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Strata CONFERENCE

Making Data Work

Feb. 26 – 28, 2013

SANTA CLARA, CA

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Machine Learning on Spark

Shivaram Venkataraman
UC Berkeley

amplab UC BERKELEY

Machine learning

Computer Science

Statistics

Spam filters

Click prediction

Machine learning

Recommendations

Search ranking

Machine learning techniques

Classification

Clustering

Regression

Active learning

Collaborative filtering

Implementing Machine Learning

- Machine learning algorithms are
  - Complex, multi-stage
  - Iterative

- MapReduce/Hadoop unsuitable
- Need efficient primitives for **data sharing**

Machine Learning using Spark

- Spark RDDs → efficient data sharing
- In-memory caching accelerates performance
  - Up to 20x faster than Hadoop
- Easy to use high-level programming interface
  - Express complex algorithms ~100 lines.

Machine learning techniques

Classification

Clustering

Regression

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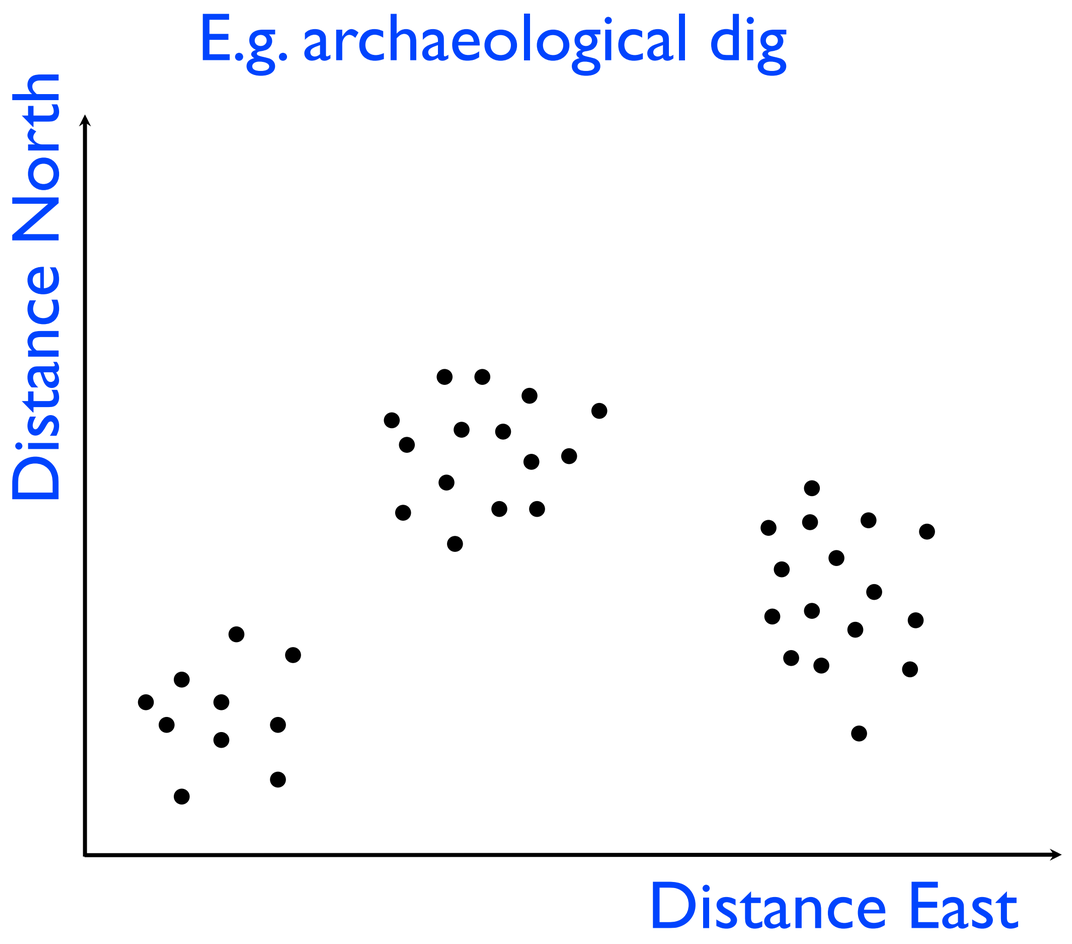
Collaborative filtering

K-Means Clustering using Spark

Focus: Implementation and Performance

Clustering

Grouping data according to similarity



Clustering

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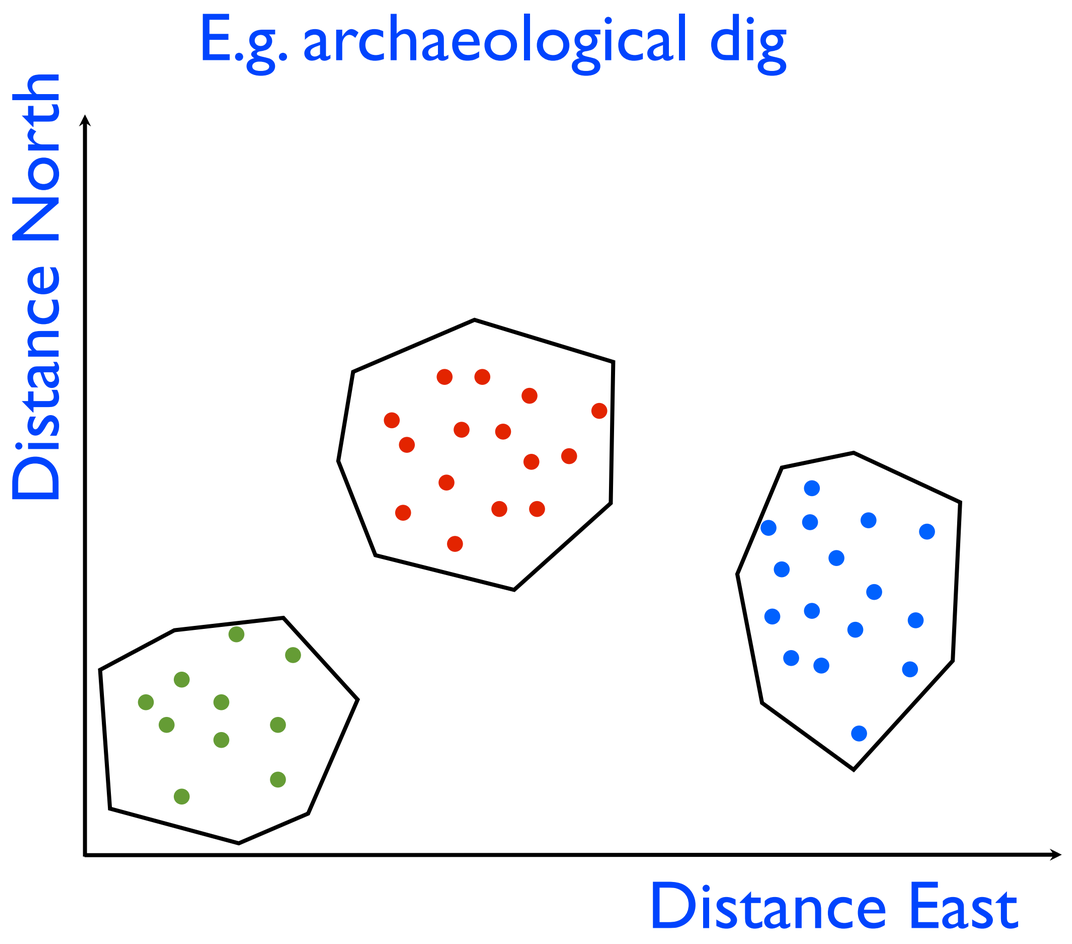
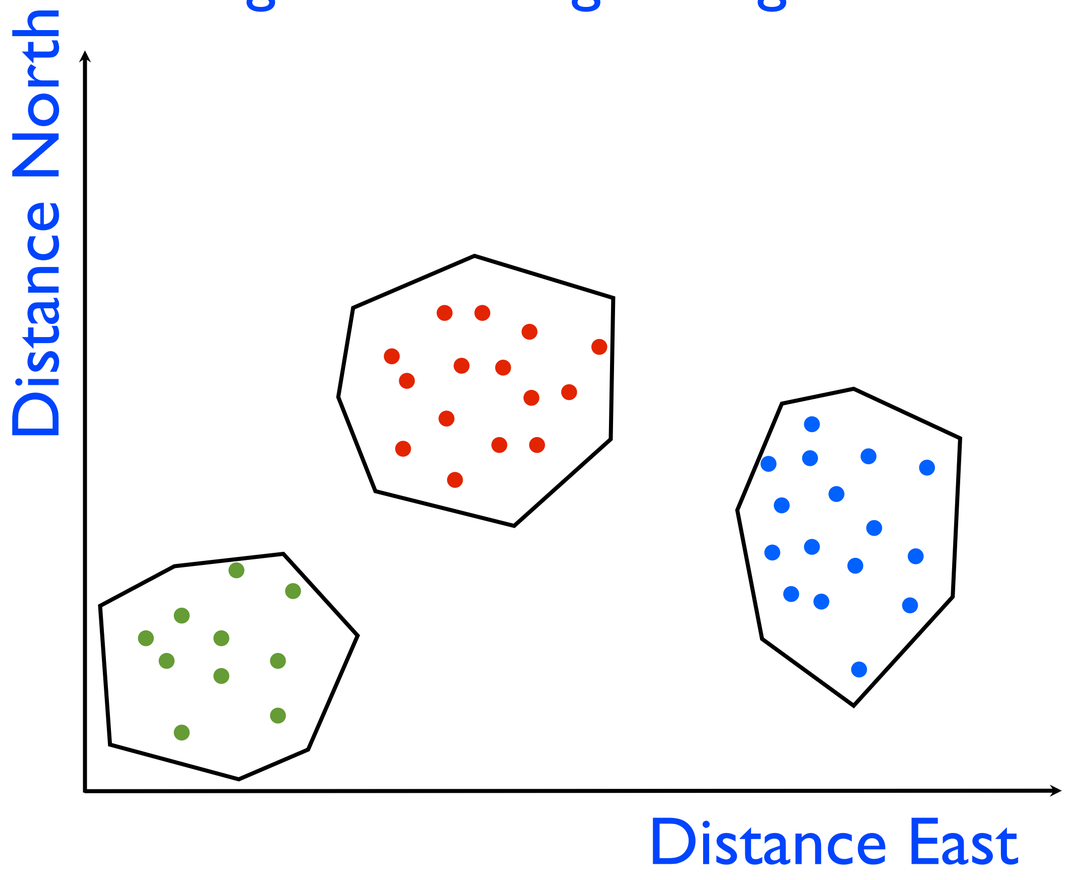


