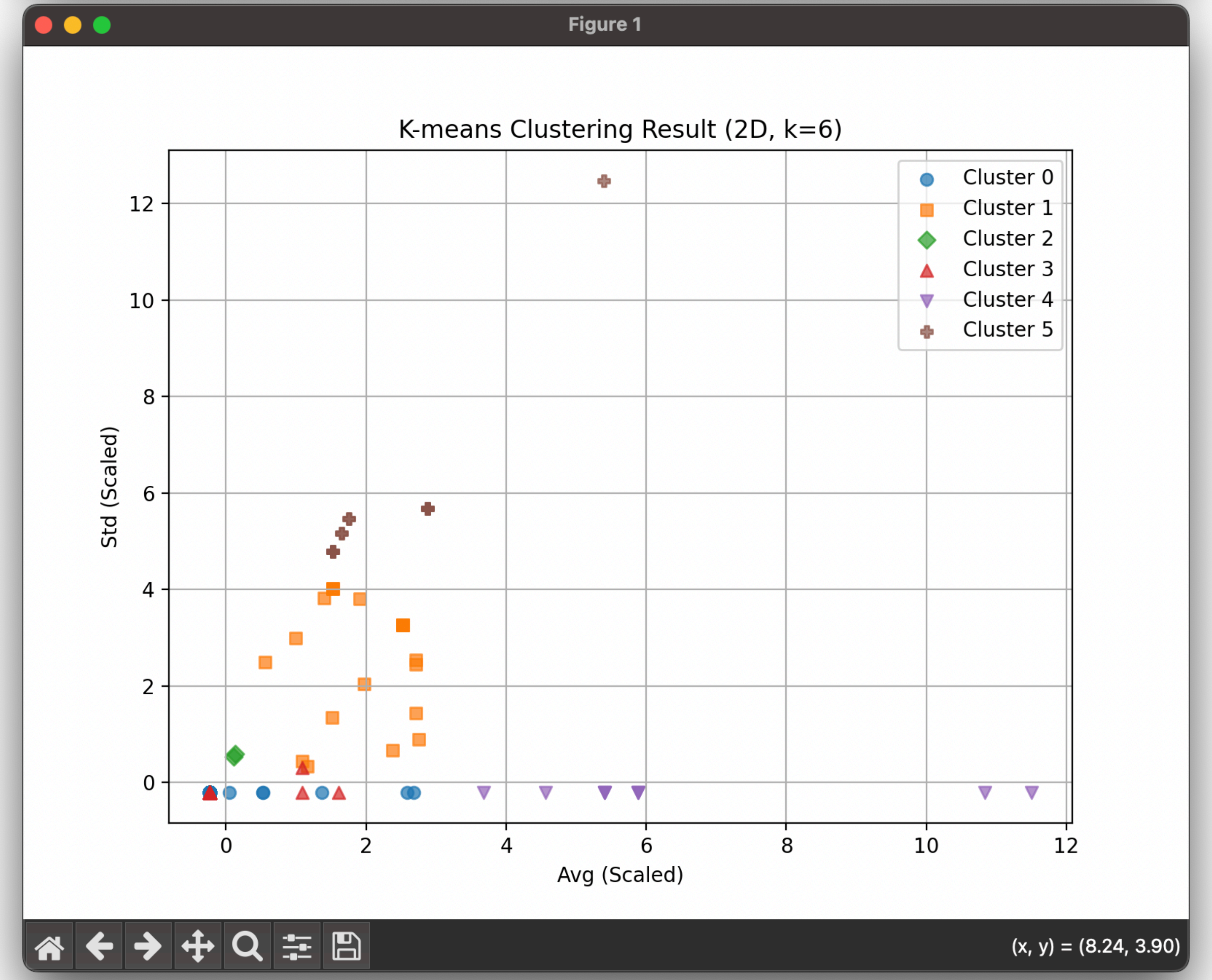
Ex file : ‘Mall_Customer.csv’

# 3. K-means Clustering Algorithm

## 3-4. Result(..?)

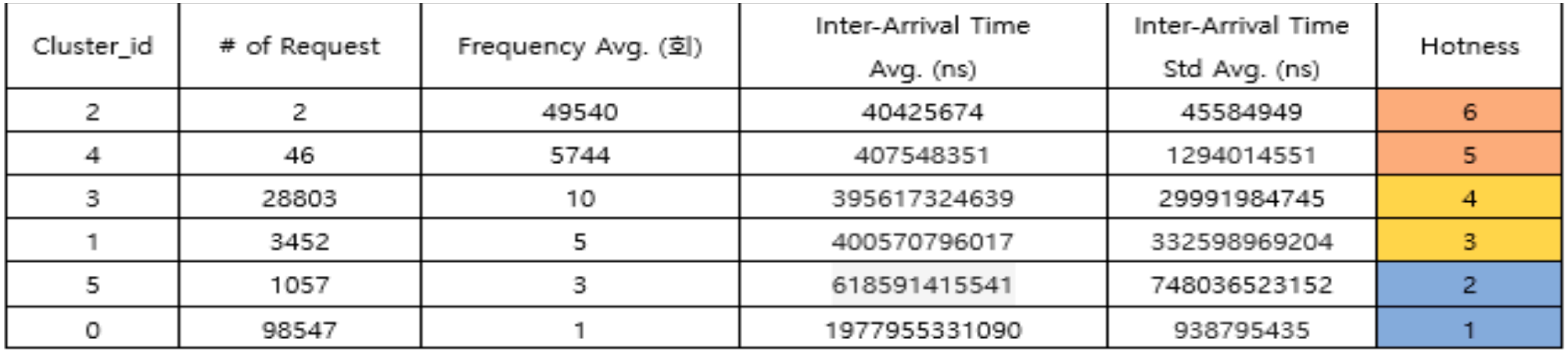






# 3. K-means Clustering Algorithm

## 3-4. Result(..?)



| Cluster_id | # of Request | Frequency Avg. (회) | Inter-Arrival Time Avg. (ns) | Inter-Arrival Time Std Avg. (ns) | Hotness |
|---|---|---|---|---|---|
| 2 | 2 | 49540 | 40425674 | 45584949 | 6 |
| 4 | 46 | 5744 | 407548351 | 1294014551 | 5 |
| 3 | 28803 | 10 | 395617324639 | 29991984745 | 4 |
| 1 | 3452 | 5 | 400570796017 | 332598969204 | 3 |
| 5 | 1057 | 3 | 618591415541 | 748036523152 | 2 |
| 0 | 98547 | 1 | 1977955331090 | 938795435 | 1 |

Classification results when progressed normally

# 4. Review & Future Plan

**Review**

- What caused the inaccurate results ?
- > Suspected candidates : Scaling, **Data missing**
- We can use a variety of learning methods for classification.

**What I learned**

- Main Idea : Efficient lifespan management through classification according to number of updates.

- Unsupervised Learning: K-Means Clustering

# 4. Review & Future Plan

**Review**

- First application after learning ML concept
- First study of ML paper
- Necessity to study more about Python

**Future Plan**

- Read the paper, ‘Reliable Storage Study with ML’
- Language review(C, Py) for smooth implementation
- OS ..?

# References

- SSD 쓰기 증폭을 줄이기 위한 머신러닝 기반 정교한 Hotness 분류 방안 : https://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE11036160\

- K-Means Clustering : en.wikipedia.org/wiki/K-means_clustering

- K-Menas 알고리즘 : velog.io/@eogns1208/K-Means-알고리즘