Data Mining techniques application in Power Distribution Utilities

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INTRODUCTION

Content of Presentation:

- Electricity Market Liberalization Environment
- MV Costumers Characterization – An overview
- Data Mining Techniques Application
- Clustering and Consumers Characterization
  - Case Study
- Future Work

ELECTRICITY MARKET LIBERALIZATION

- ✓ **Total freedom in choosing the electricity supplier**
- ✓ **Consumers and suppliers are exposed to price risk**
- ✓ **Distribution and retail companies are looking for better tariff rates**
- ✓ **Competitive environment among retail companies to sell the electricity**

ELECTRICITY MARKET LIBERALIZATION

- ✓ **Increase of demand elasticity due to the electricity price volatility**
- ✓ **Electricity customers more concerned about their consumption behaviour**
- ✓ **Knowledge about customers' daily load profile is essential for leadership in this new context**
- ✓ **Deeper relationship between Customer and Electricity Supplier**

ELECTRICITY MARKET LIBERALIZATION

CONSUMERS' CHARACTERIZATION

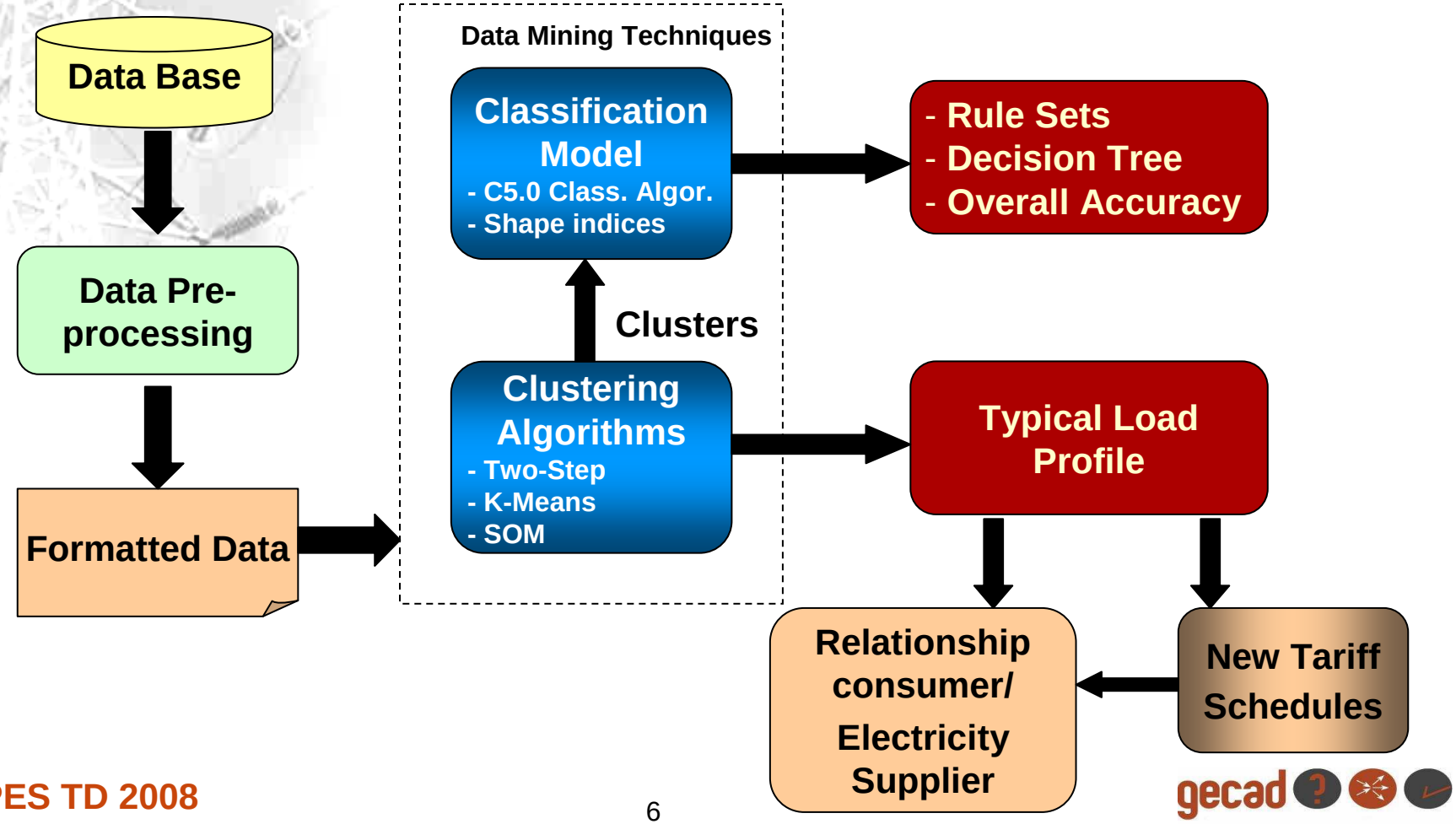
- **Advantages:**

✓ **Design of new tariffs, contracts, products and services**