K-Means Algorithm

Benefits

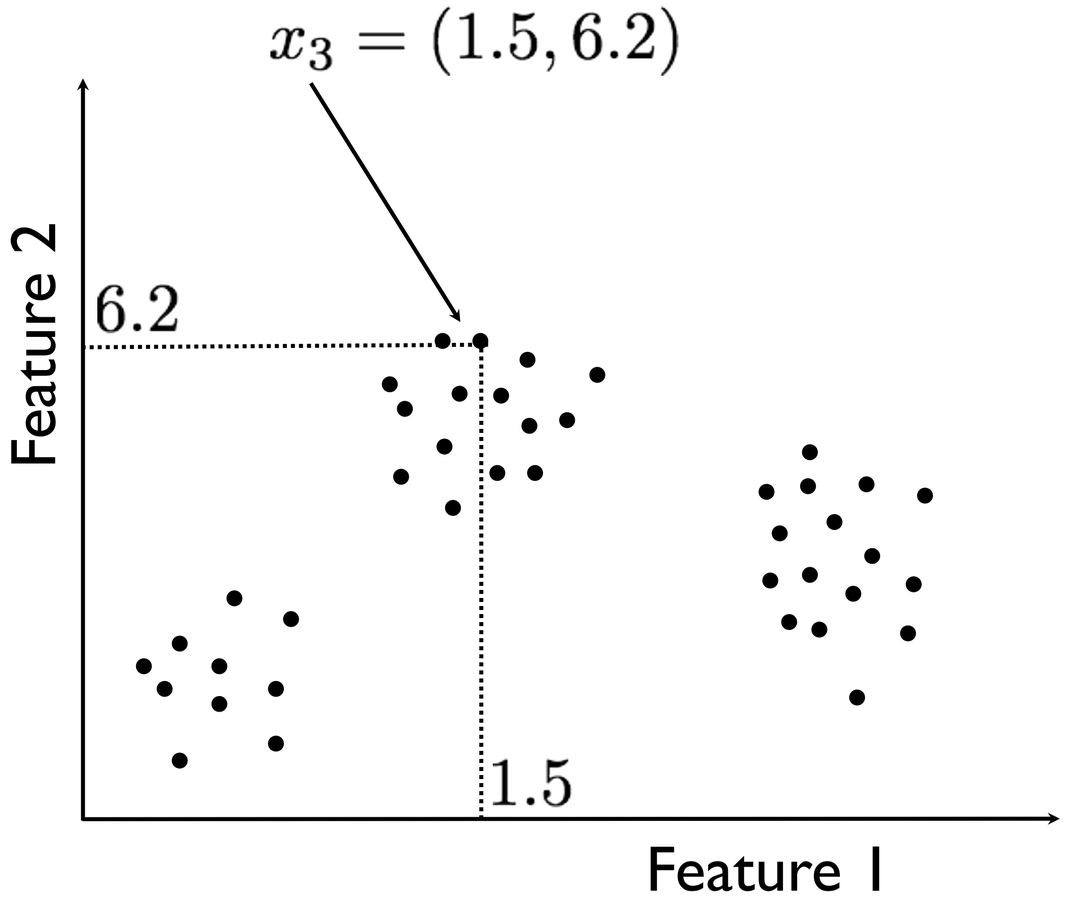
- Popular
- Fast
- Conceptually straightforward



K-Means: preliminaries

Data: Collection of values

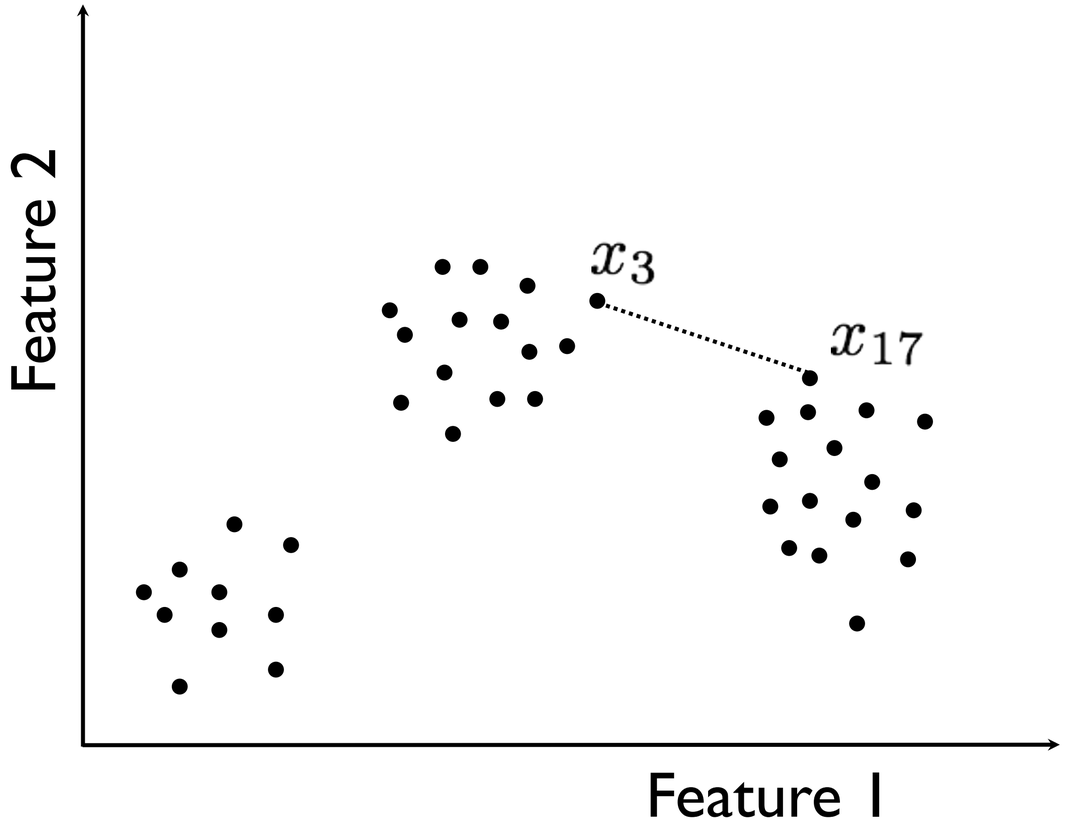
```
data = lines.map(line=>
    parseVector(line))
```



