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Data Mining

NOVA-IMS

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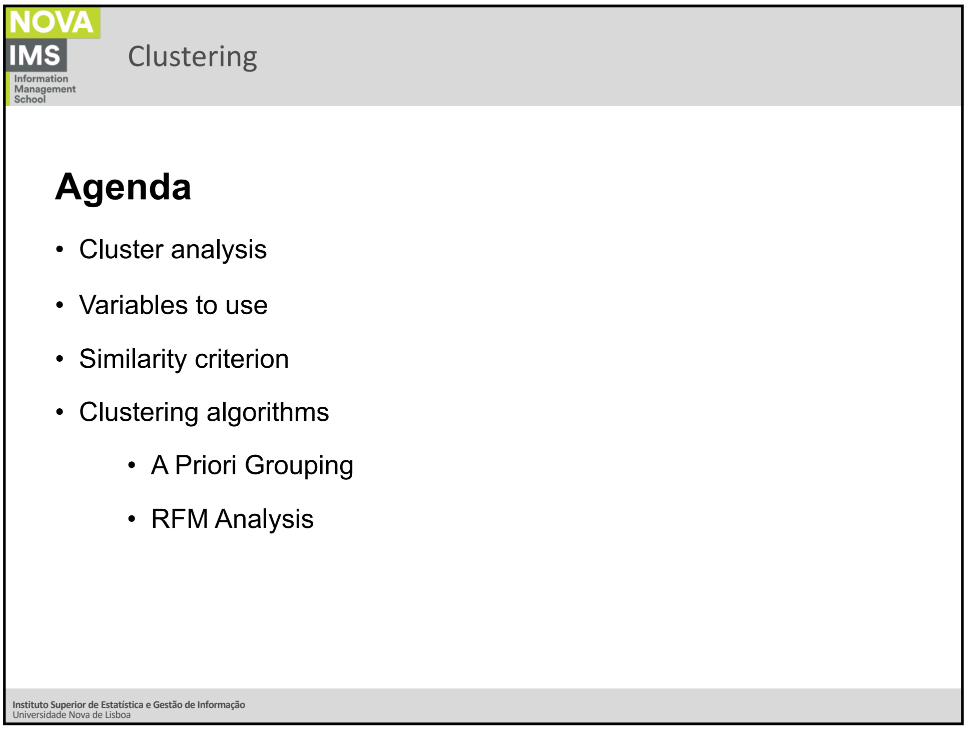

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Clustering

Agenda

- Cluster analysis
- Variables to use
- Similarity criterion
- Clustering algorithms
  - A Priori Grouping
  - RFM Analysis

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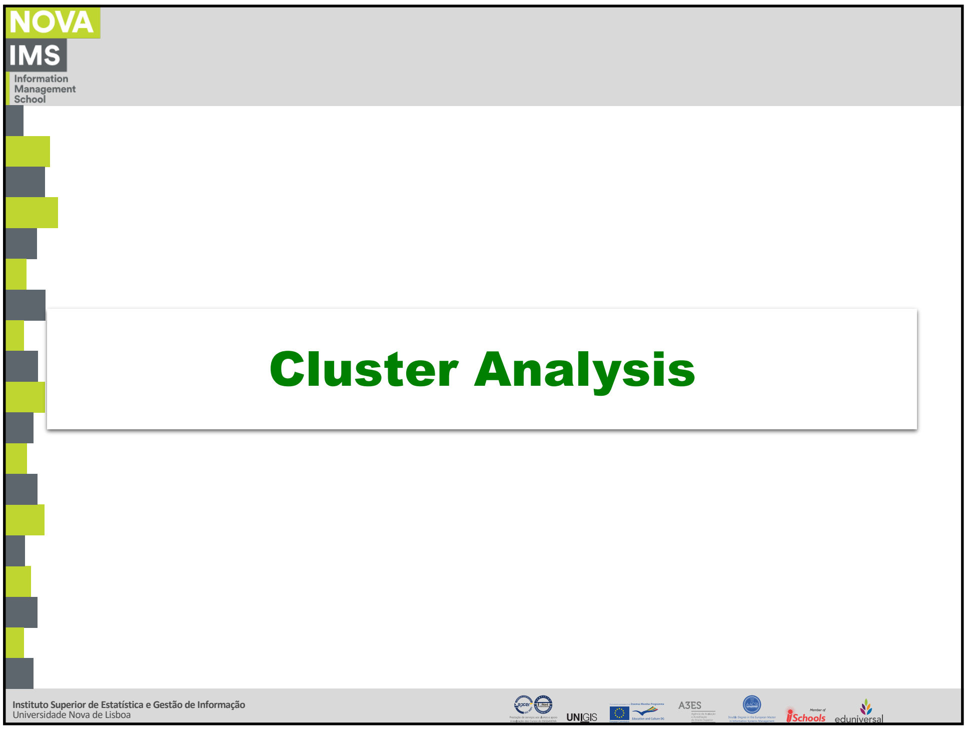

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Cluster Analysis

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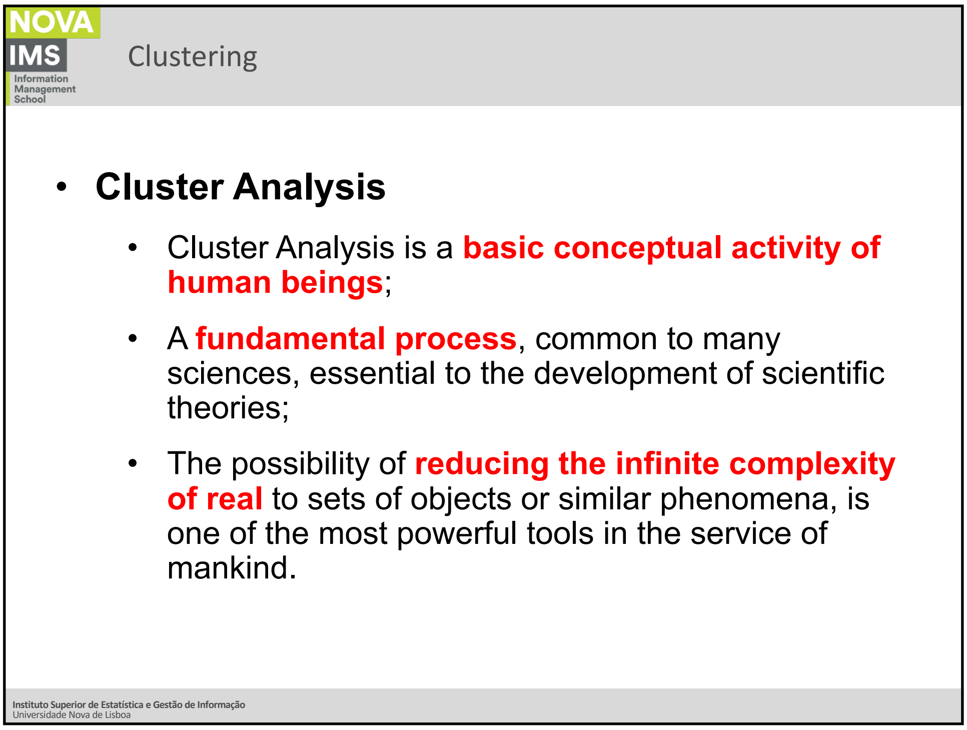

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Clustering

- **Cluster Analysis**
  - Cluster Analysis is a **basic conceptual activity of human beings**;
  - A **fundamental process**, common to many sciences, essential to the development of scientific theories;
  - The possibility of **reducing the infinite complexity of real** to sets of objects or similar phenomena, is one of the most powerful tools in the service of mankind.

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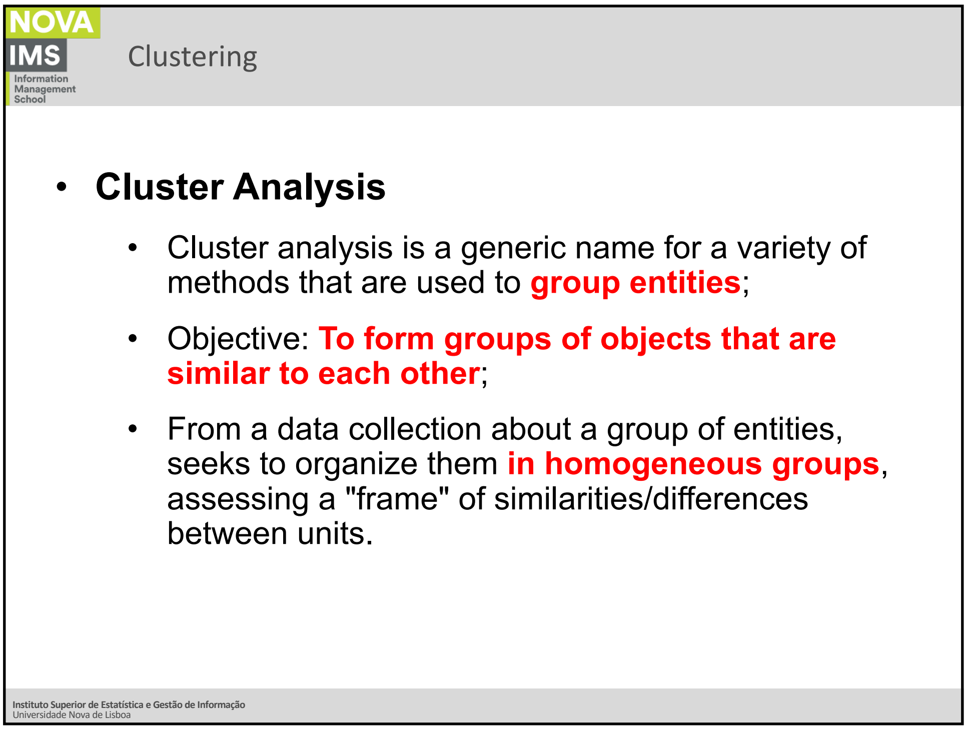

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Clustering

- **Cluster Analysis**
  - Cluster analysis is a generic name for a variety of methods that are used to **group entities**;
  - Objective: **To form groups of objects that are similar to each other**;
  - From a data collection about a group of entities, seeks to organize them **in homogeneous groups**, assessing a "frame" of similarities/differences between units.

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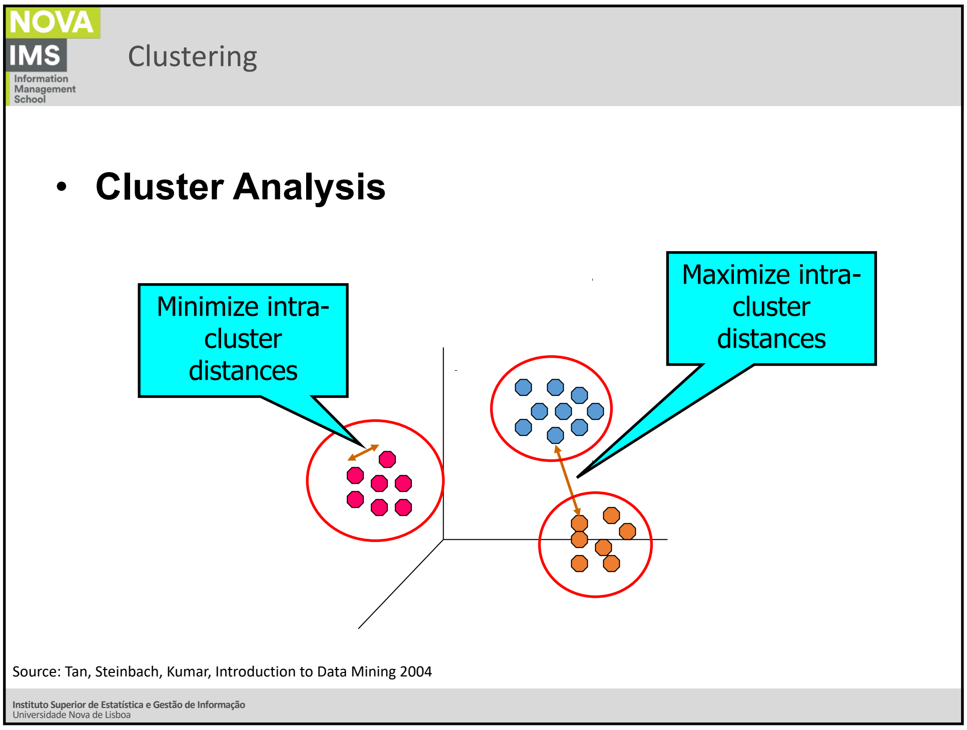

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Clustering

- **Cluster Analysis**

Minimize intra-cluster distances
Maximize intra-cluster distances

Source: Tan, Steinbach, Kumar, Introduction to Data Mining 2004

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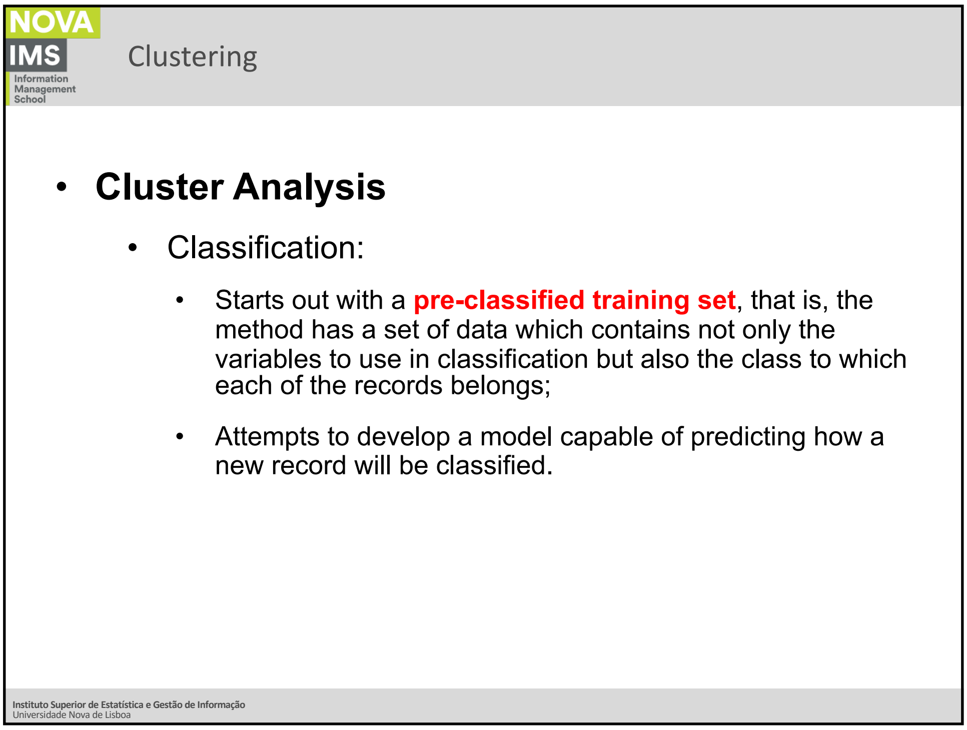

Clustering

- **Cluster Analysis**
  - Classification:
    - Starts out with a **pre-classified training set**, that is, the method has a set of data which contains not only the variables to use in classification but also the class to which each of the records belongs;
    - Attempts to develop a model capable of predicting how a new record will be classified.