✓ **Creation of incentive actions to the energy efficiency**

MV COSTUMERS CHARACTERIZATION

DETERMINATION AND CHARACTERIZATION OF MV CONSUMERS LOAD PROFILE USING DATA MINING TECHNIQUES



LOAD STUDY

Data description:

- ✓ **Sample of 229 MV Consumers**
- ✓ **Collect period of data**

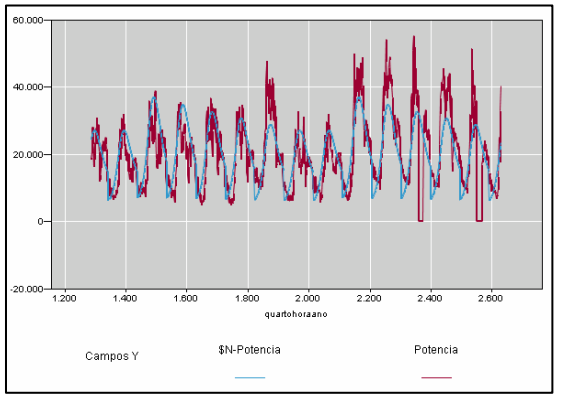
  (3 months in the Summer / Winter – from the Portuguese Distribution Company)
- ✓ **Consumed power recorded with a cadence of 15 minutes**
- ✓ **96 values obtained per day**

$$I^{(m)} = \{I_1^{(m)}, \ldots, I_{96}^{(m)}\}$$

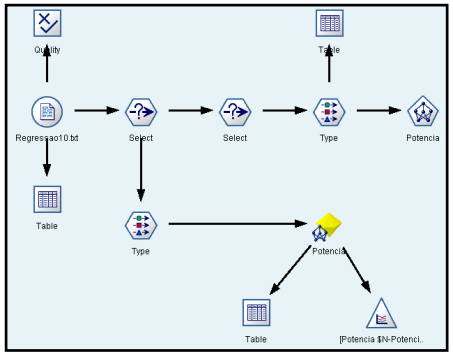
with m = number of customers

DATA PREPARATION

Data-Cleaning



- ✓ **21 customer's files were discarded**
  - Some damaged files were detected
  - Customers without registered values
  - 208 customers remained to be analyzed
- ✓ **To estimate missing values of measures a multi layer perceptron – MLP – artificial neural net was used**
- ✓ **The errors of the metered load curves are attenuated without making significant alterations in the real measures**



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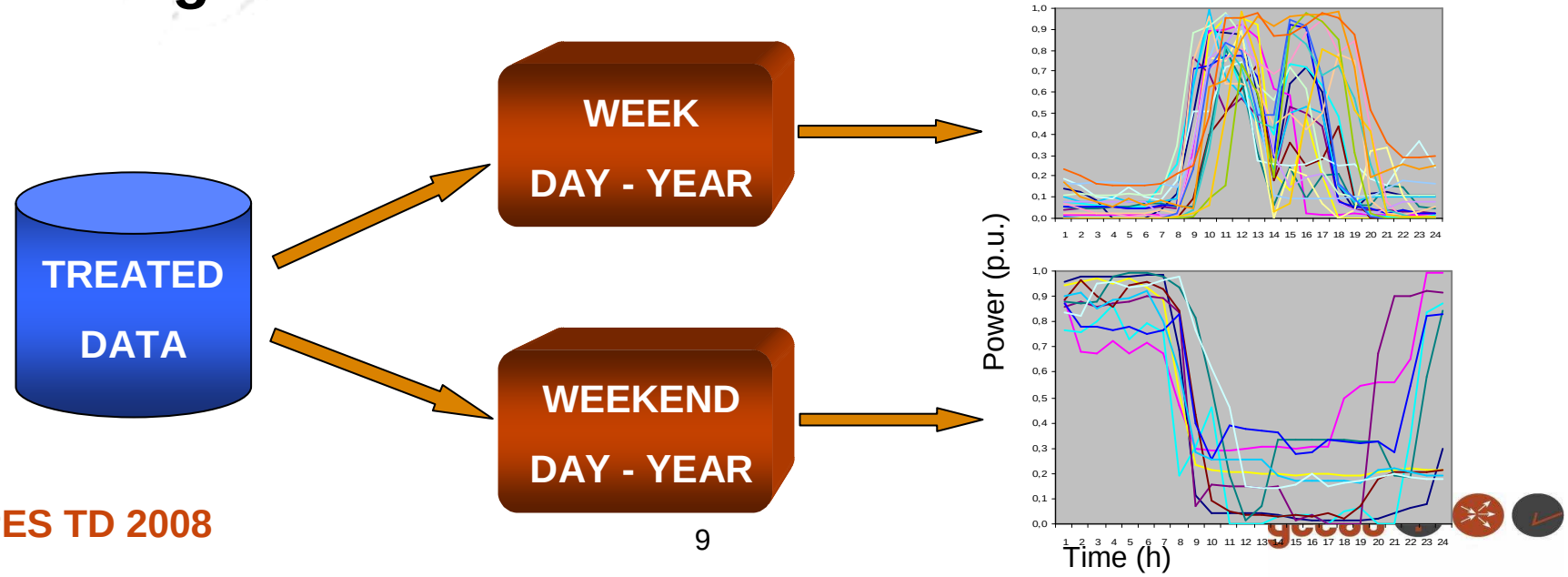
DATA PREPARATION