K-Means: preliminaries

Dissimilarity:
Squared Euclidean distance

```
dist = p.squaredDist(q)
```



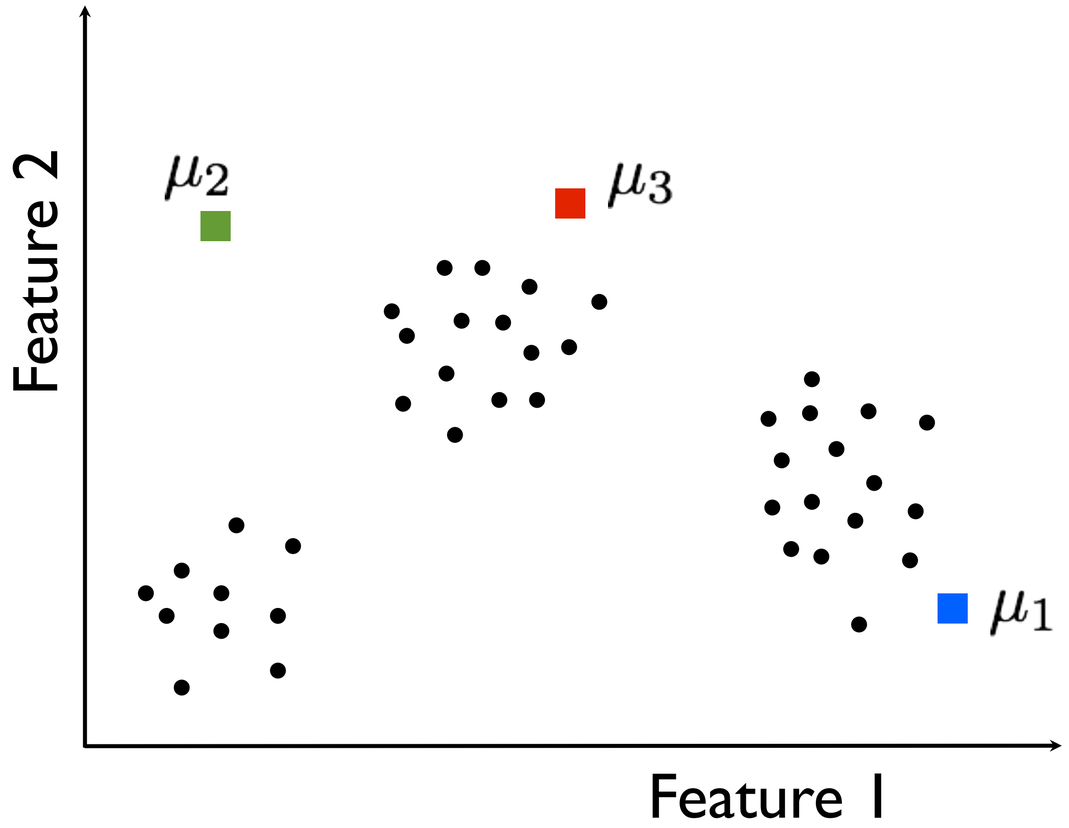
K-Means: preliminaries

K = Number of clusters

$\mu_1, \mu_2, \ldots, \mu_K$

Data assignments to clusters

$S_1, S_2, \ldots, S_K$



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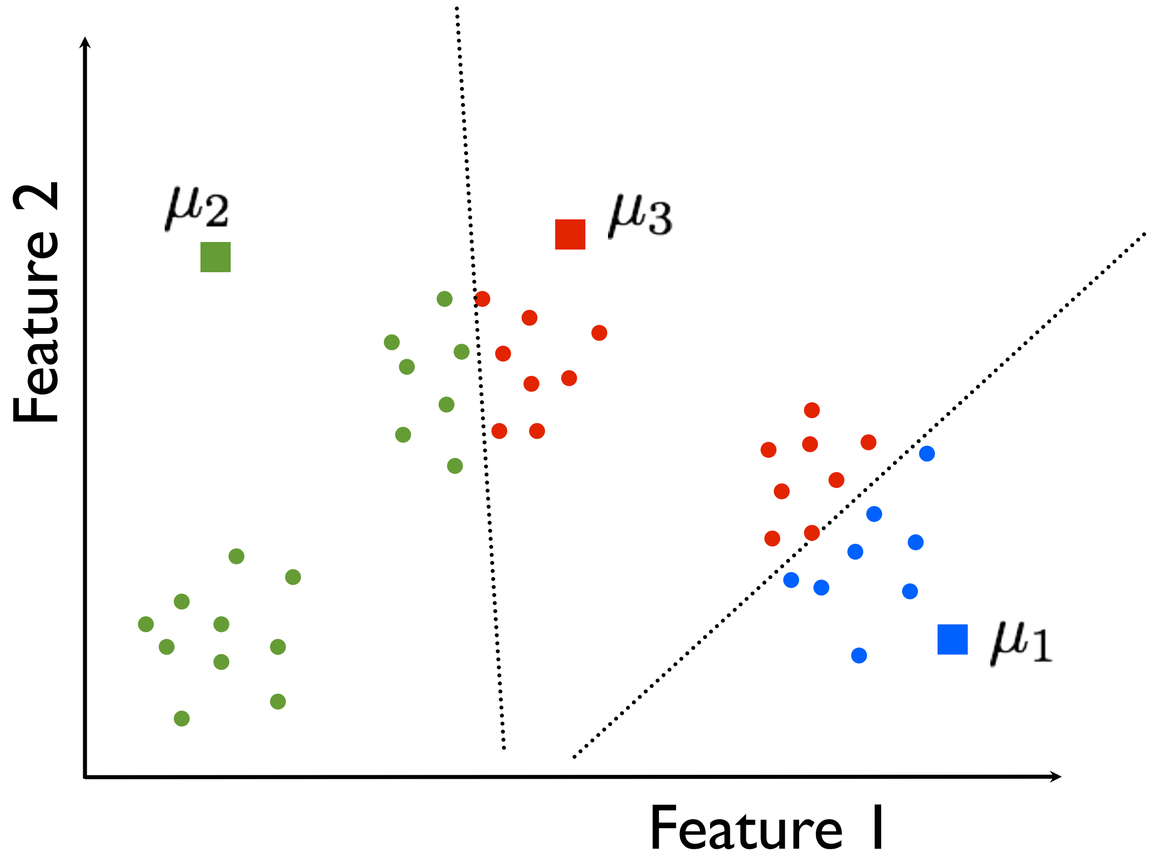
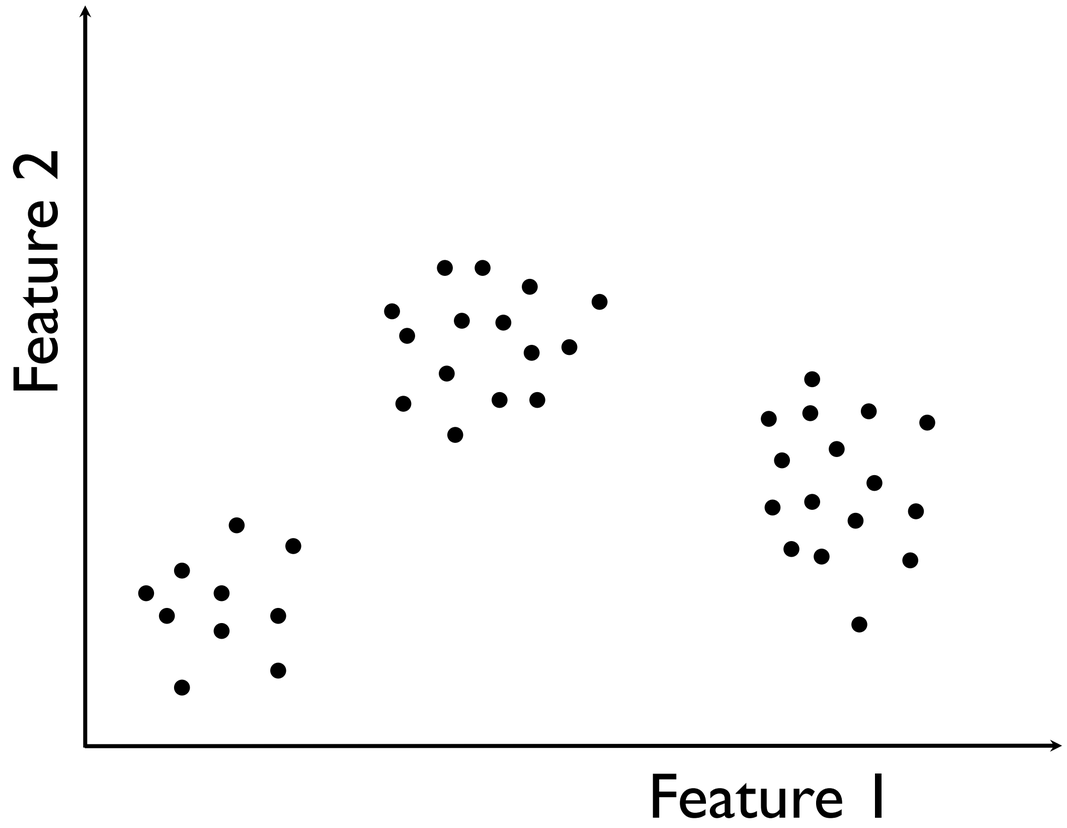


K-Means Algorithm

- Initialize K cluster centers
- Repeat until convergence:
  - Assign each data point to the cluster with the closest center.
  - Assign each cluster center to be the mean of its cluster's data points.