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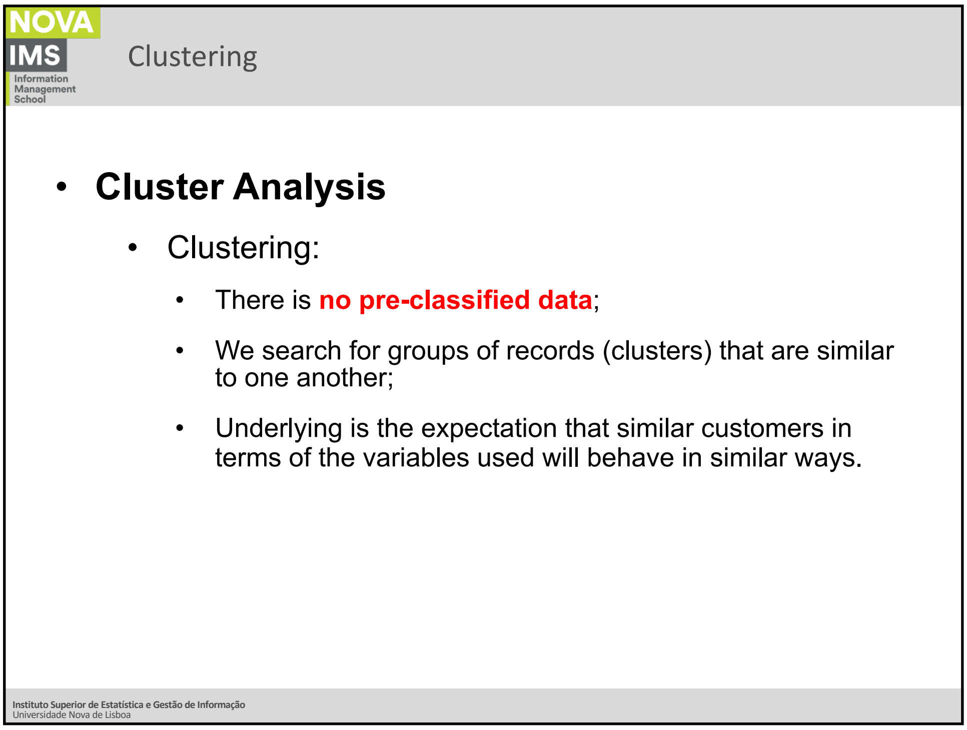

Clustering

- **Cluster Analysis**
  - Clustering:
    - There is **no pre-classified data**;
    - We search for groups of records (clusters) that are similar to one another;
    - Underlying is the expectation that similar customers in terms of the variables used will behave in similar ways.

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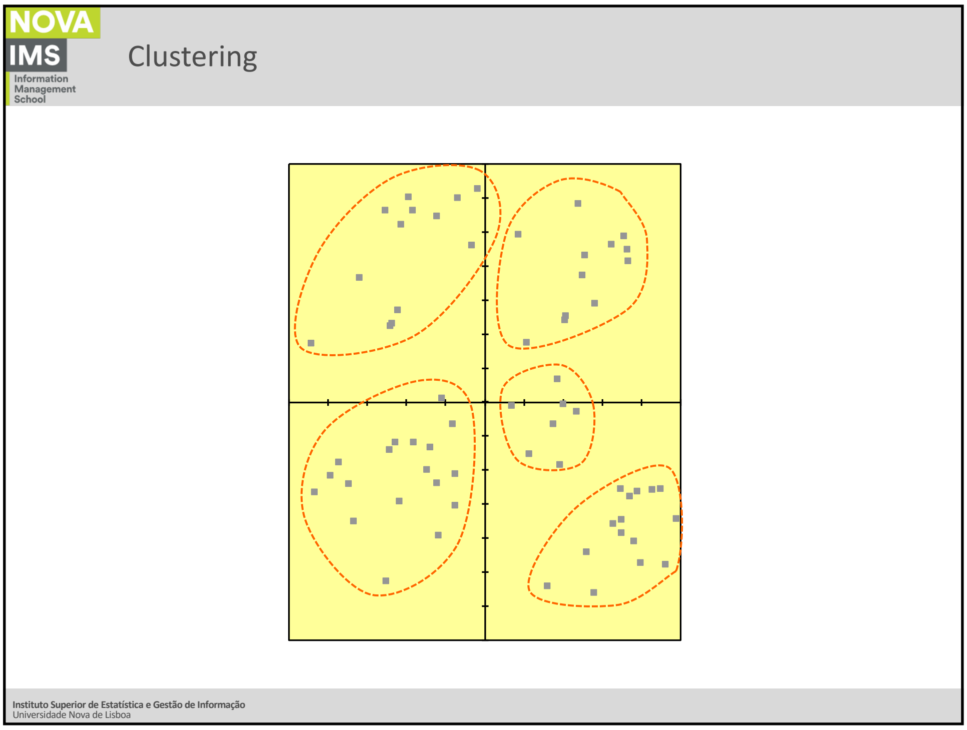

Clustering

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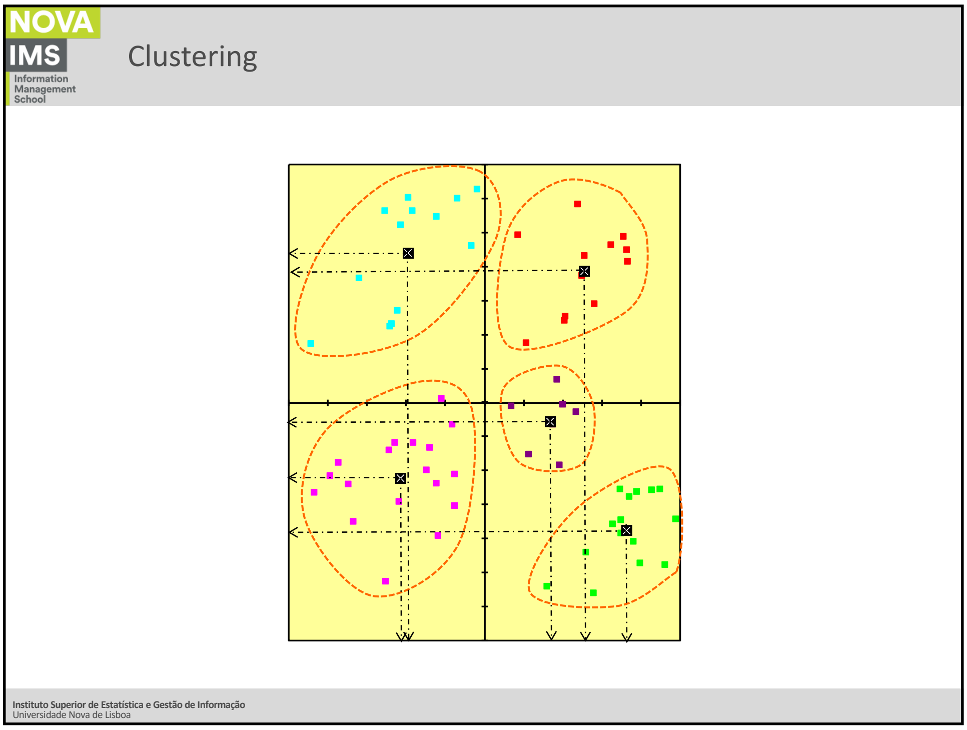

Clustering

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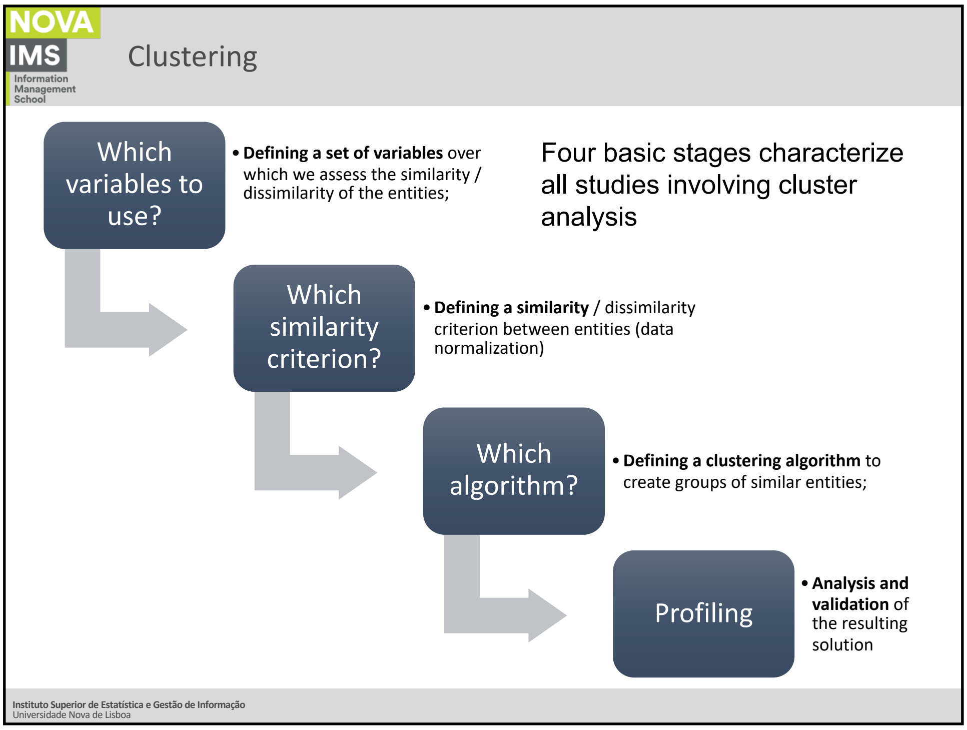

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Clustering

Four basic stages characterize all studies involving cluster analysis

- **Defining a set of variables** over which we assess the similarity / dissimilarity of the entities;
- **Defining a similarity** / dissimilarity criterion between entities (data normalization)
- **Defining a clustering algorithm** to create groups of similar entities;
- **Analysis and validation** of the resulting solution

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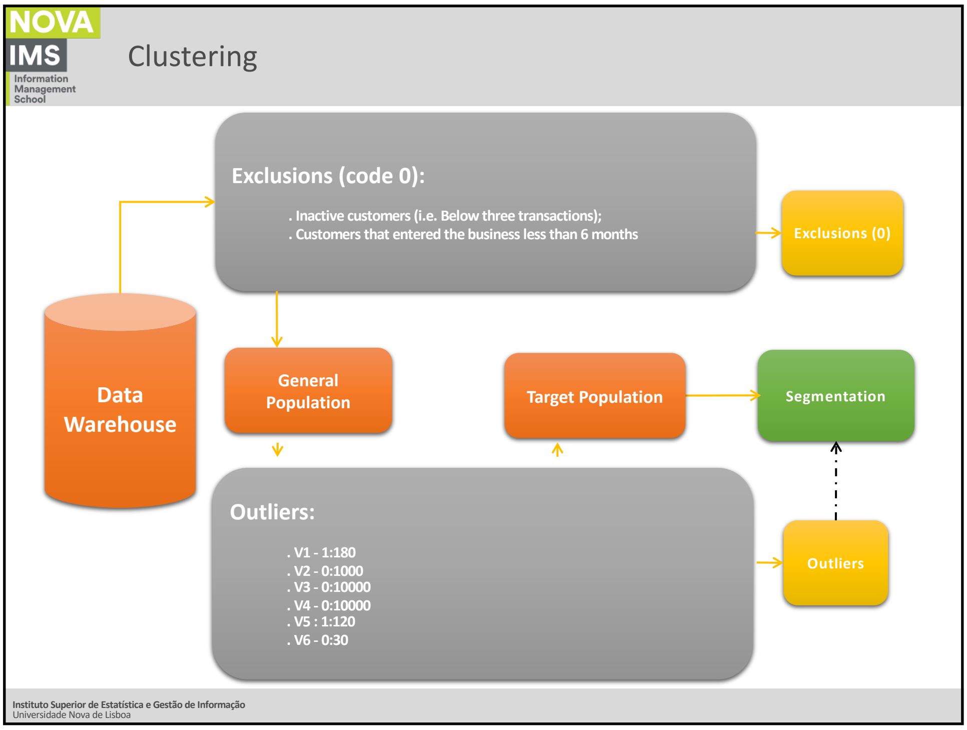