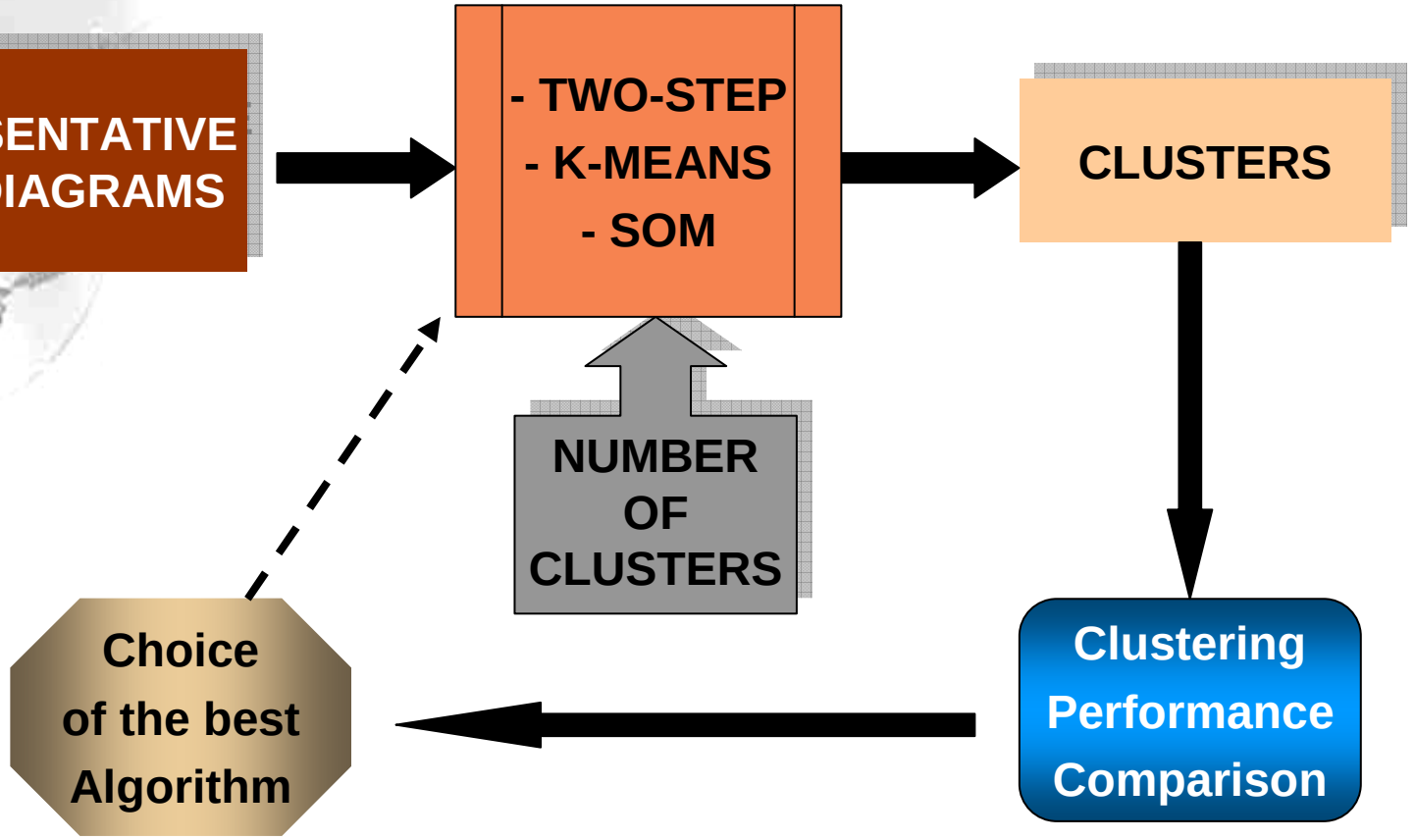
Pre – processing data:

- ✓ **The Power consumption was normalized to the [0-1] range**
- ✓ **A representative load diagram has been built for each customer by averaging the related load diagrams**

REPRESENTATIVE DIAGRAMS:



CLUSTERING PROCESS



CLUSTERING PROCESS

Choice of the Clustering Algorithm:

Mean Index Adequacy (MIA):

$$MIA = \sqrt{\frac{1}{K} \times \sum_{k=1}^{K} d^2(r^{(k)}, L^{(k)})}$$

Cluster Dispersion Index (CDI):

$$CDI = \frac{\sqrt{\frac{1}{K} \sum_{k=1}^{K} \left[\frac{1}{2.n^{(k)}} \sum_{n=1}^{n^{(k)}} d^2(l^{(m)}, L^{(k)}) \right]}}{\sqrt{\frac{1}{2K} \sum_{k=1}^{K} d^2(r^{(k)}, R)}}$$

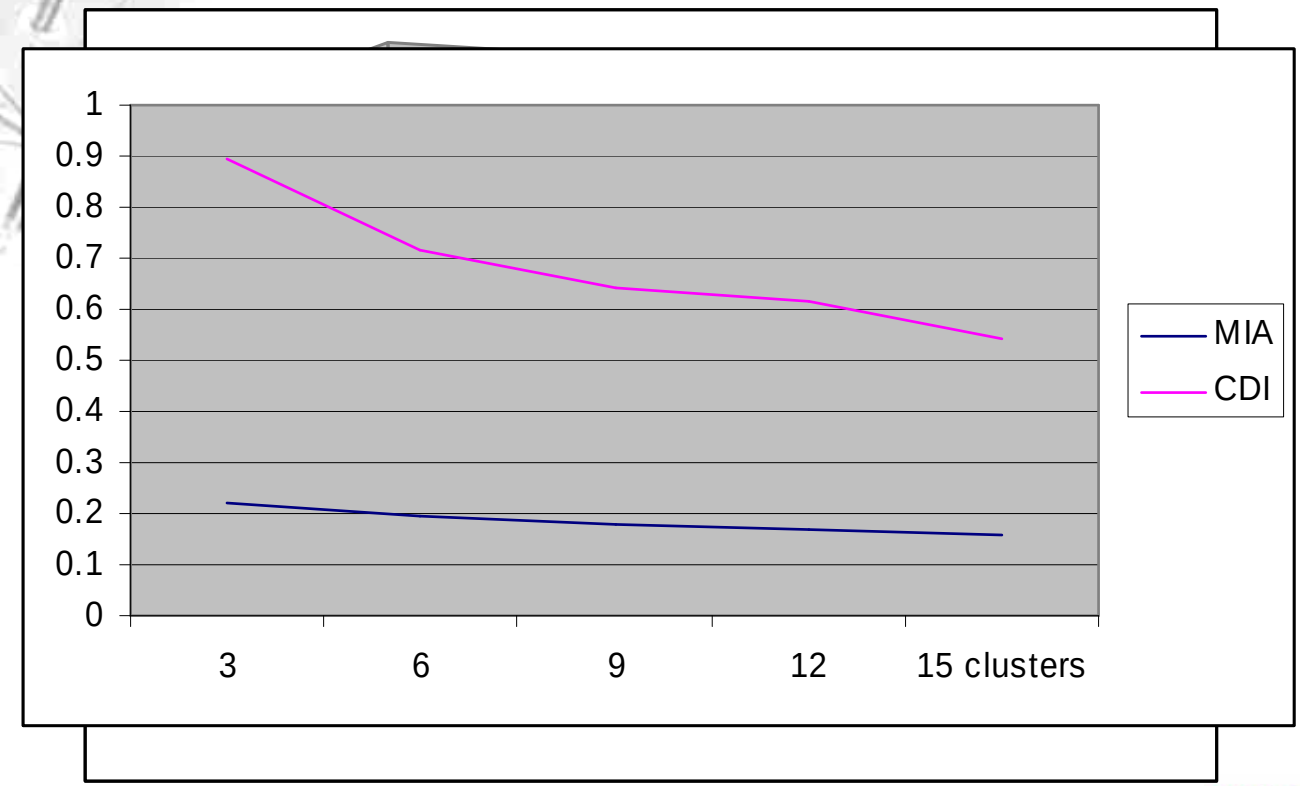
CLUSTERING PROCESS

Comparison of the clustering performance:

Two-Step Cluster Analysis

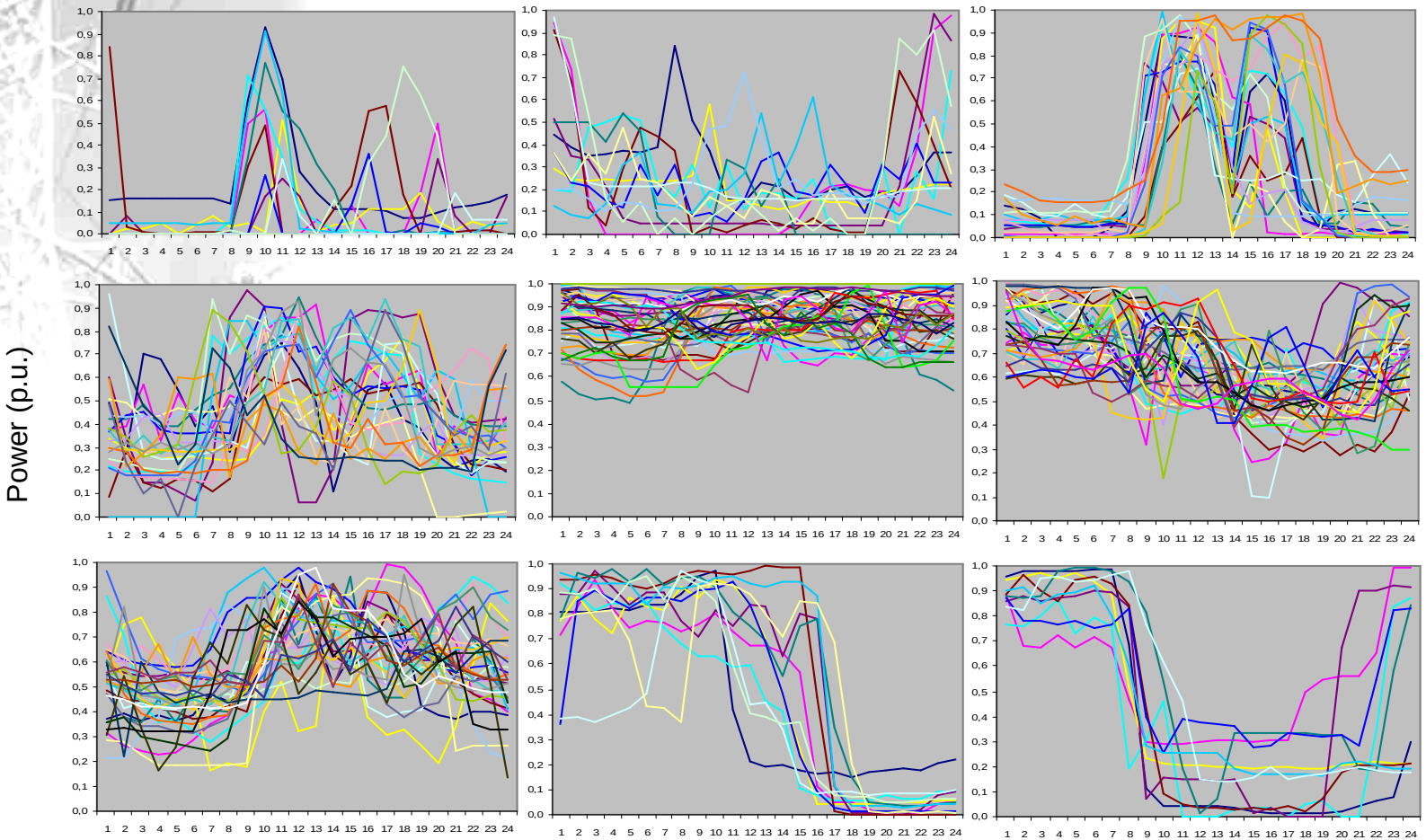
K-means

***Kohonen Net* – Self Organizing Features Maps**



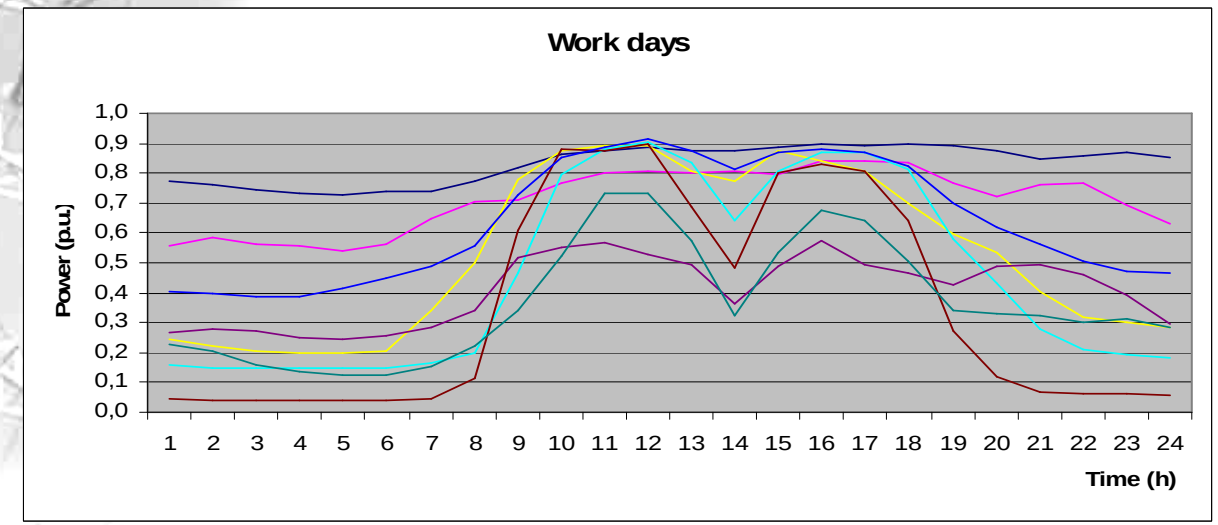