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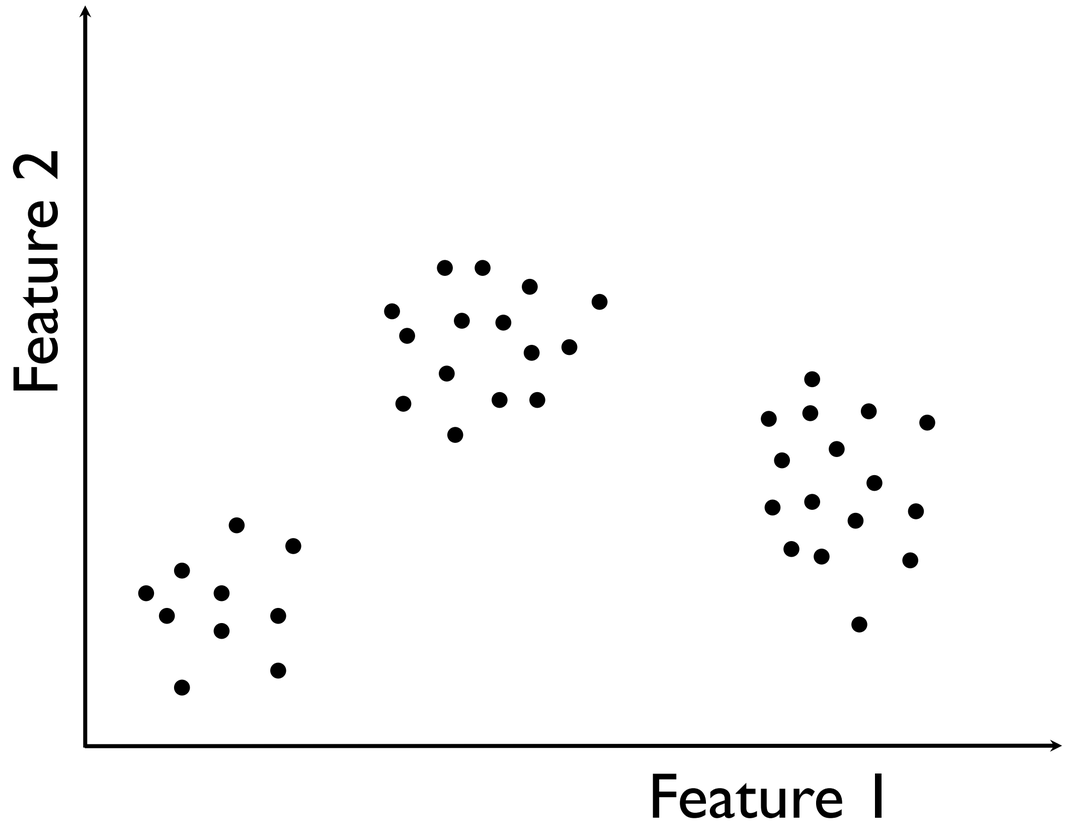