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Clustering

Exclusions (code 0):

- . Inactive customers (i.e. Below three transactions);
- . Customers that entered the business less than 6 months

Outliers:

- . V1 - 1:180
- . V2 - 0:1000
- . V3 - 0:10000
- . V4 - 0:10000
- . V5 : 1:120
- . V6 - 0:30

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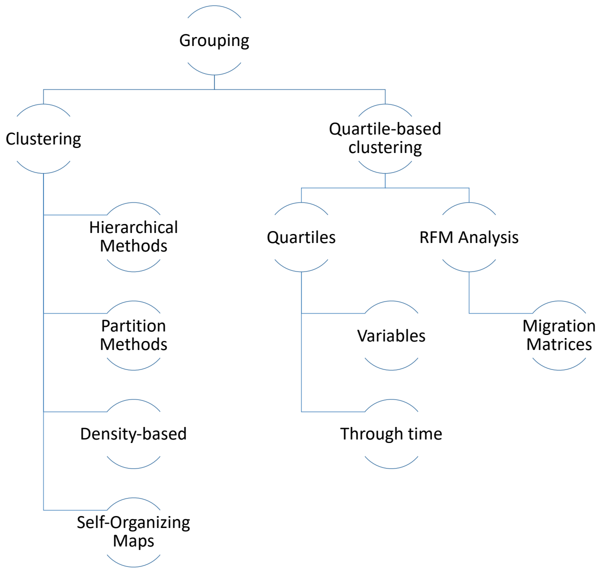
Clustering



Grouping

Clustering

- Hierarchical Methods
- Partition Methods
- Density-based
- Self-Organizing Maps

Quartile-based clustering

- Quartiles
  - Variables
  - Through time
- RFM Analysis
  - Migration Matrices

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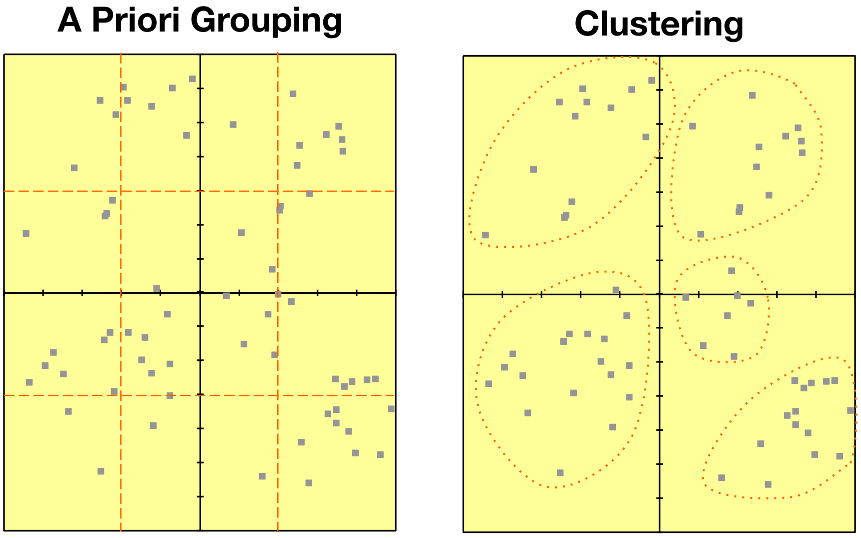
Clustering



A Priori Grouping

Clustering

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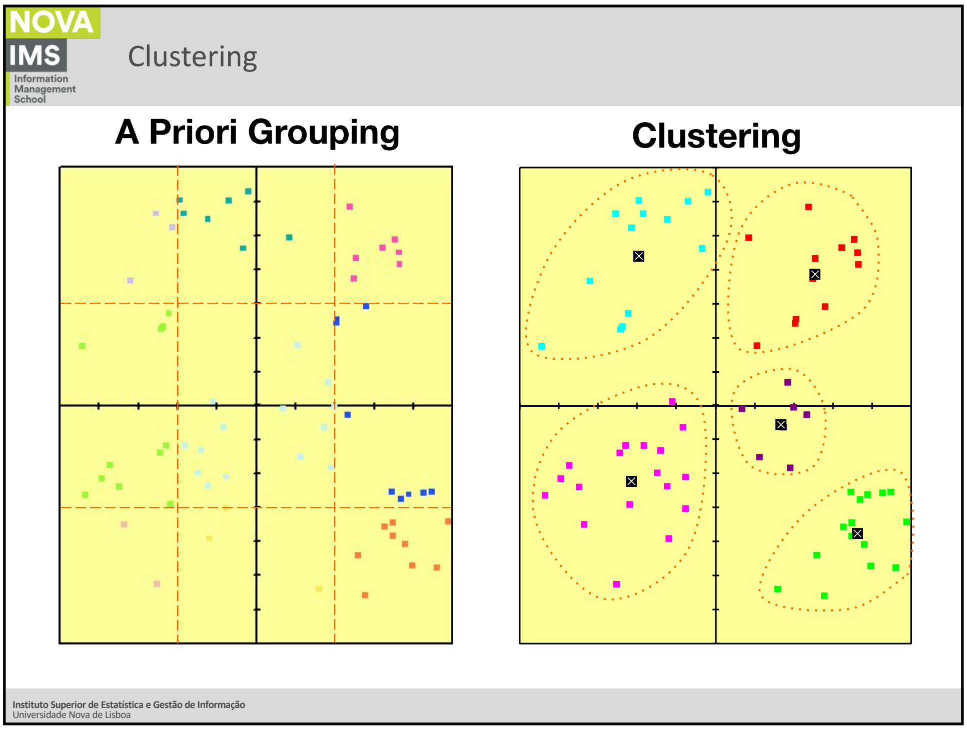

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Clustering

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Decide on the Variables to Use

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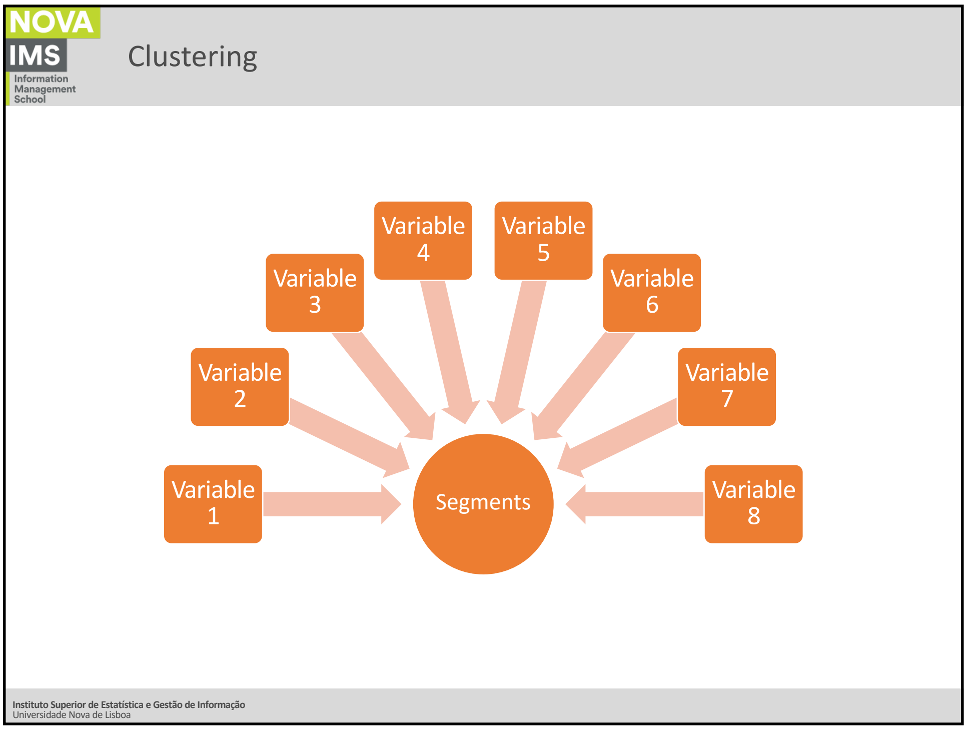

Clustering

Variable 1

Variable 2

Variable 3

Variable 4

Variable 5

Variable 6

Variable 7

Variable 8

Segments

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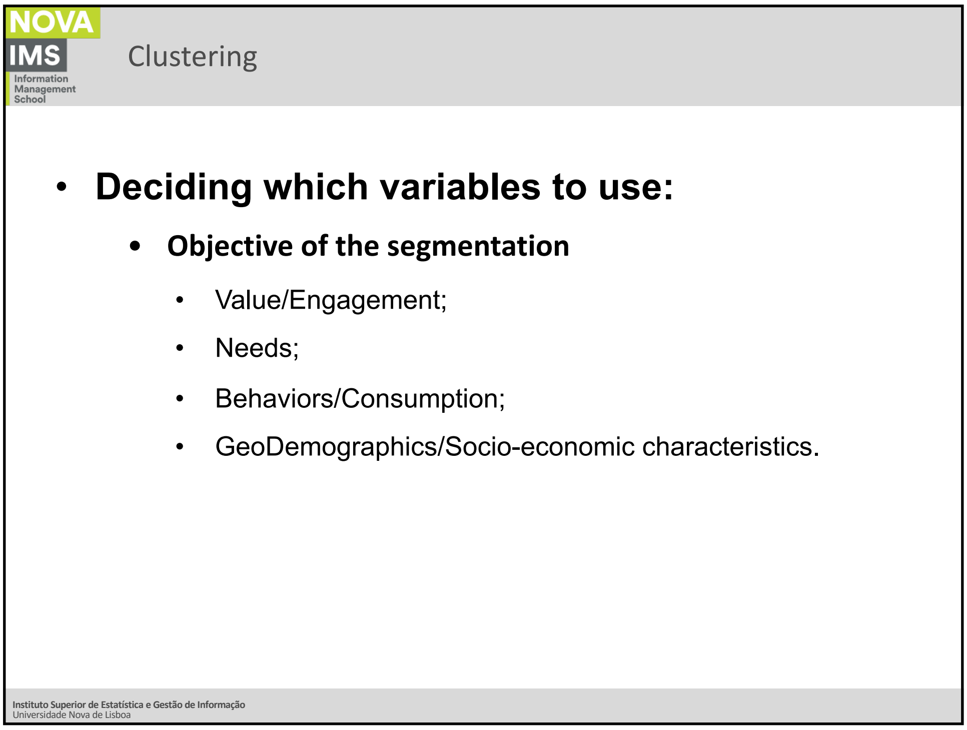

Clustering

- **Deciding which variables to use:**
  - **Objective of the segmentation**
    - Value/Engagement;
    - Needs;
    - Behaviors/Consumption;
    - GeoDemographics/Socio-economic characteristics.

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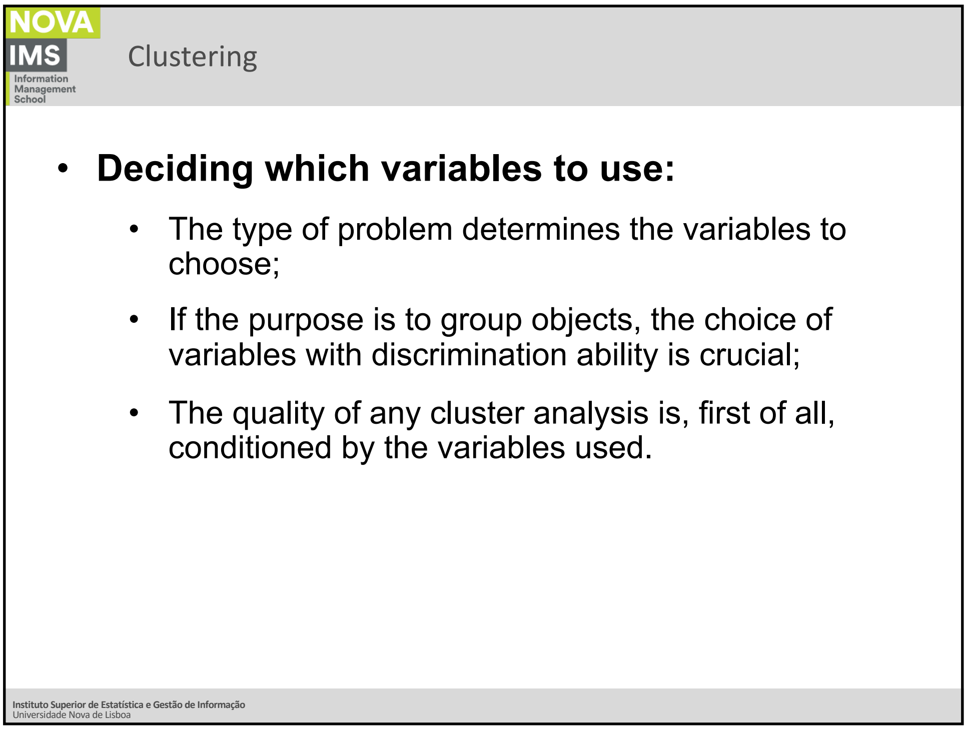

Clustering

- **Deciding which variables to use:**
  - The type of problem determines the variables to choose;
  - If the purpose is to group objects, the choice of variables with discrimination ability is crucial;
  - The quality of any cluster analysis is, first of all, conditioned by the variables used.