TWO-STEP CLUSTERING APLICATION

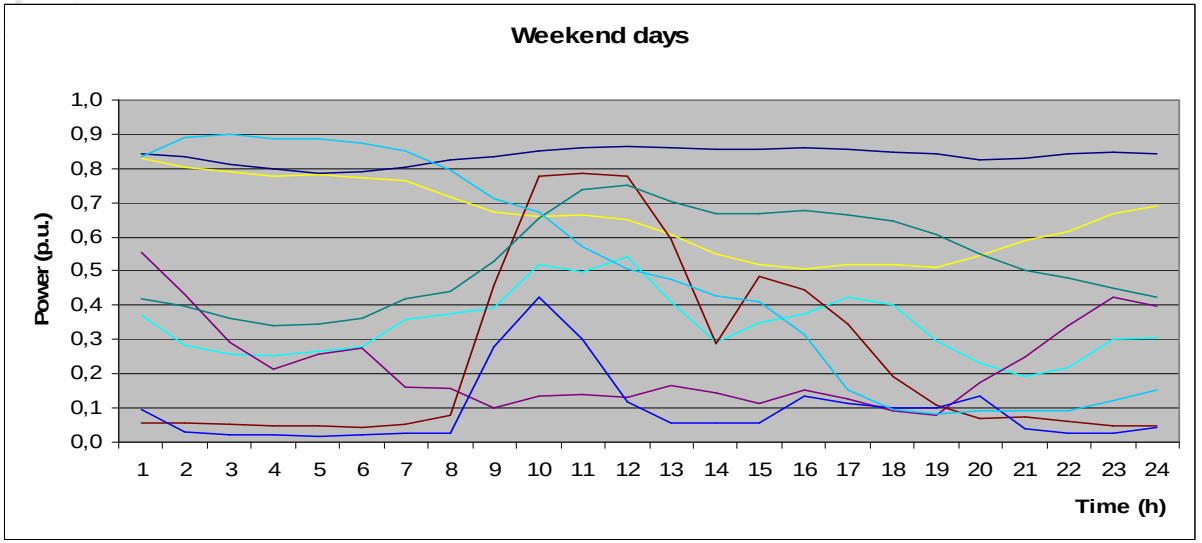
- **Using the Two-step cluster algorithm the clusters were obtained using the representative load diagrams**