K-Means Algorithm

- Initialize K cluster centers

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centers = data.takeSample(
    false, K, seed)
```

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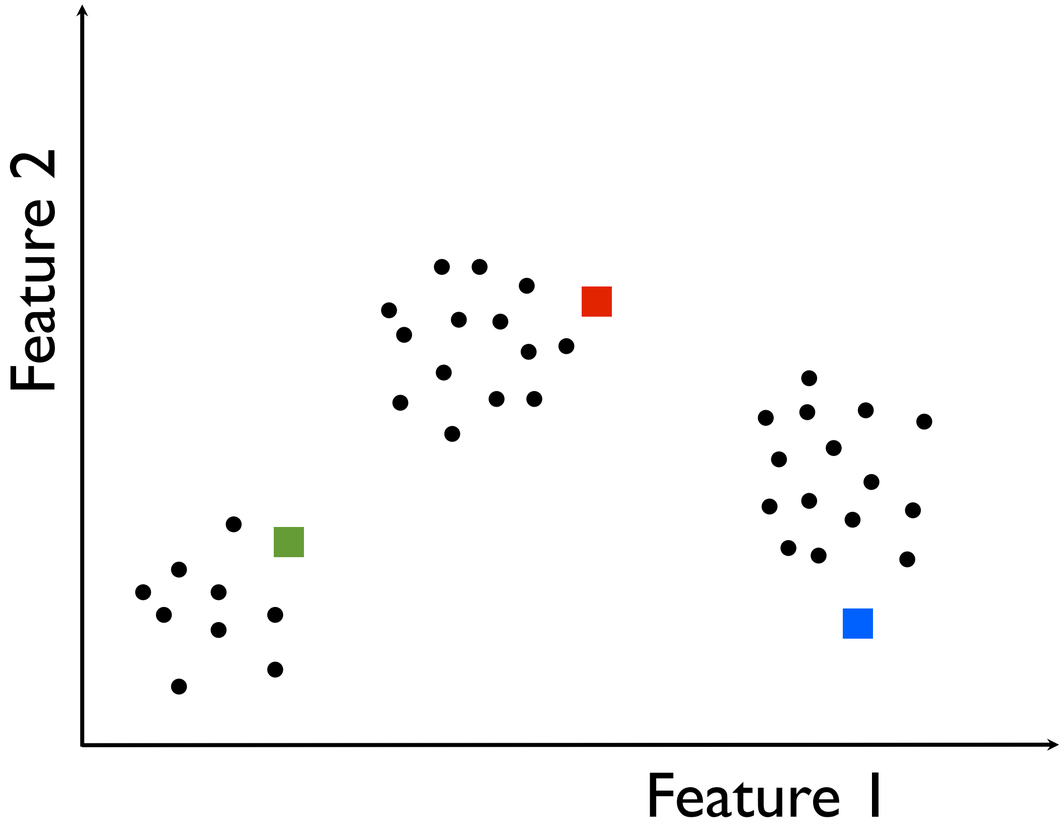

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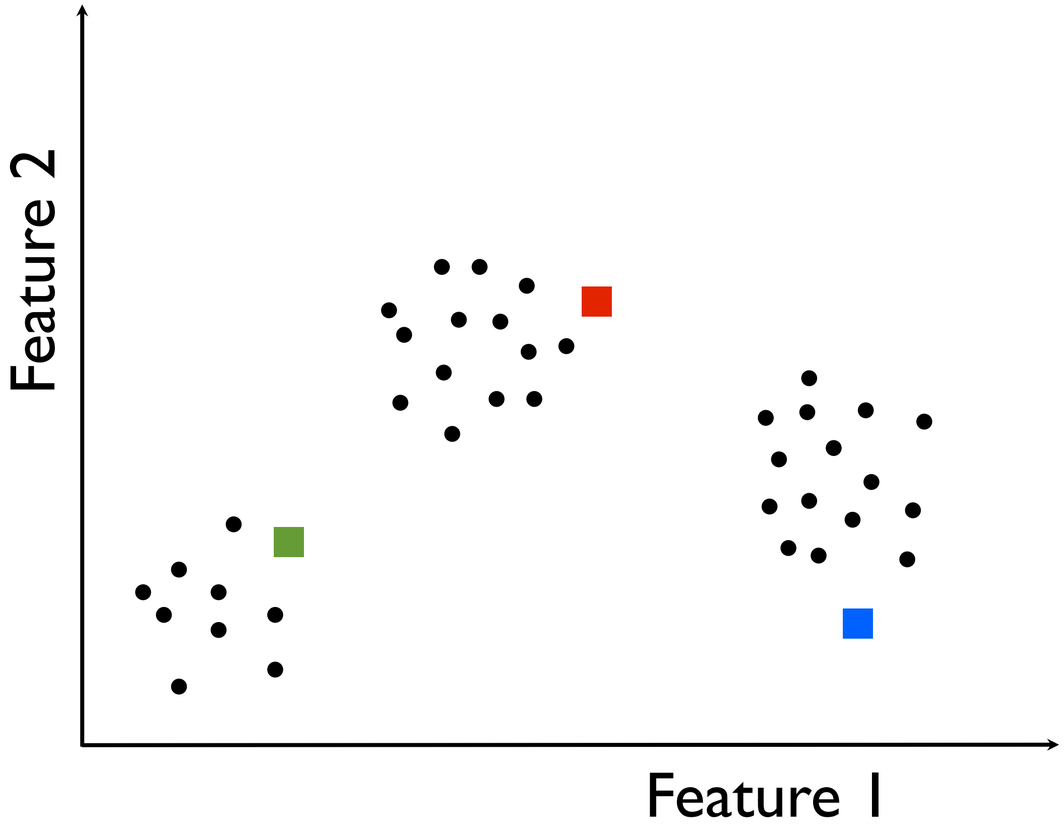

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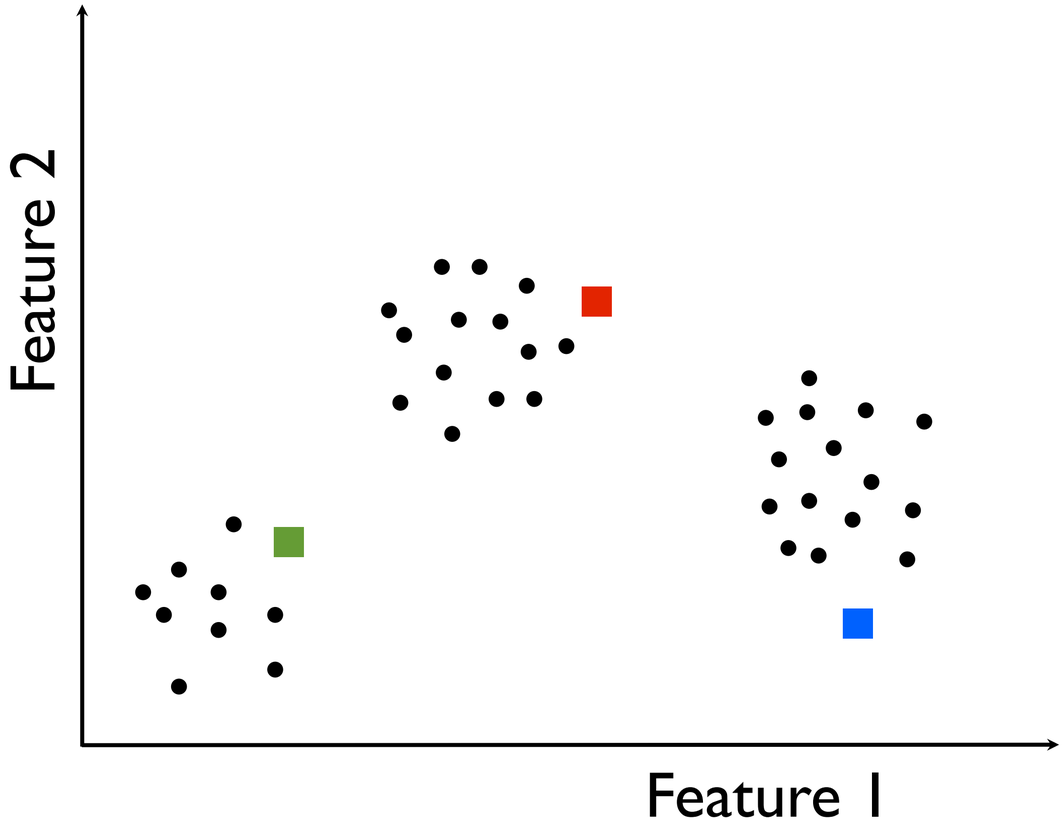

K-Means Algorithm

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closest = data.map(p =>
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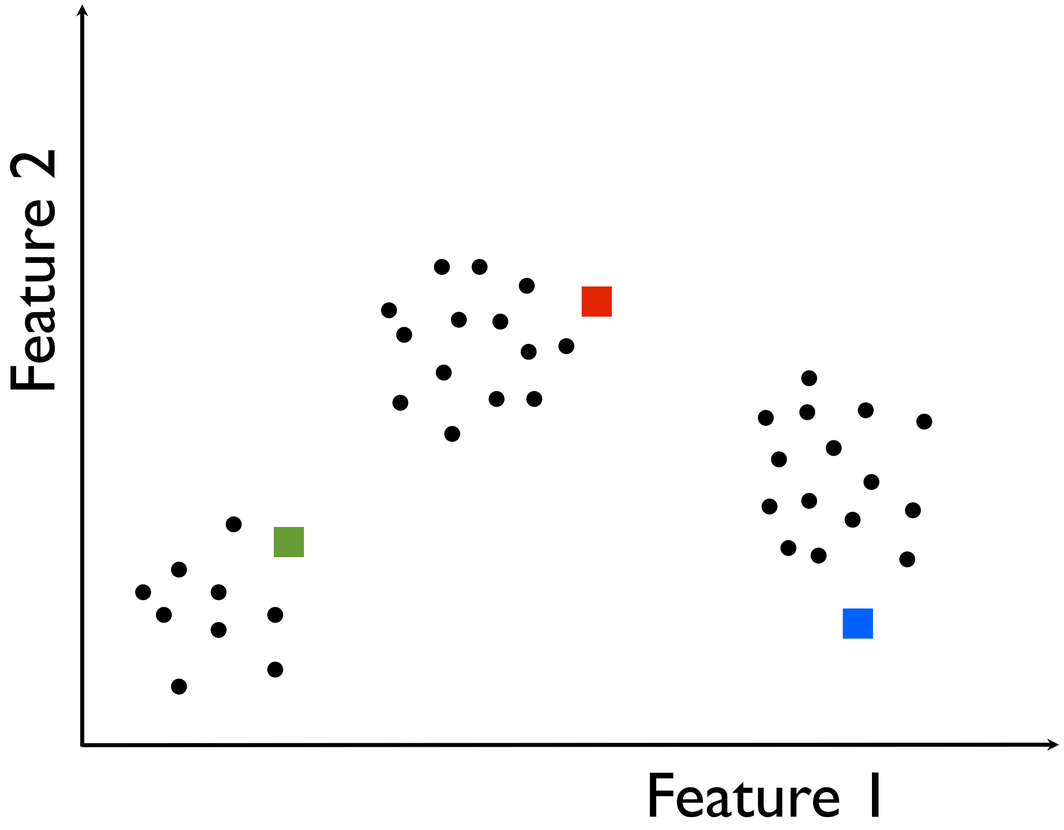

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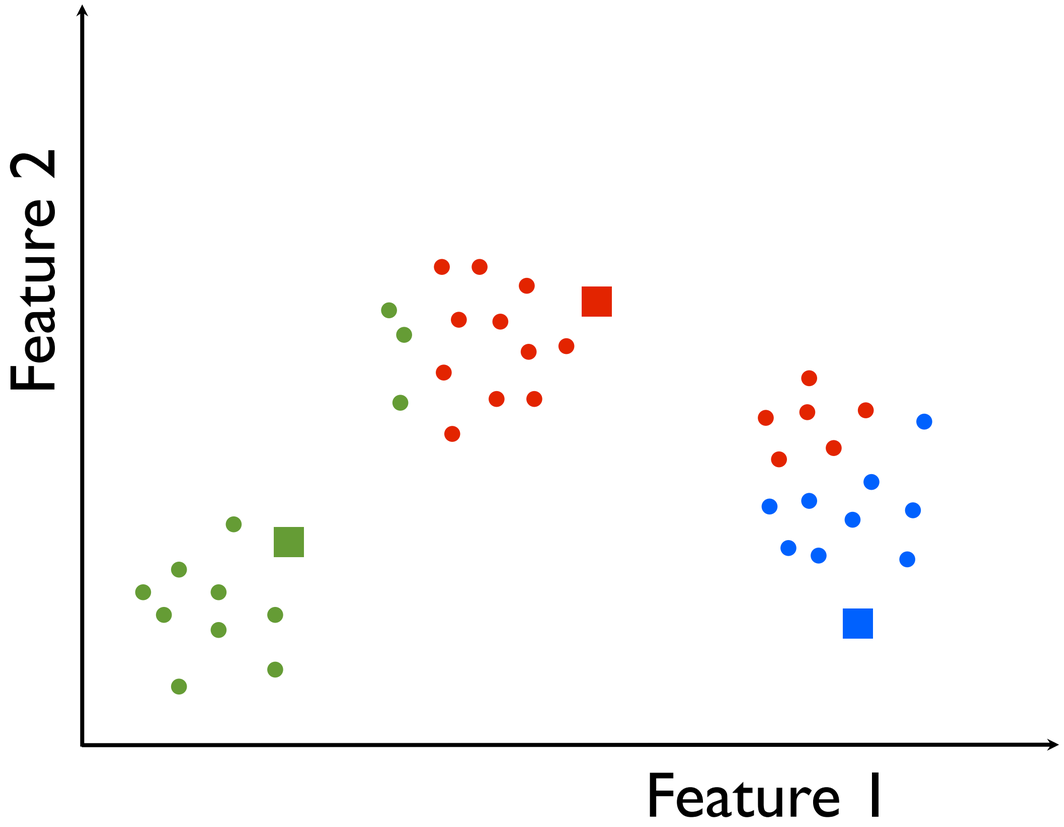

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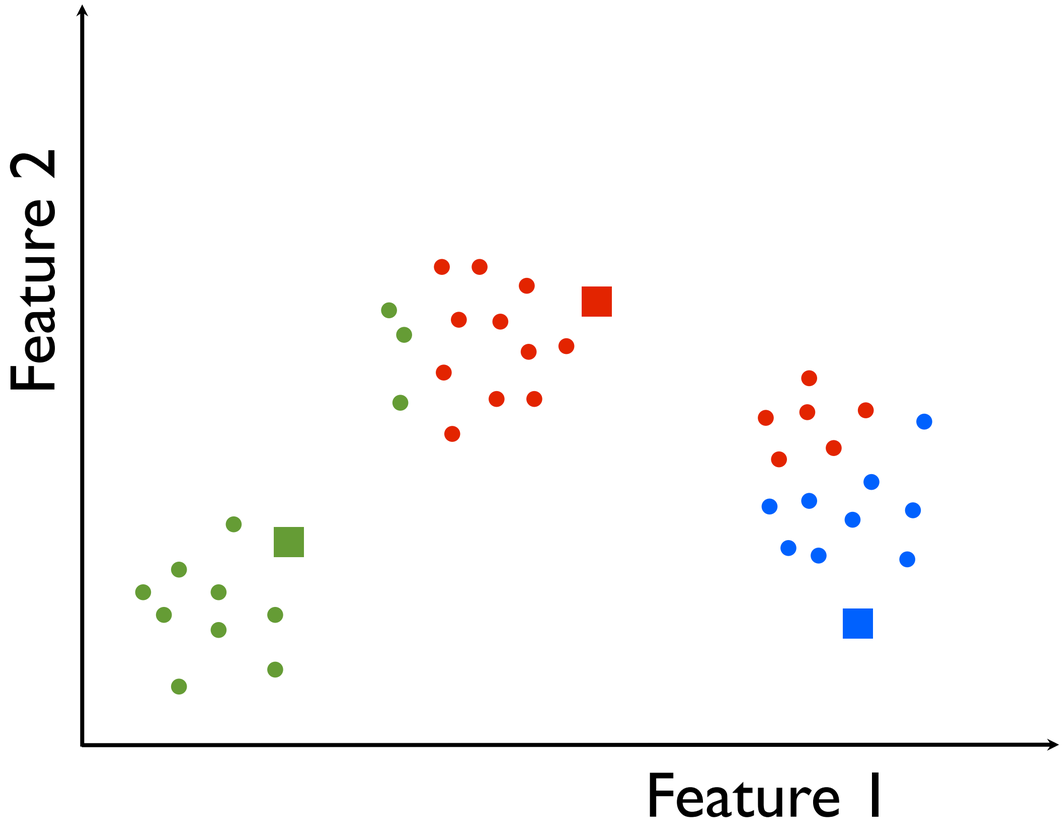

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pointsGroup =
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```

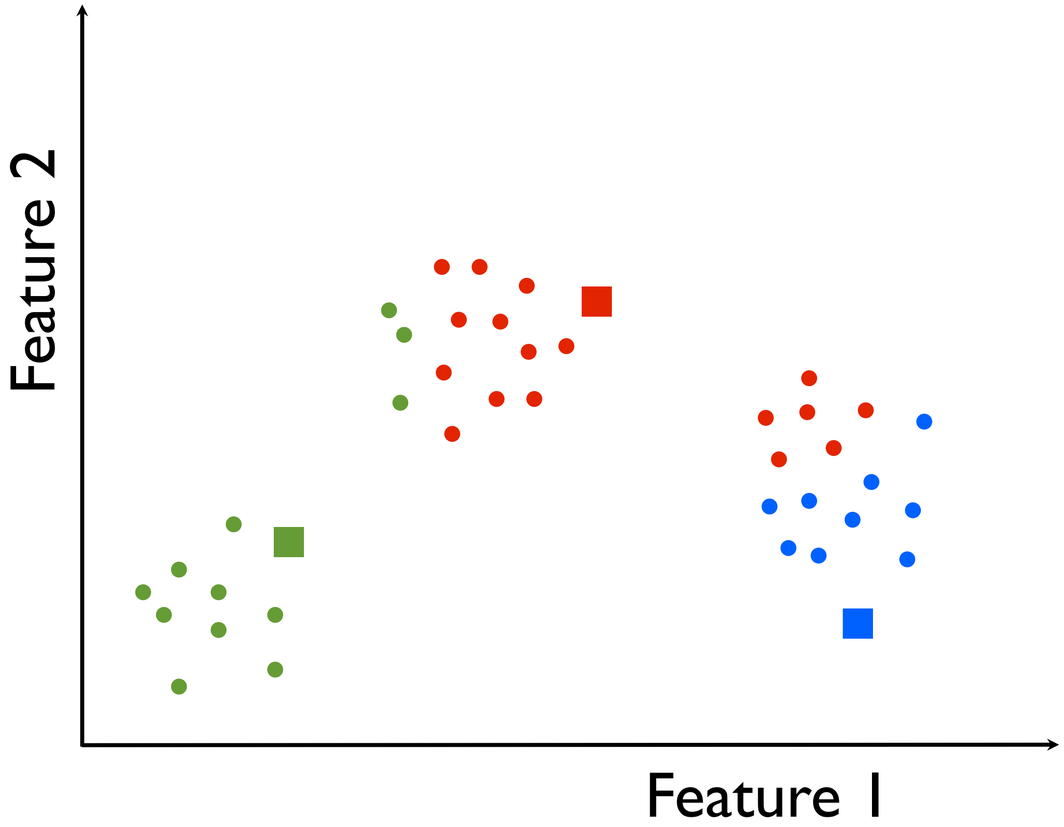

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pointsGroup =
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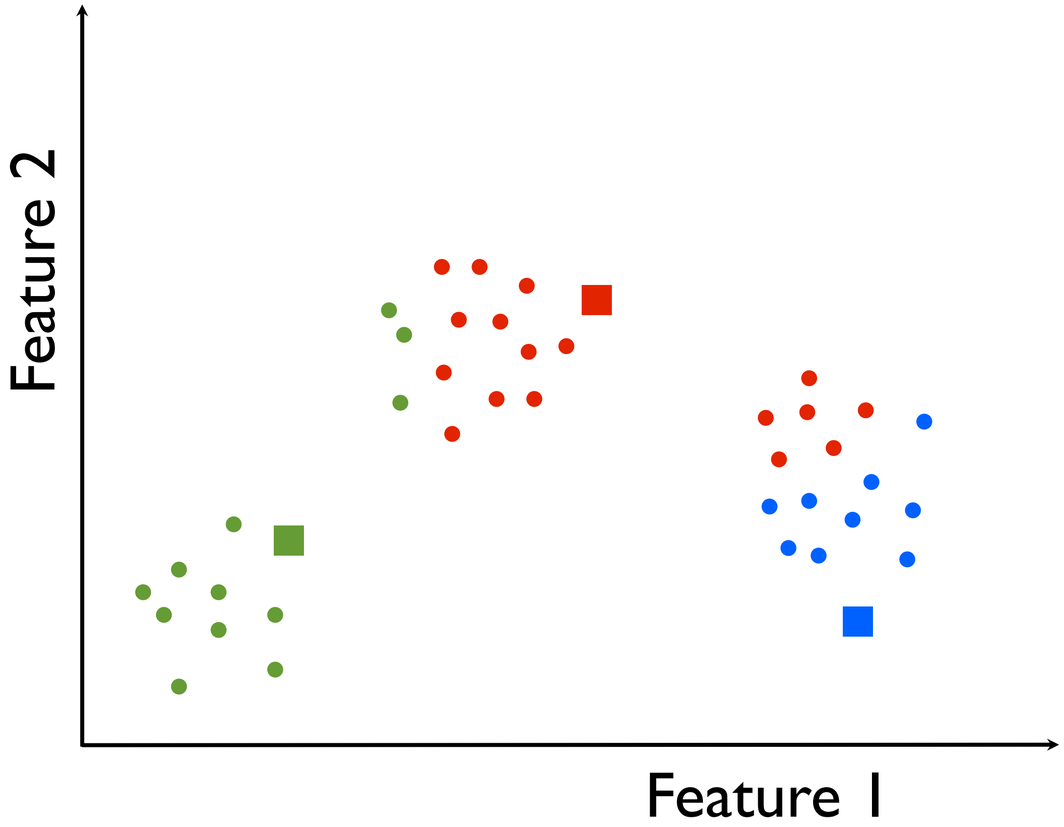
newCenters = pointsGroup.mapValues(
    ps => average(ps))
```