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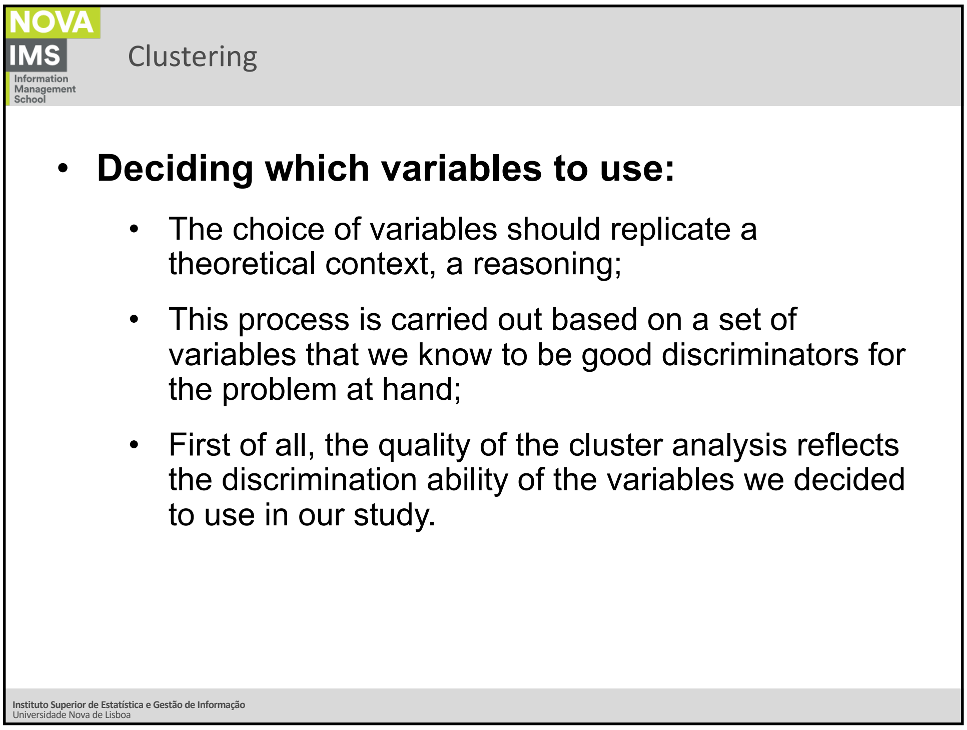

Clustering

- **Deciding which variables to use:**
  - The choice of variables should replicate a theoretical context, a reasoning;
  - This process is carried out based on a set of variables that we know to be good discriminators for the problem at hand;
  - First of all, the quality of the cluster analysis reflects the discrimination ability of the variables we decided to use in our study.

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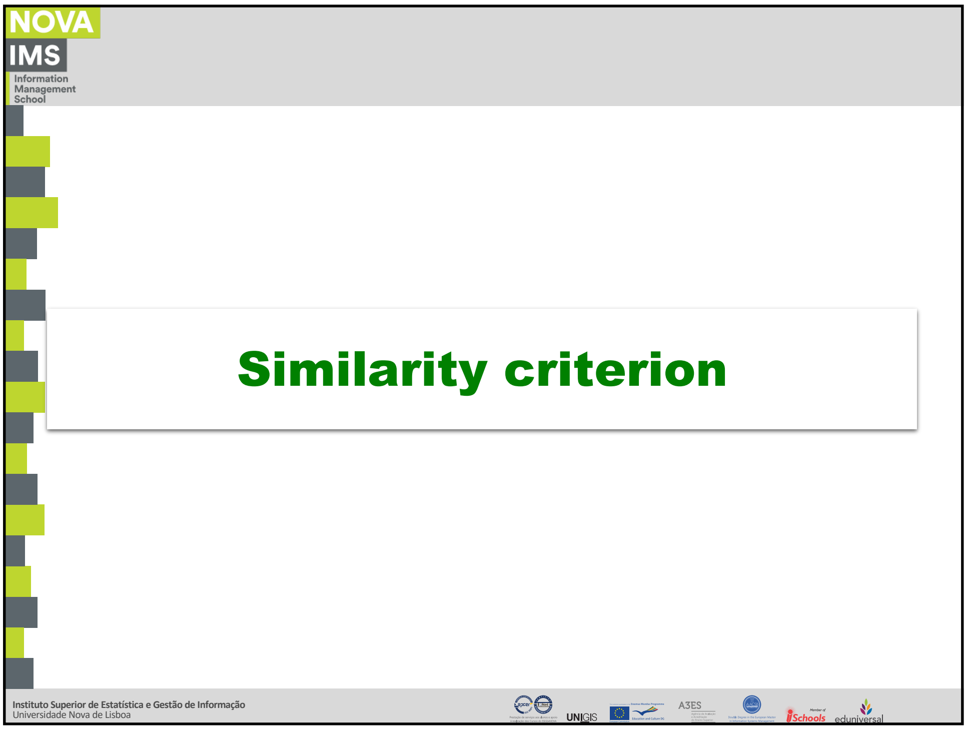

Similarity criterion

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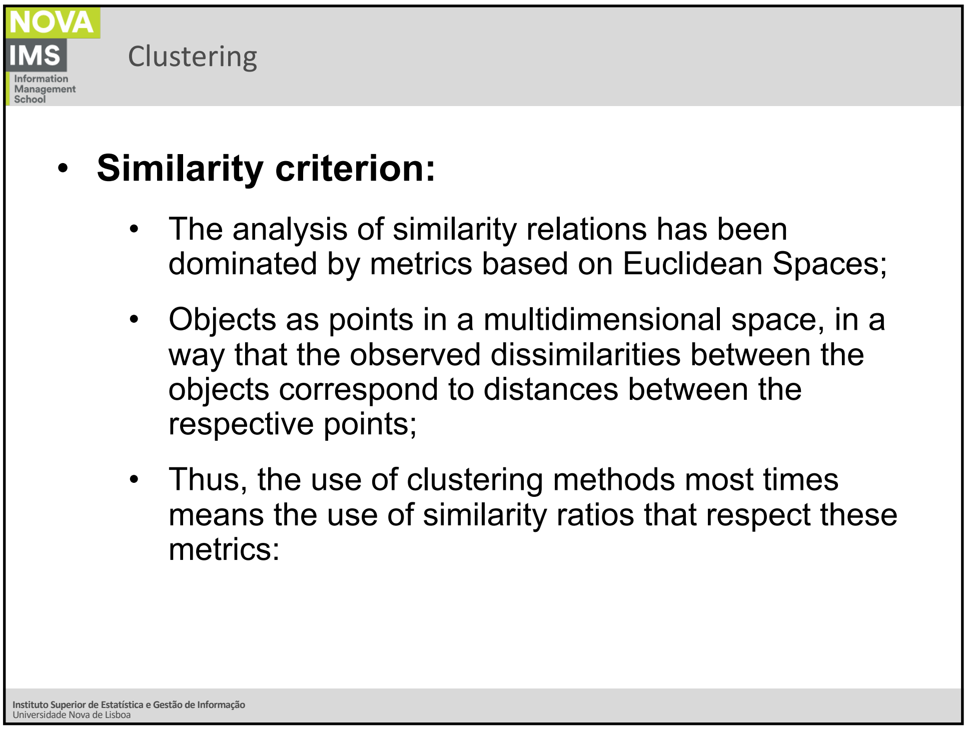

Clustering

- **Similarity criterion:**
  - The analysis of similarity relations has been dominated by metrics based on Euclidean Spaces;
  - Objects as points in a multidimensional space, in a way that the observed dissimilarities between the objects correspond to distances between the respective points;
  - Thus, the use of clustering methods most times means the use of similarity ratios that respect these metrics:

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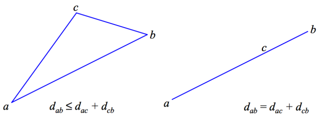
Clustering

- **Similarity criterion:**

- In mathematics, a true measure of distance, called a *metric*, obeys three properties. These metric axioms are as follows, where d_{ab} denotes the distance between objects *a* and *b*:

  1. $d_{ab} = d_{ba}$ *(measure is symmetric)*
  2. $d_{ab} \geq 0$ and = 0 if and only if $a = b$ *(distances are always positive except when the objects are identical)*
  3. $d_{ab} \leq d_{ac} + d_{ca}$ *(triangle inequality)*

Exhibit 5.1 Illustration of the triangle inequality for distances in Euclidean space.



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Clustering

- **Similarity criterion:**

- Euclidian distance: the distance between two elements (*i,j*) is the square root of the sum of the squares of the differences between *i* and *j* values for all variables (*v=1, 2,...., p*):

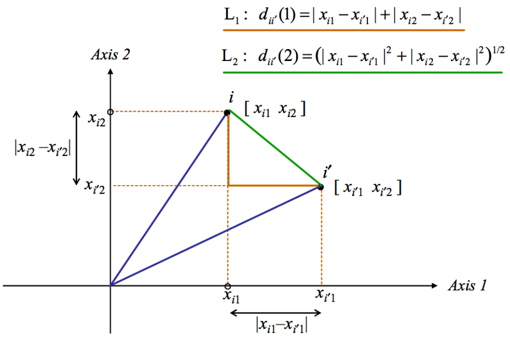
$$d_{ij} = \sqrt{\sum_{v=1}^{p} \left(X_{iv} - X_{jv}\right)^2} \, euclidean\, also\, known\, as\ L_2$$

$$d_{ij} = \sum_{v=1}^{p} \left|X_{iv} - X_{jv}\right| City\, Block\, or\, L_1$$

Clustering

- **Similarity criterion:**

- Euclidian distance: the distance between two elements (*i,j*) is the square root of the sum of the squares of the differences between *i* and *j* values for all variables (*v=1, 2,...., p*):



$$L_1:\ d_{ii'}(1) = |x_{i1} - x_{i'1}| + |x_{i2} - x_{i'2}|$$

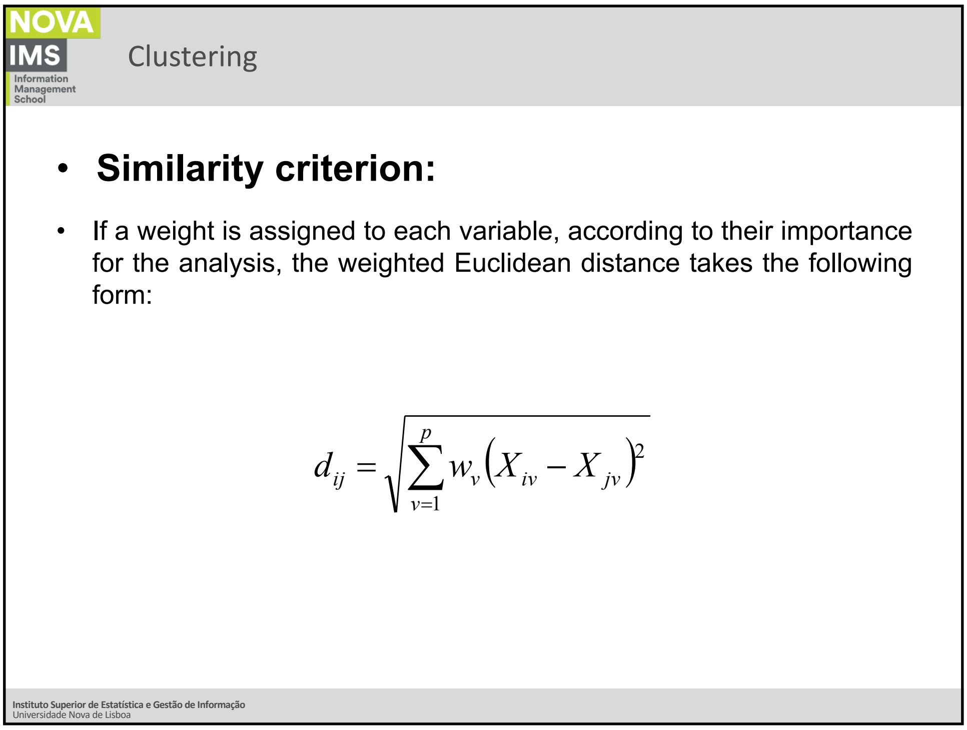
$$L_2:\ d_{ii'}(2) = (|x_{i1} - x_{i'1}|^2 + |x_{i2} - x_{i'2}|^2)^{1/2}$$

Clustering

- **Similarity criterion:**

- Minkowski distance: is defined from the absolute distance, and can be considered as a generalization of both the Euclidean distance and the Manhattan distance. It coincides with Euclidean distance when *r=2* and with Manhattan distance when *r=1*:

$$d_{ij} = \left(\sum_{v=1}^{p} \left| X_{iv} - X_{jv} \right|^{r} \right)^{1/r}$$