REPRESENTATIVE LOAD DIAGRAMS

- ✓ **Representative diagram for each cluster**

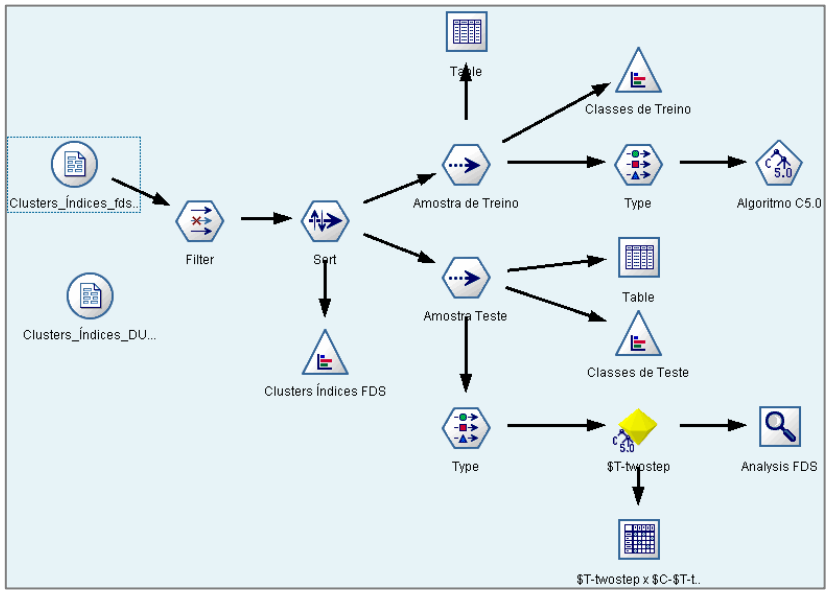




CLASSIFICATION MODEL

Objective:

- ✓ **To build a classification model, that applied to new unclassified records, will allow to foresee the class to which it belongs**
- ✓ **In the future it will allow to attribute to each new consumer the consumption profile that best represents it**



CLASSIFICATION MODEL

C5.0 Algorithm

- ✓ **Decision Tree:**
  - **Application simplicity**
  - **Result in tree form**
  - **Generation of rules**

$$f1 = \frac{P_{av,day}}{P_{\max,day}} \qquad f2 = \frac{P_{\min,day}}{P_{\max,day}}$$

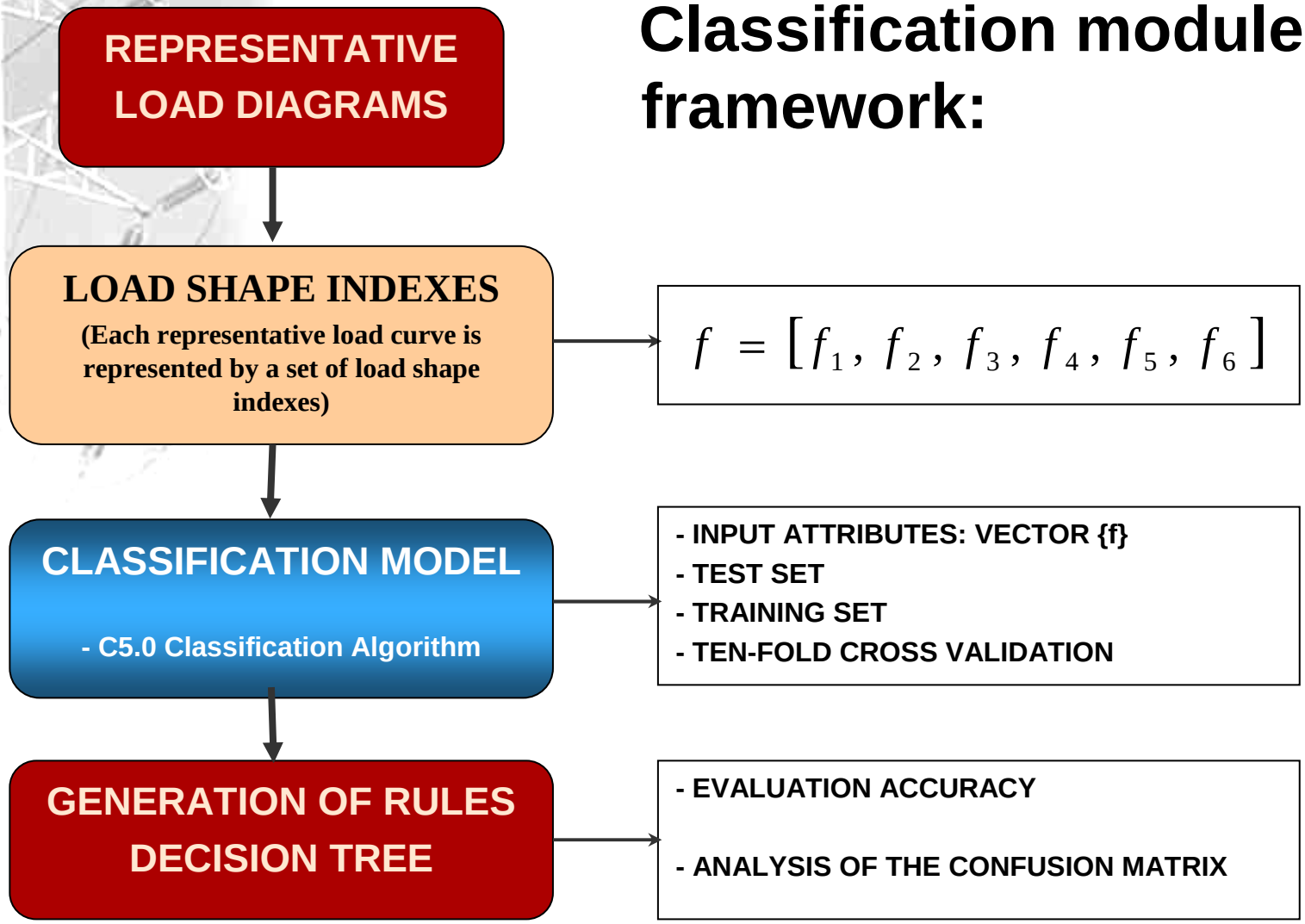
$$f3 = \frac{P_{\min,day}}{P_{av,day}} \qquad f4 = \frac{1}{3}\frac{P_{av,night}}{P_{av,day}}$$