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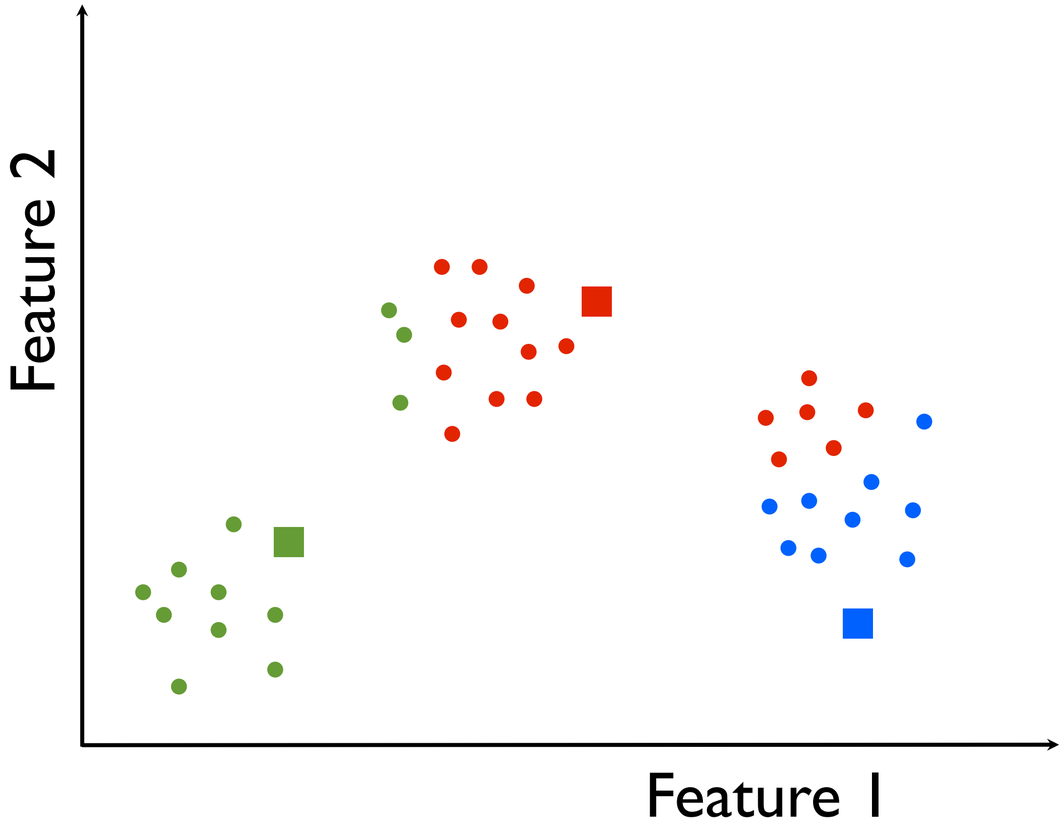