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Clustering

- **Similarity criterion:**
  - If a weight is assigned to each variable, according to their importance for the analysis, the weighted Euclidean distance takes the following form:

$$d_{ij} = \sqrt{\sum_{v=1}^{p} w_v \left(X_{iv} - X_{jv}\right)^2}$$

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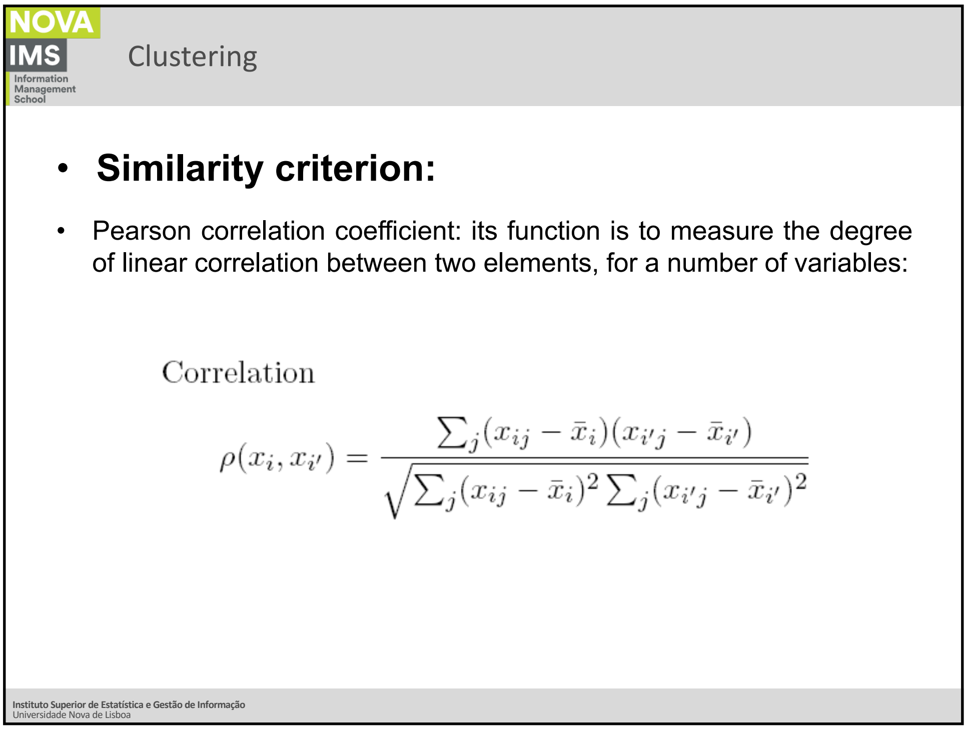

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Clustering

- **Similarity criterion:**
  - Pearson correlation coefficient: its function is to measure the degree of linear correlation between two elements, for a number of variables:

Correlation

$$\rho(x_i, x_{i'}) = \frac{\sum_j (x_{ij} - \bar{x}_i)(x_{i'j} - \bar{x}_{i'})}{\sqrt{\sum_j (x_{ij} - \bar{x}_i)^2 \sum_j (x_{i'j} - \bar{x}_{i'})^2}}$$

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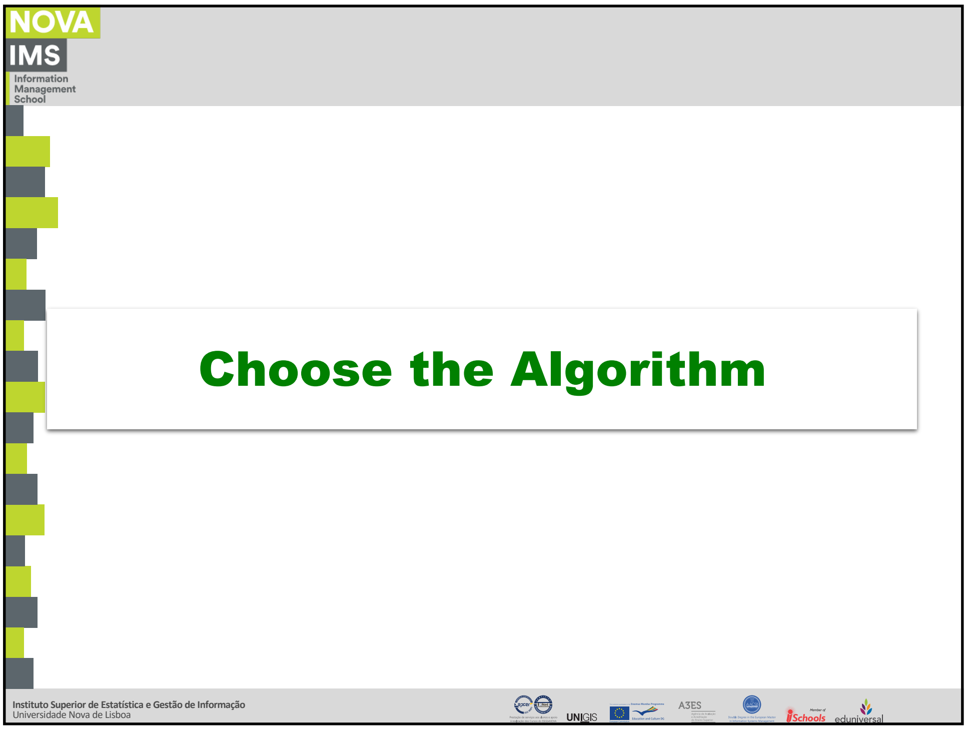

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Choose the Algorithm

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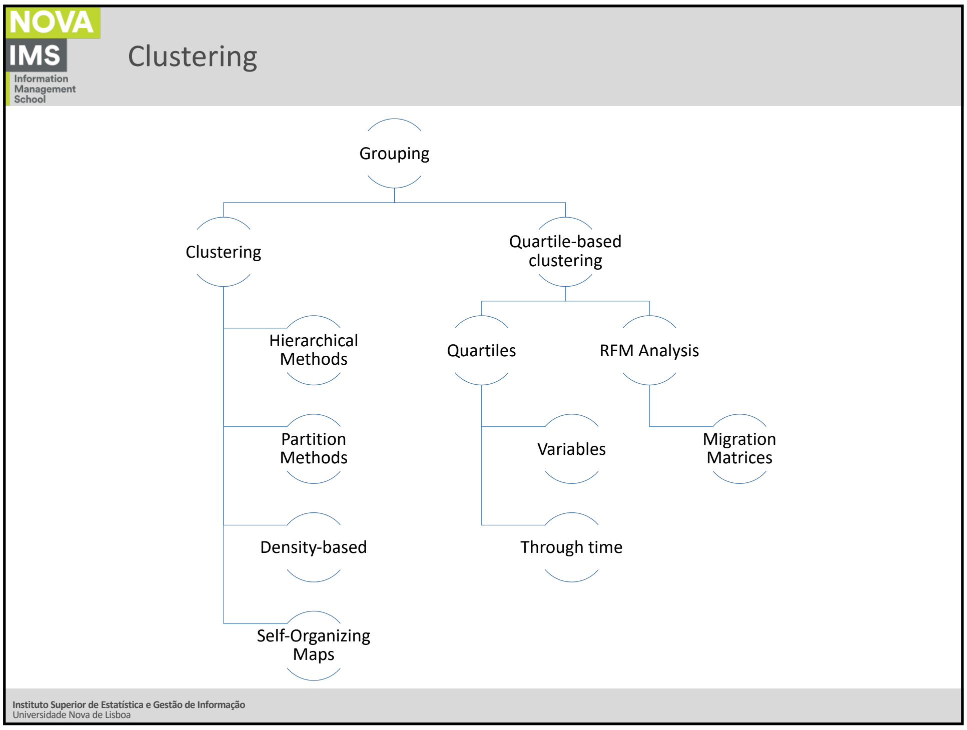

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Clustering

- Grouping
  - Clustering
    - Hierarchical Methods
    - Partition Methods
    - Density-based
    - Self-Organizing Maps
  - Quartile-based clustering
    - Quartiles
      - Variables
      - Through time
    - RFM Analysis
      - Migration Matrices

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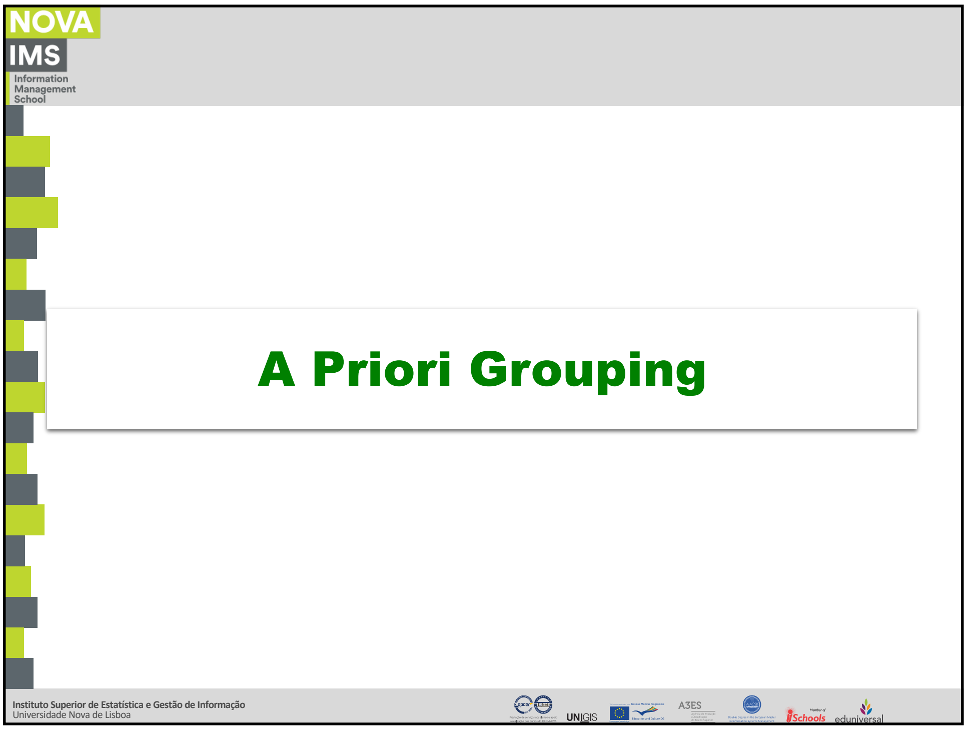

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A Priori Grouping

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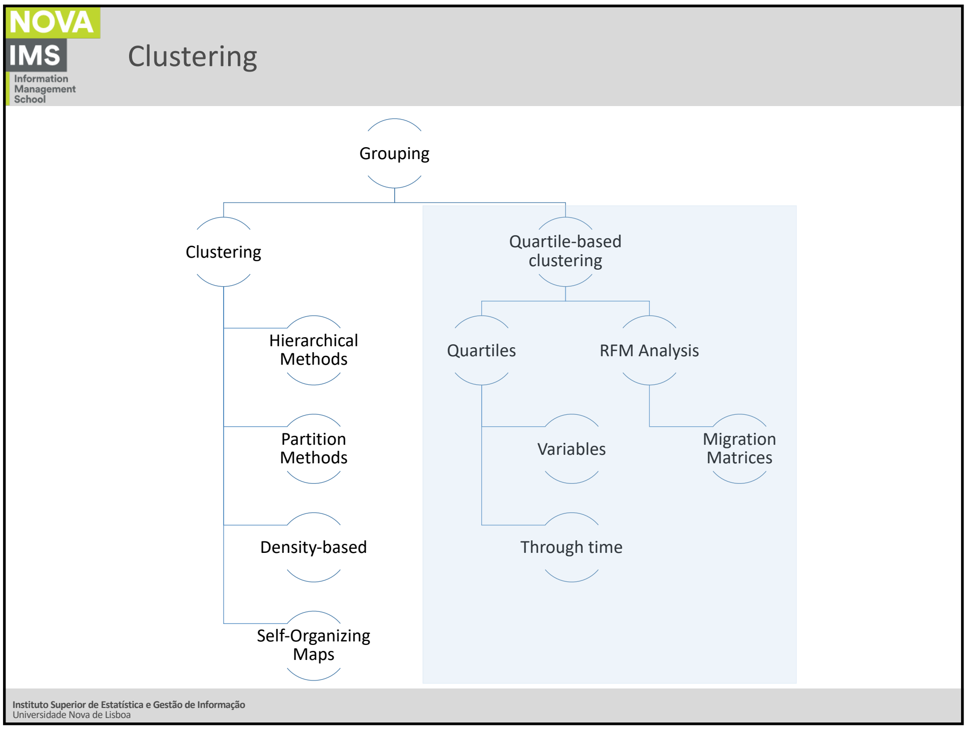

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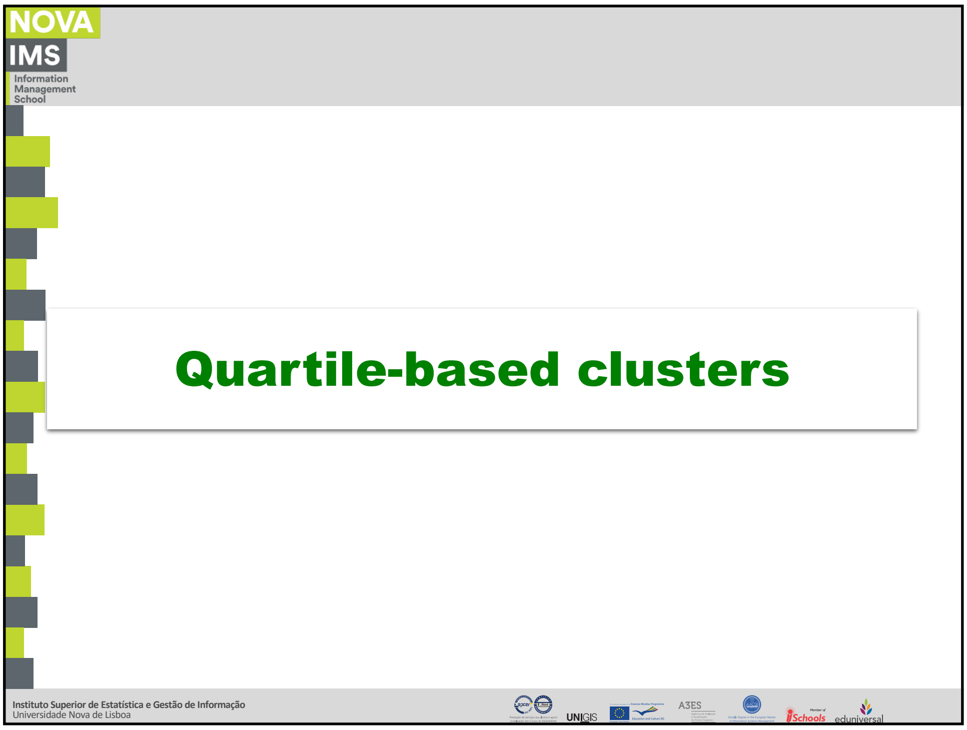