$$f5 = \frac{1}{8}\frac{P_{av,lunch}}{P_{av,day}}$$

Derive from the daily load diagrams

- ✓ **Give information about:**
  - **The daily load curve shape**
  - **The consumption pattern of each consumer**

CLASSIFICATION MODEL



Classification module framework:

CLASSIFICATION

✓ Rule set for the working days classification model:

if $f_3 \leq 0{,}48$ and $f_2 \leq 0{,}13$ and $f_5 \leq 0{,}55$ and $f_1 \leq 0{,}35$ and $f_4 \leq 0{,}31$	then cluster 8
if $f_3 \leq 0{,}48$ and $f_2 \leq 0{,}13$ and $f_5 \leq 0{,}55$ and $f_1 \leq 0{,}35$ and $f_4 > 0{,}31$	then cluster 9
if $f_3 \leq 0{,}48$ and $f_2 \leq 0{,}13$ and $f_5 \leq 0{,}55$ and $f_1 > 0{,}35$	then cluster 5
if $f_3 \leq 0{,}48$ and $f_2 \leq 0{,}13$ and $f_5 > 0{,}55$ and $f_2 \leq 0{,}06$	then cluster 7
if $f_3 \leq 0{,}48$ and $f_2 \leq 0{,}13$ and $f_5 > 0{,}55$ and $f_2 > 0{,}06$	then cluster 6
if $f_3 \leq 0{,}48$ and $f_2 > 0{,}13$ and $f_4 \leq 0{,}24$	then cluster 4
if $f_3 \leq 0{,}48$ and $f_2 \leq 0{,}13$ and $f_4 > 0{,}24$	then cluster 5
if $f_3 > 0{,}48$ and $f_3 \leq 0{,}78$and $f_2 \leq 0{,}44$	then cluster 3
if $f_3 > 0{,}48$ and $f_3 \leq 0{,}78$and $f_2 > 0{,}44$	then cluster 2
if $f_3 > 0{,}48$ and $f_3 > 0{,}78$	then cluster 1

✓ Overall accuracy:

94,83%

CONSUMER-SUPPLIER RELATIONSHIP

- ✓ **The Knowledge can be used by the Retail Companies**
  - **Identify diagrams' peaks**
  - **Develop specific consumer's contracts**
  - **Optimization of the offers of electric power purchase**

CONSUMER-SUPPLIER RELATIONSHIP

- ✓ **The Knowledge can be used by the electric power consumers**
  - **Choice of the electricity supplier with the best tariff schedule proposal**
  - **Modulation of their electric consumption habits**
  - **In the execution of electric energy interruption contracts**

FURTHER WORK

- ✓ **Compare the efficiency of the C5.0 algorithm with different classification algorithms**
- ✓ **The design of new prices categories in order to adequately adapt the tariff schedules to the cluster consumption pattern**
- ✓ **Formulation of new tariffs schedules in articulation with electricity markets**

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