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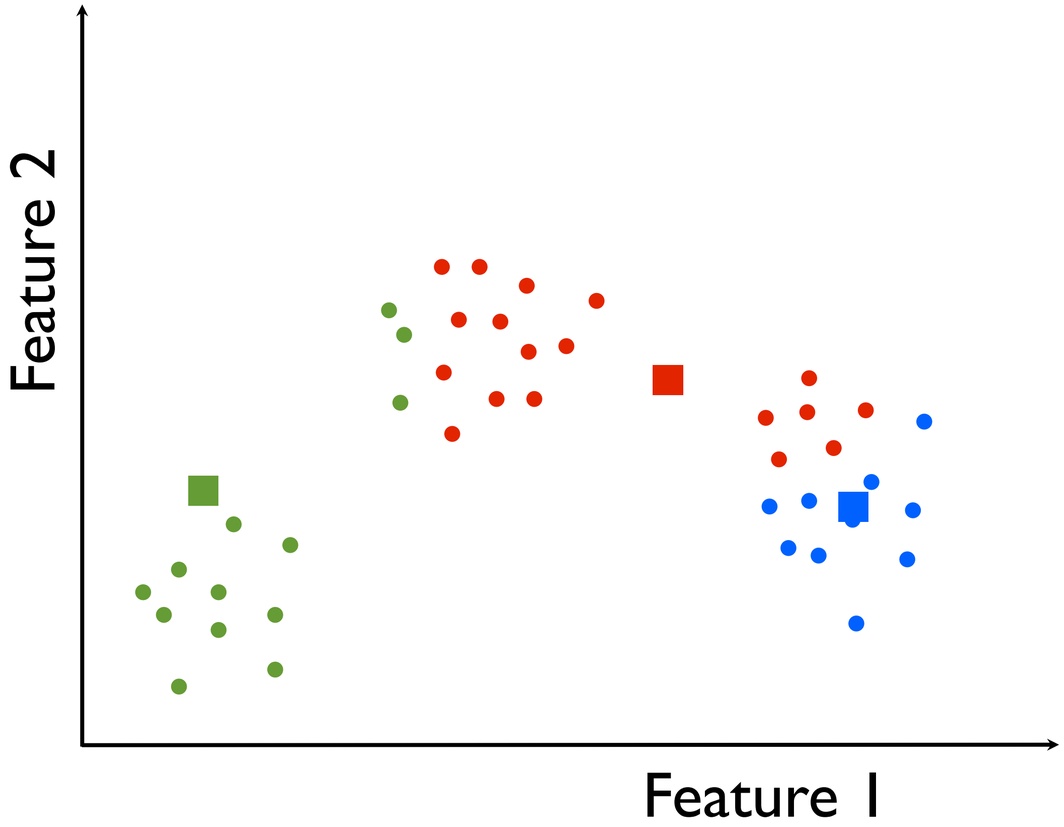

K-Means Algorithm

- Initialize K cluster centers

```
centers = data.takeSample(
    false, K, seed)
```

- Repeat until convergence:

```
while (dist(centers, newCenters) > ε)

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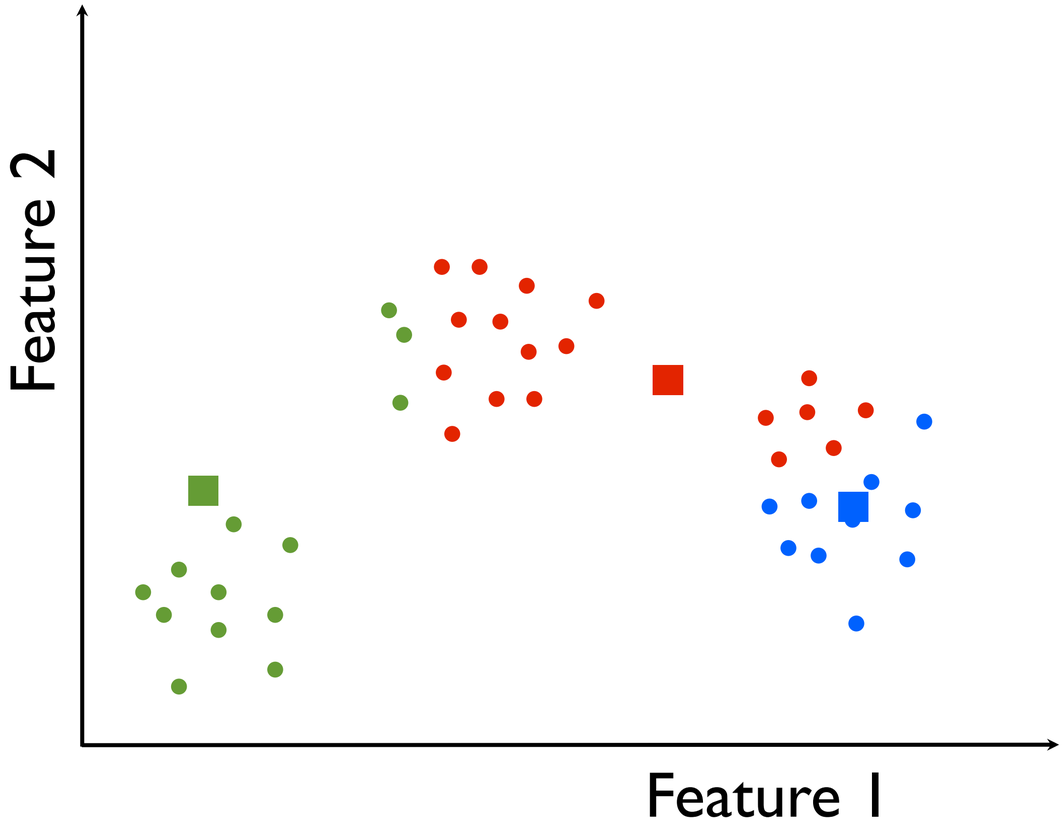

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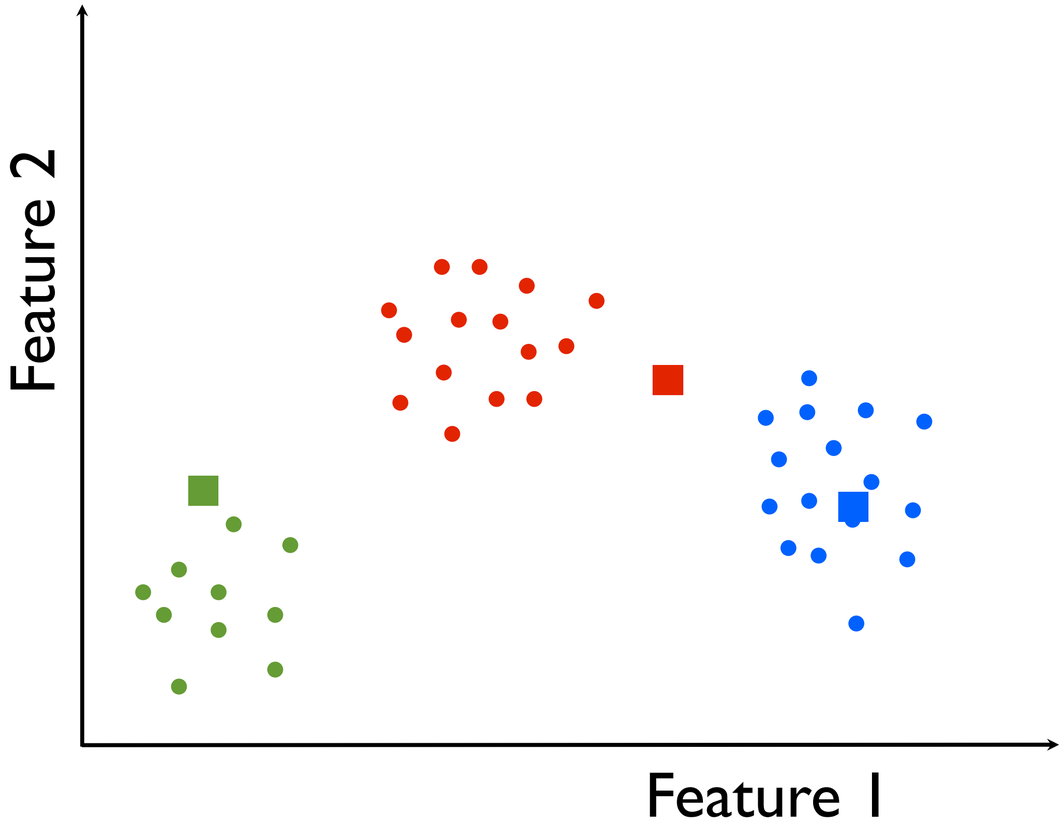
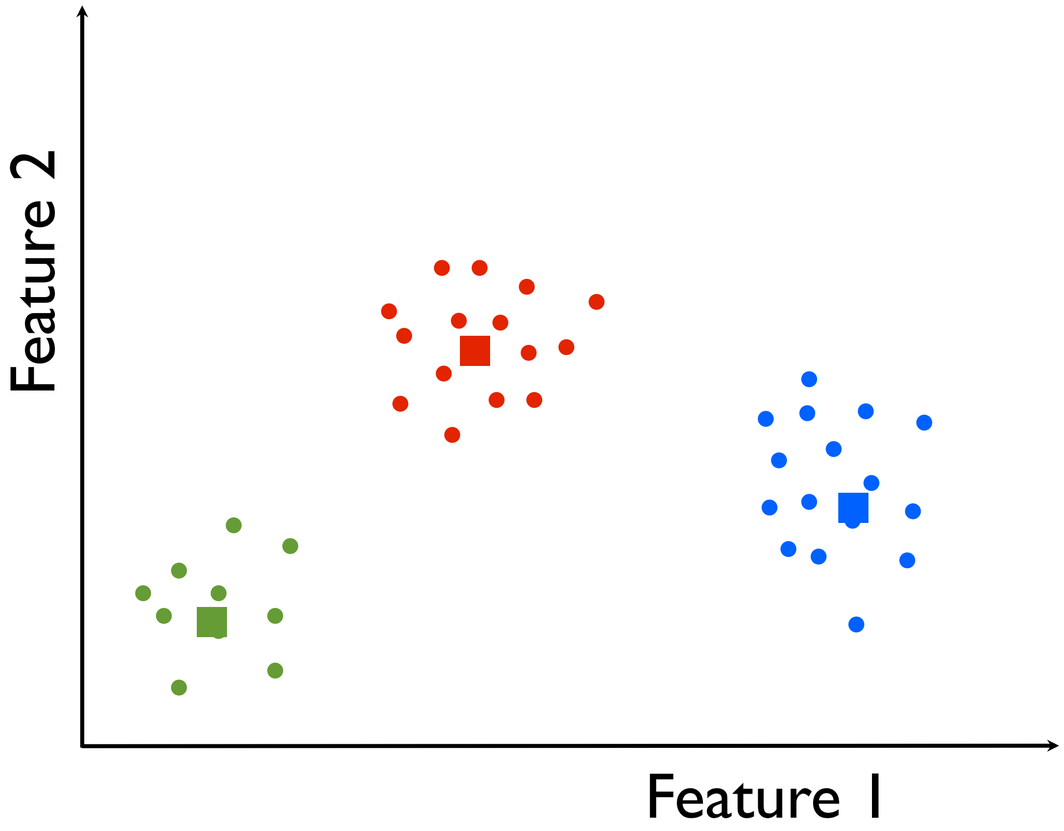


K-Means Source