Quartile-based clusters

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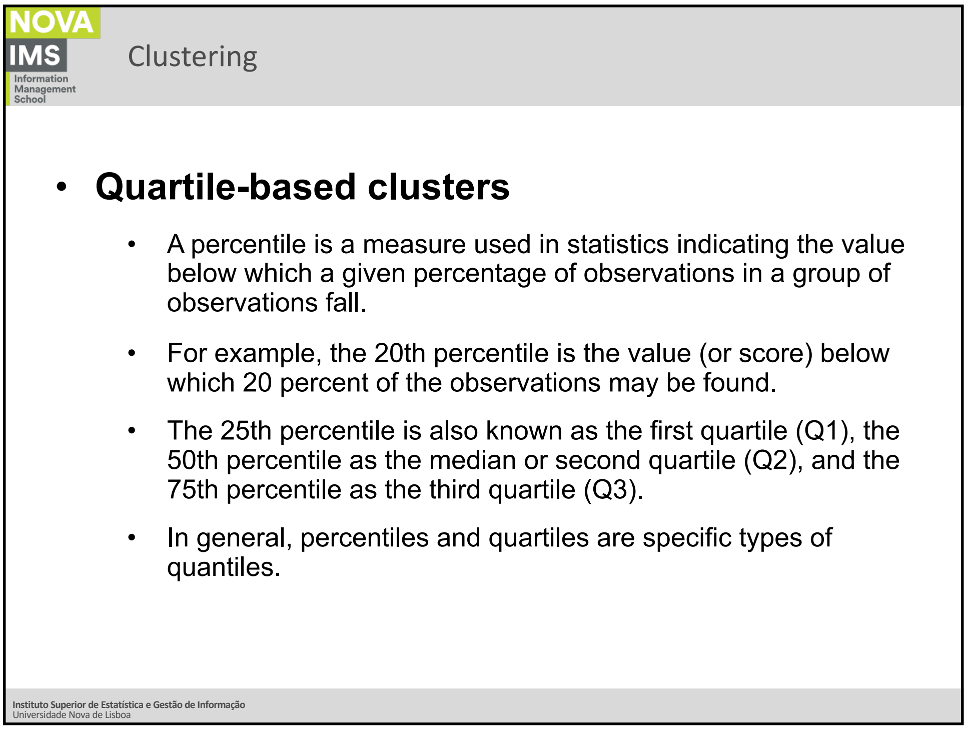

Clustering

- **Quartile-based clusters**
  - A percentile is a measure used in statistics indicating the value below which a given percentage of observations in a group of observations fall.
  - For example, the 20th percentile is the value (or score) below which 20 percent of the observations may be found.
  - The 25th percentile is also known as the first quartile (Q1), the 50th percentile as the median or second quartile (Q2), and the 75th percentile as the third quartile (Q3).
  - In general, percentiles and quartiles are specific types of quantiles.

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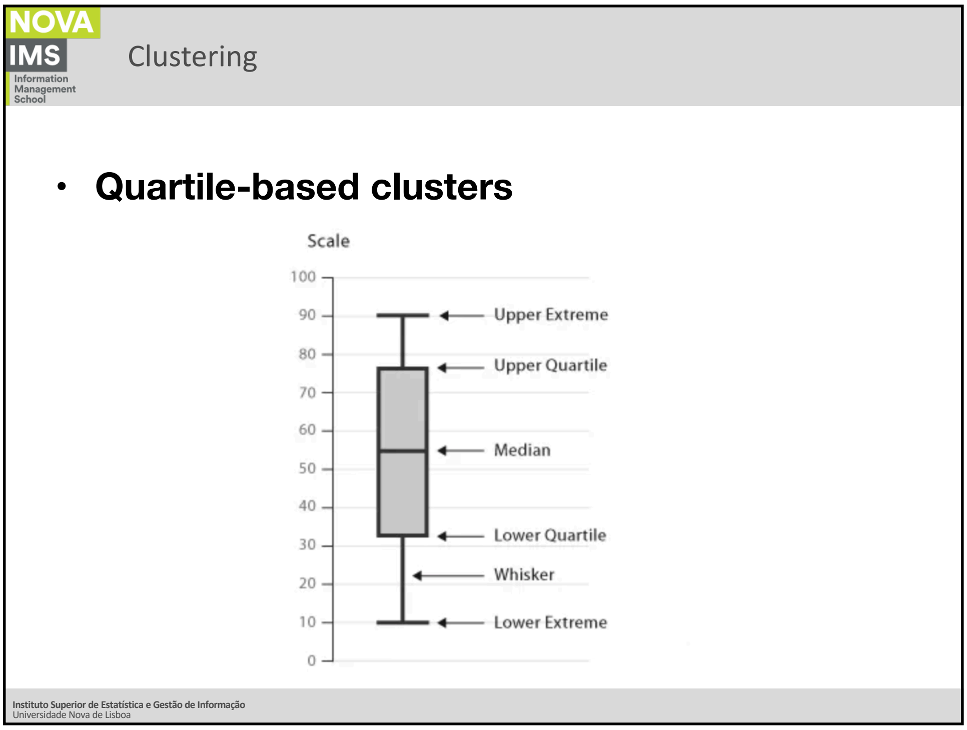

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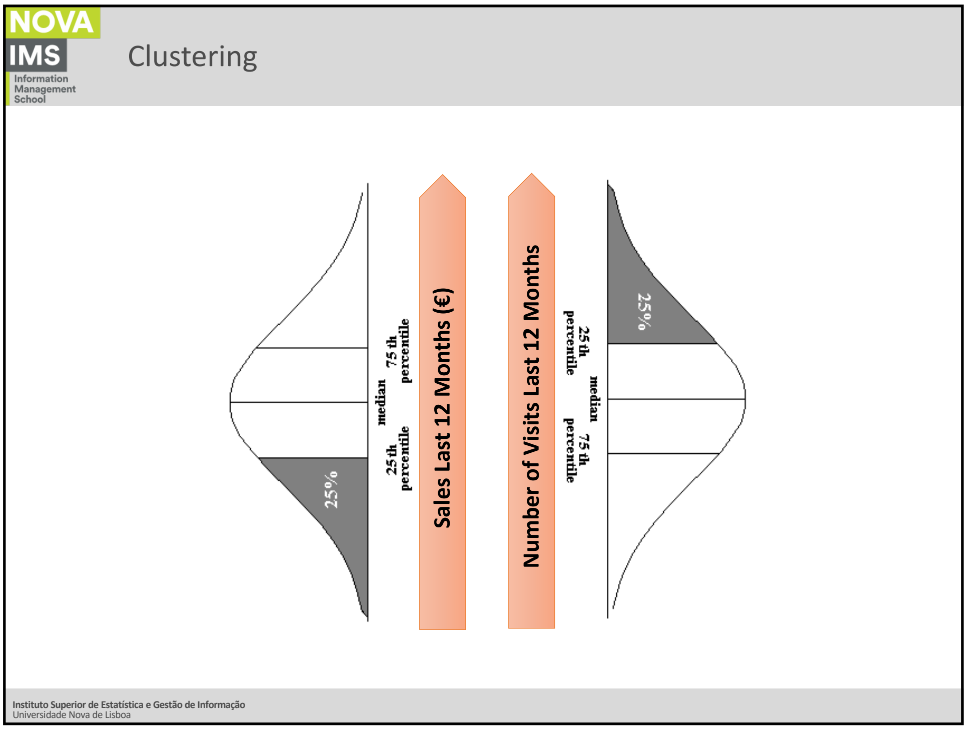
Clustering

- **Quartile-based clusters**



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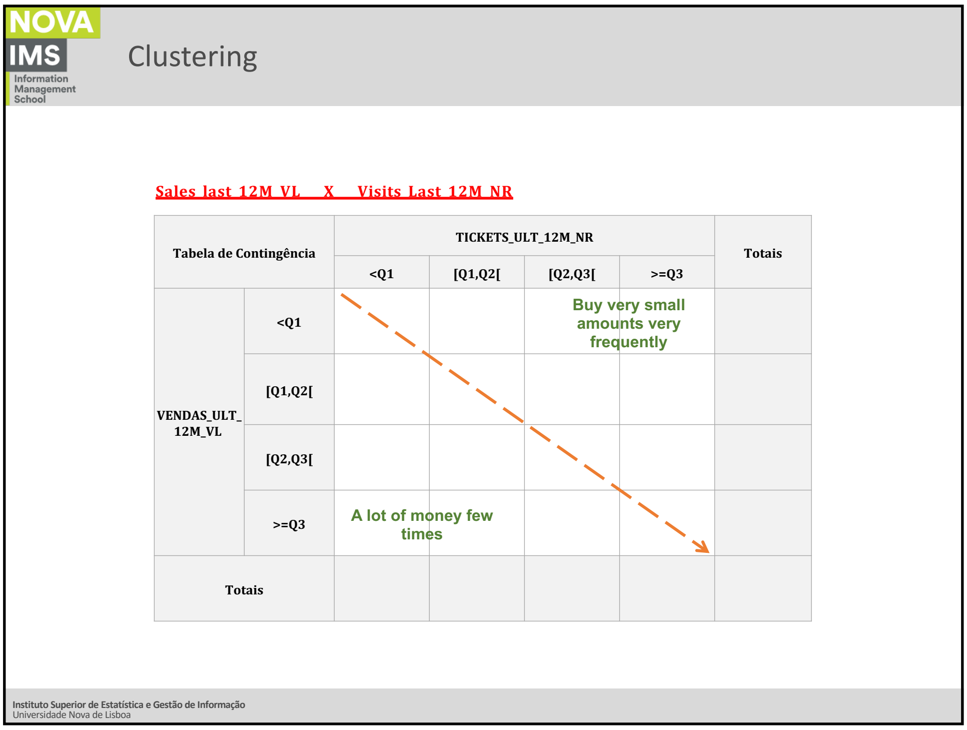

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Clustering

Sales last 12M VL   X   Visits Last 12M NR

Tabela de Contingência		TICKETS_ULT_12M_NR				Totais
		<Q1	[Q1,Q2[	[Q2,Q3[	>=Q3	
VENDAS_ULT_12M_VL	<Q1			Buy very small amounts very frequently		
	[Q1,Q2[					
	[Q2,Q3[					
	>=Q3	A lot of money few times				
Totais						

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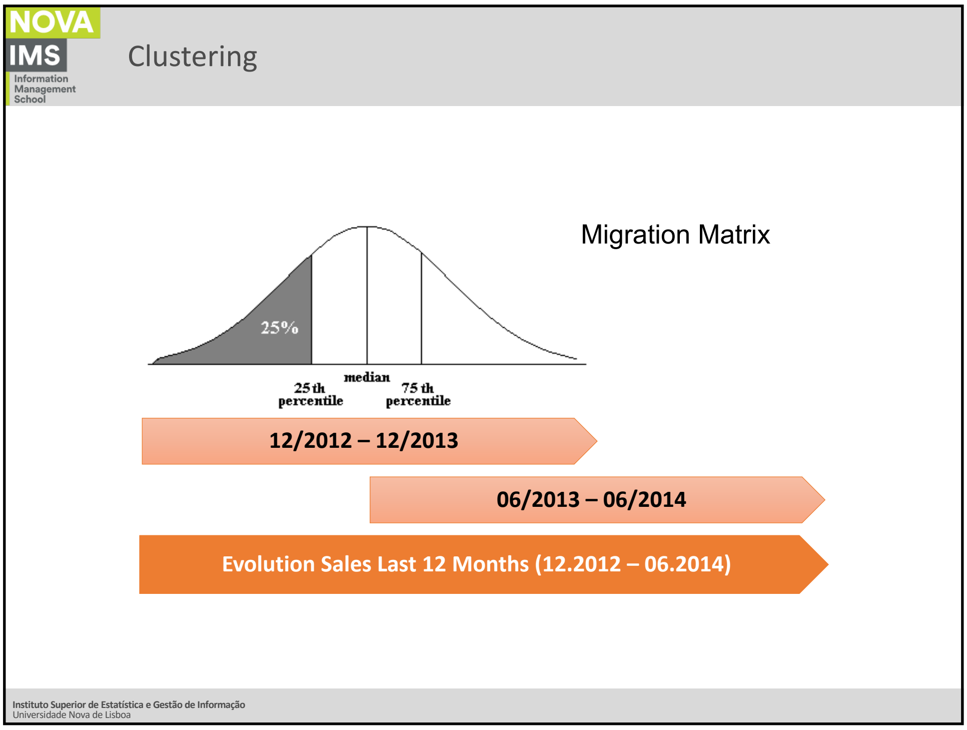

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Clustering

Migration Matrix

12/2012 – 12/2013

06/2013 – 06/2014

Evolution Sales Last 12 Months (12.2012 – 06.2014)

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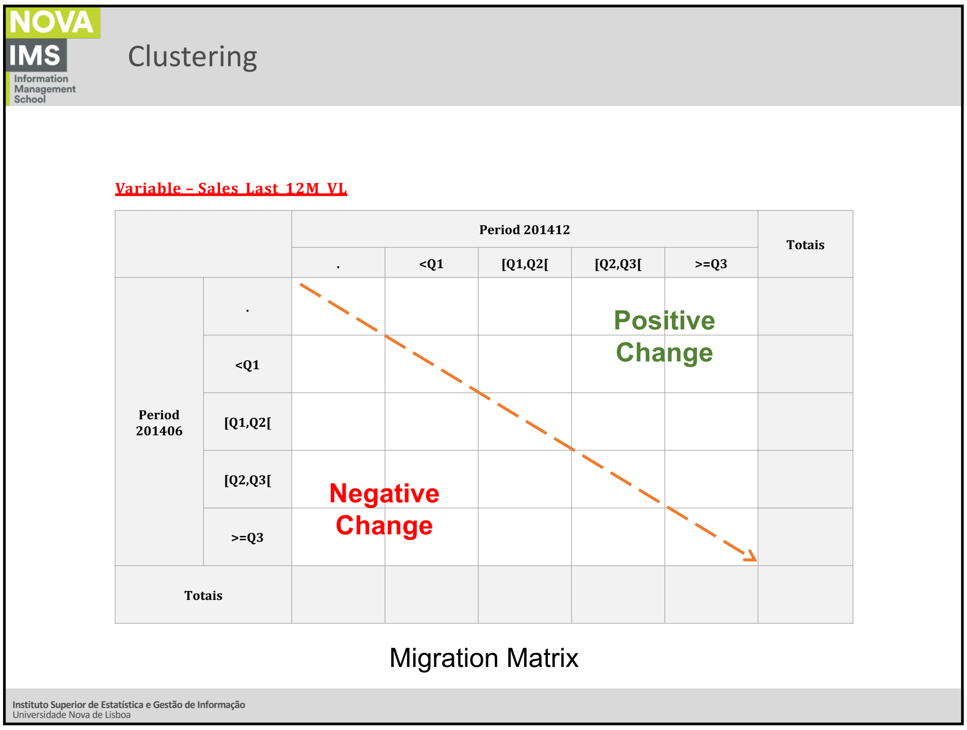
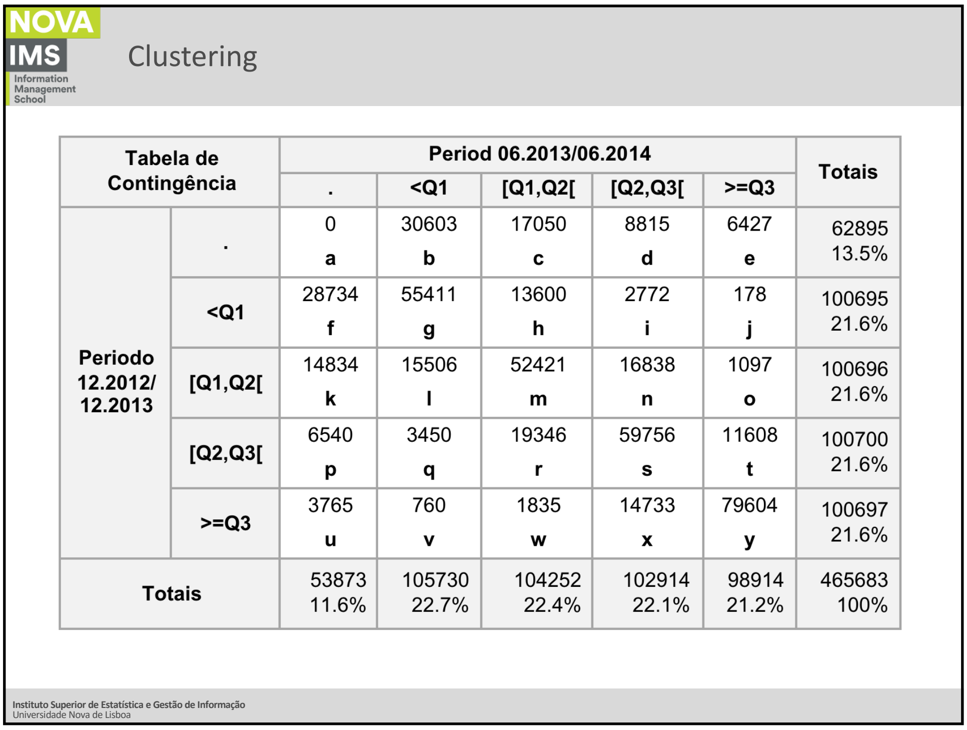


Clustering

Variable – Sales Last 12M VL

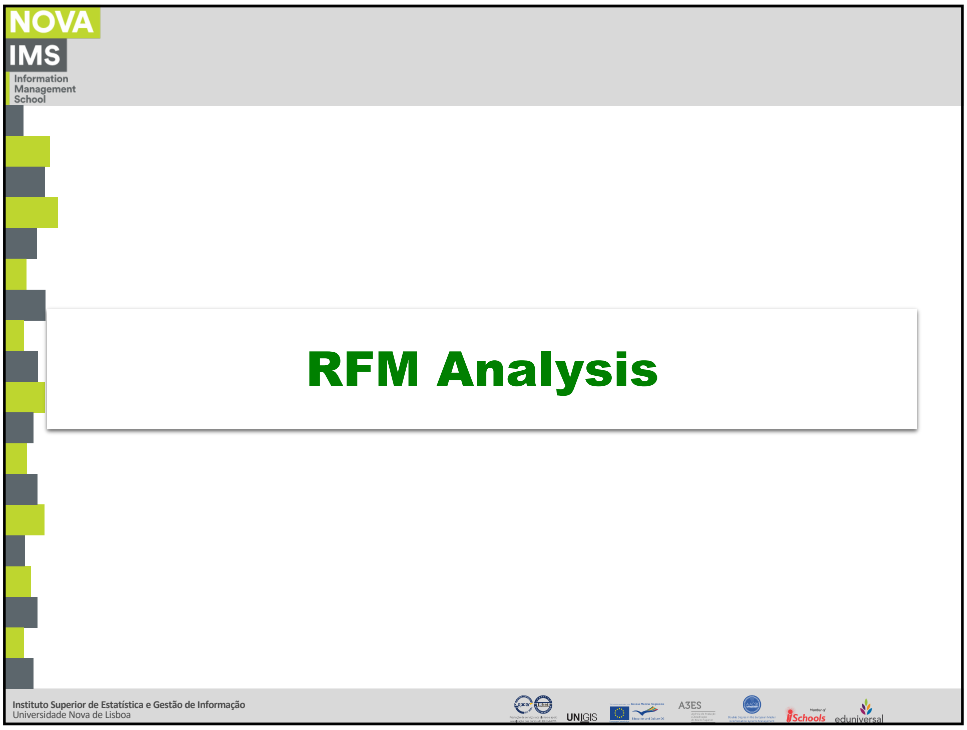
		Period 201412					Totais
		.	<Q1	[Q1,Q2[	[Q2,Q3[	>=Q3	
Period 201406	.						
	<Q1						
	[Q1,Q2[						
	[Q2,Q3[						
	>=Q3						
Totais							

Migration Matrix



Clustering

Tabela de Contingência		Period 06.2013/06.2014					Totais
		.	<Q1	[Q1,Q2[	[Q2,Q3[	>=Q3	
Periodo 12.2012/ 12.2013	.	0 a	30603 b	17050 c	8815 d	6427 e	62895 13.5%
	<Q1	28734 f	55411 g	13600 h	2772 i	178 j	100695 21.6%
	[Q1,Q2[	14834 k	15506 l	52421 m	16838 n	1097 o	100696 21.6%
	[Q2,Q3[	6540 p	3450 q	19346 r	59756 s	11608 t	100700 21.6%
	>=Q3	3765 u	760 v	1835 w	14733 x	79604 y	100697 21.6%
Totais		53873 11.6%	105730 22.7%	104252 22.4%	102914 22.1%	98914 21.2%	465683 100%



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RFM Analysis

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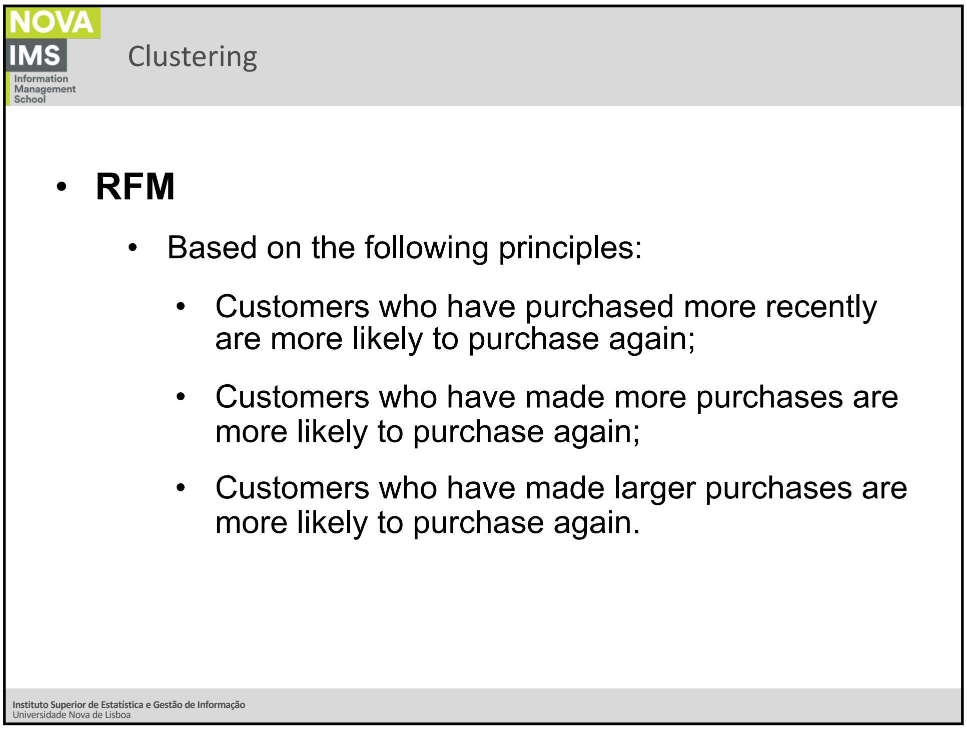

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Clustering

- **RFM**
  - Based on the following principles:
    - Customers who have purchased more recently are more likely to purchase again;
    - Customers who have made more purchases are more likely to purchase again;
    - Customers who have made larger purchases are more likely to purchase again.

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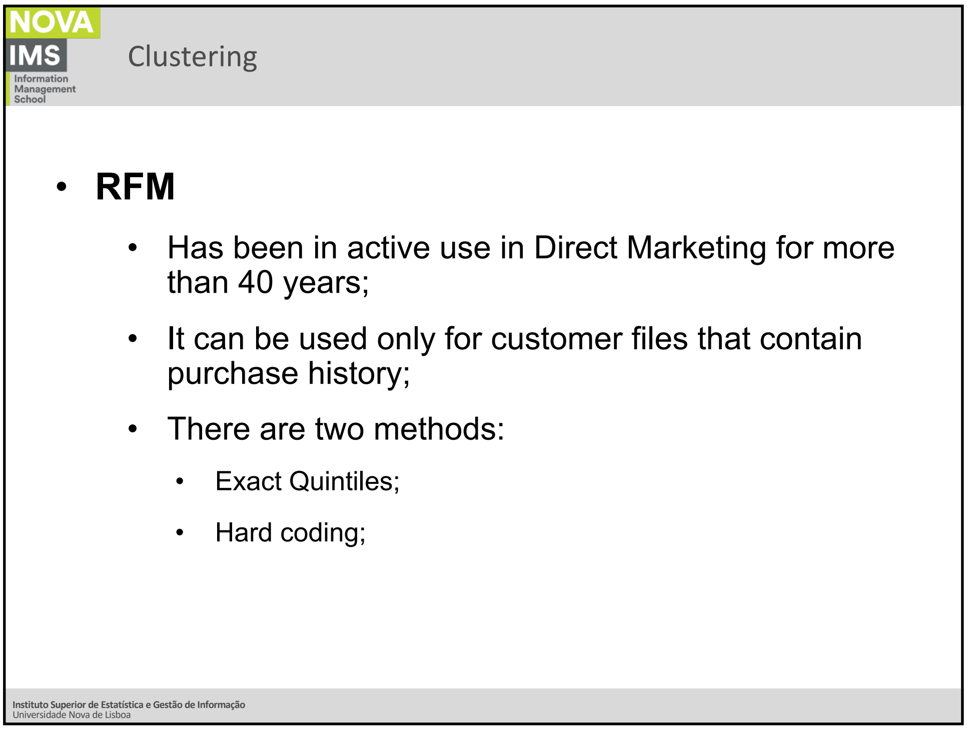

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Clustering

- **RFM**
  - Has been in active use in Direct Marketing for more than 40 years;
  - It can be used only for customer files that contain purchase history;
  - There are two methods:
    - Exact Quintiles;
    - Hard coding;