```
centers = data.takeSample(
    false, K, seed)
while (d > ε)
{
 closest = data.map(p =>
     (closestPoint(p,centers),p))
 pointsGroup =
     closest.groupByKey()
 newCenters =pointsGroup.mapValues(
     ps => average(ps))
 d = distance(centers, newCenters)
 centers = newCenters.map(_)
}
```



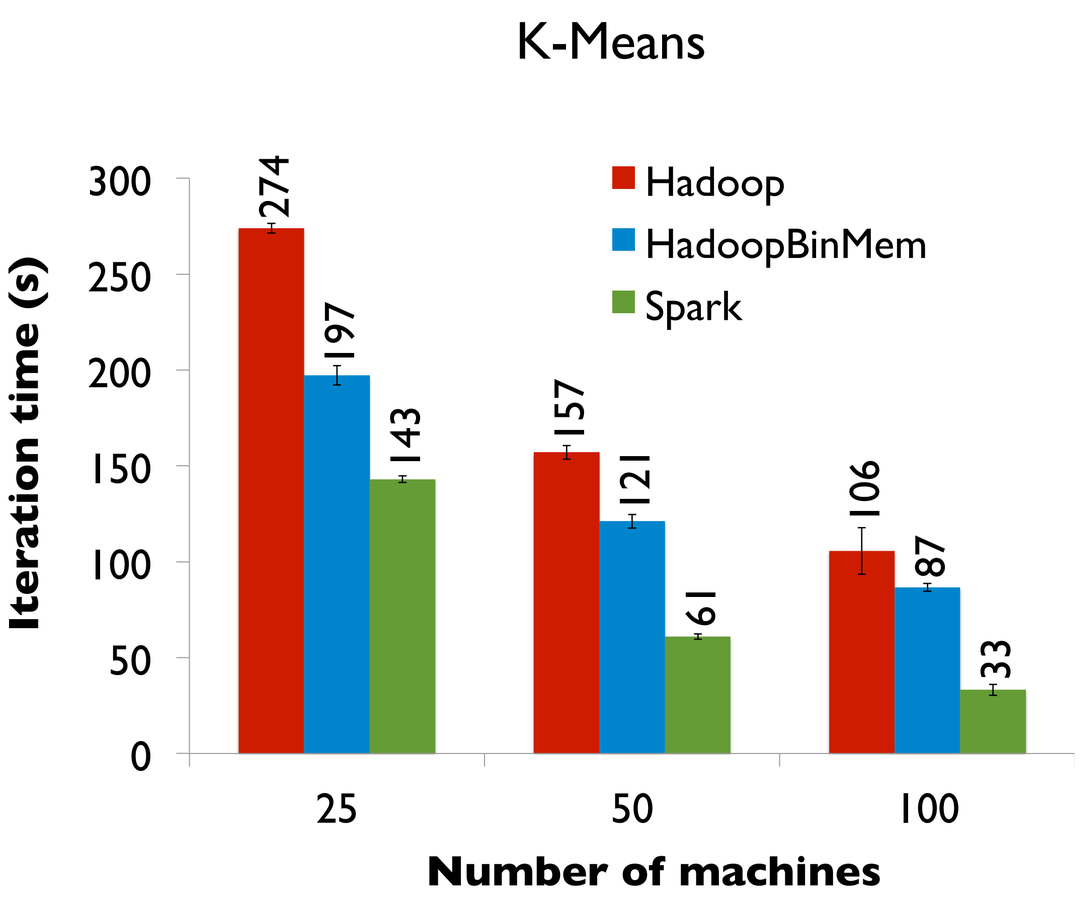
Ease of use

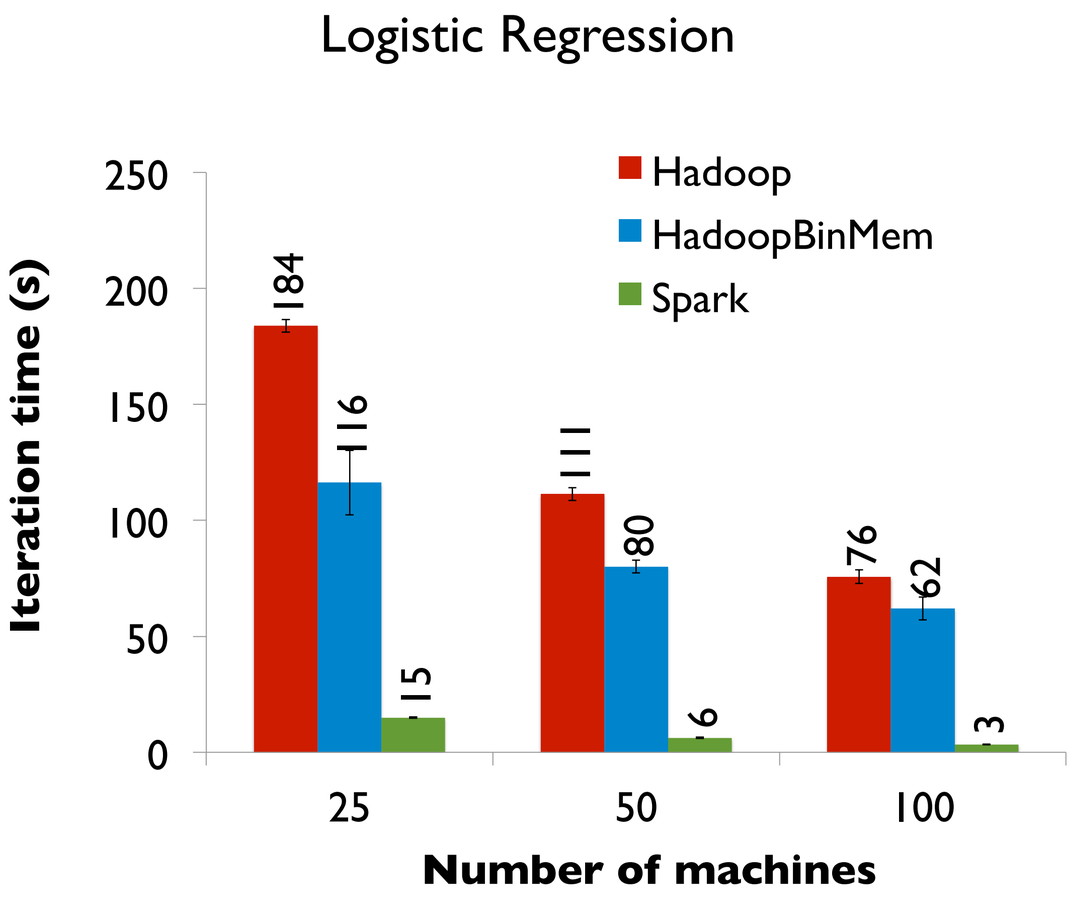
- Interactive shell:

  Useful for featurization, pre-processing data

- Lines of code for K-Means
  - Spark ~ 90 lines – (Part of hands-on tutorial !)
  - Hadoop/Mahout ~ 4 files, > 300 lines

Performance





[Zaharia et. al, NSDI'12]

Conclusion

- Spark: Framework for cluster computing
- Fast and easy machine learning programs

- K means clustering using Spark
- Hands-on exercise this afternoon !

Examples and more: www.spark-project.org