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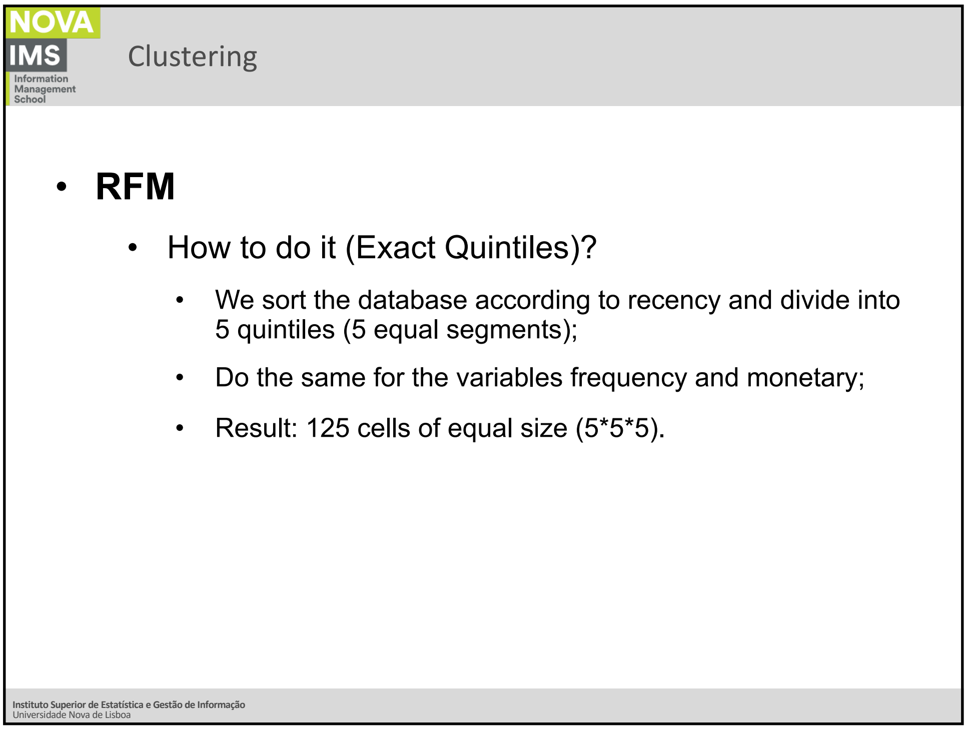

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Clustering

- **RFM**
  - How to do it (Exact Quintiles)?
    - We sort the database according to recency and divide into 5 quintiles (5 equal segments);
    - Do the same for the variables frequency and monetary;
    - Result: 125 cells of equal size (5*5*5).

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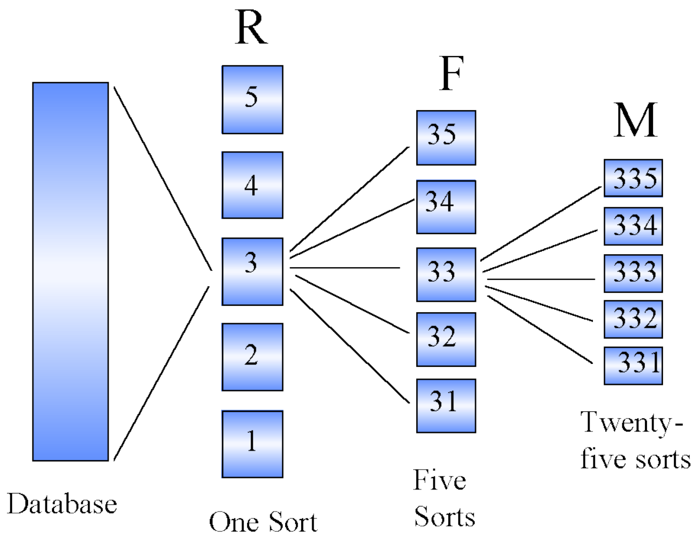
Clustering



R

F

M

Database

5
4
3
2
1

One Sort

35
34
33
32
31

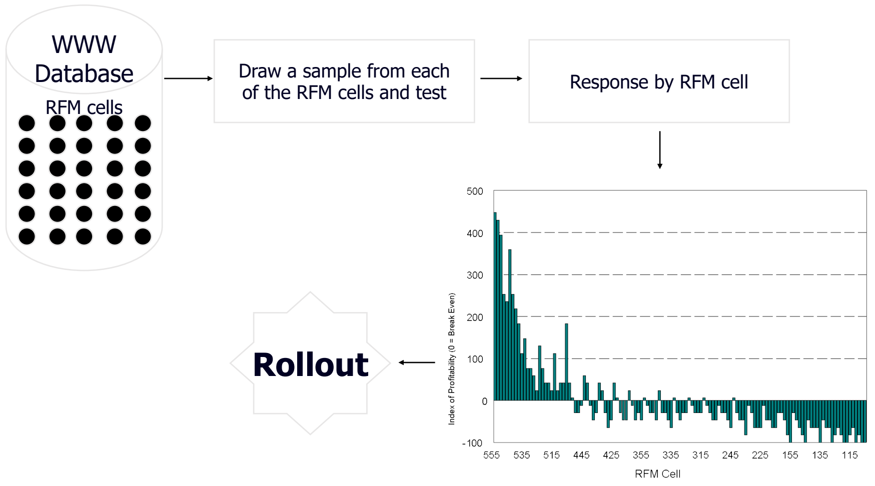
Five Sorts

335
334
333
332
331

Twenty-five sorts

Clustering

Typical use



WWW Database

RFM cells

Draw a sample from each of the RFM cells and test

Response by RFM cell

Rollout

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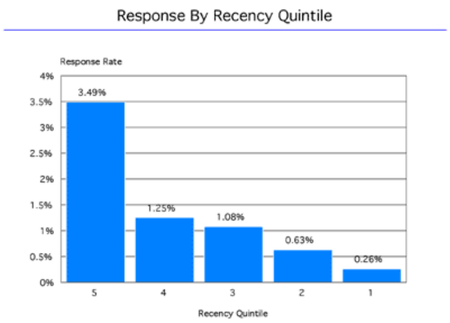
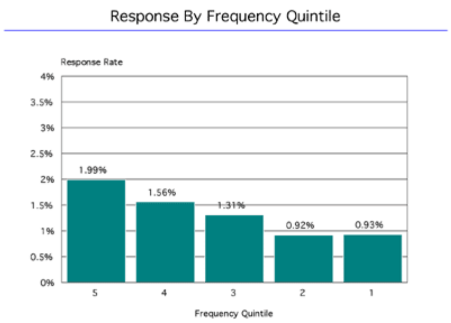
Clustering





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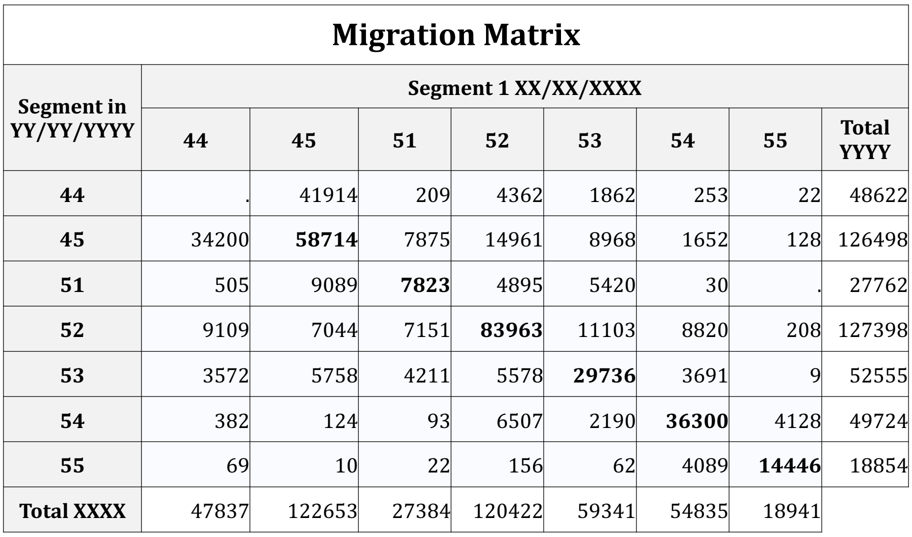
Clustering



Migration Matrix

Segment in YY/YY/YYYY	Segment 1 XX/XX/XXXX							
	44	45	51	52	53	54	55	Total YYYY
44	.	41914	209	4362	1862	253	22	48622
45	34200	**58714**	7875	14961	8968	1652	128	126498
51	505	9089	**7823**	4895	5420	30	.	27762
52	9109	7044	7151	**83963**	11103	8820	208	127398
53	3572	5758	4211	5578	**29736**	3691	9	52555
54	382	124	93	6507	2190	**36300**	4128	49724
55	69	10	22	156	62	4089	**14446**	18854
Total XXXX	47837	122653	27384	120422	59341	54835	18941	

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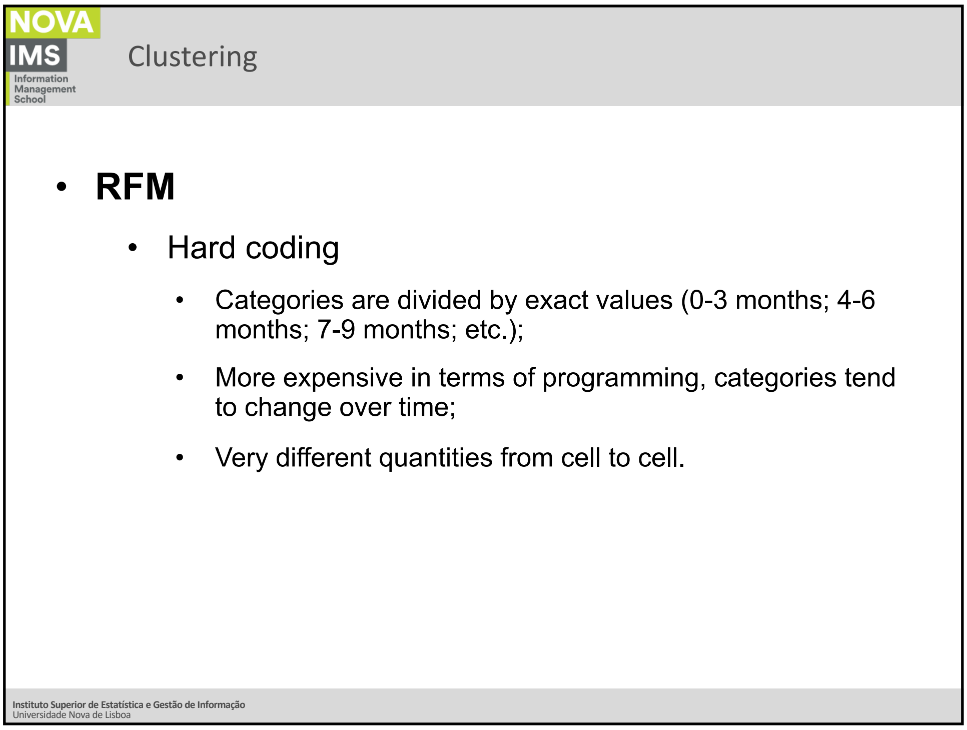

Clustering

- **RFM**
  - Hard coding
    - Categories are divided by exact values (0-3 months; 4-6 months; 7-9 months; etc.);
    - More expensive in terms of programming, categories tend to change over time;
    - Very different quantities from cell to cell.

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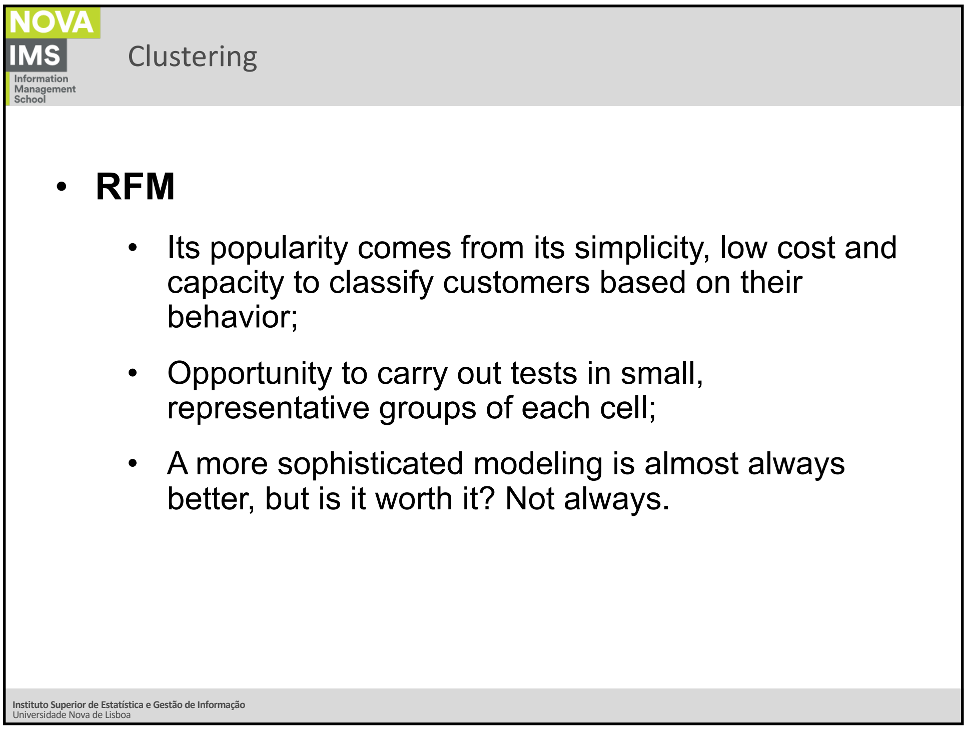

Clustering

- **RFM**
  - Its popularity comes from its simplicity, low cost and capacity to classify customers based on their behavior;
  - Opportunity to carry out tests in small, representative groups of each cell;
  - A more sophisticated modeling is almost always better, but is it worth it? Not always.

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Questions?

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