Data Mining & Business Intelligence: Practical Tools

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Outline

- Why Data Mining?
- What is Data Mining?
- Data Mining Tools
  - Open Source Tools: WEKA, Rapid Miner
  - Non-Open Source Tools: SPSS, MS SQL 2005 Analytics Service (SSAS), Oracle Data Miner (ODM)

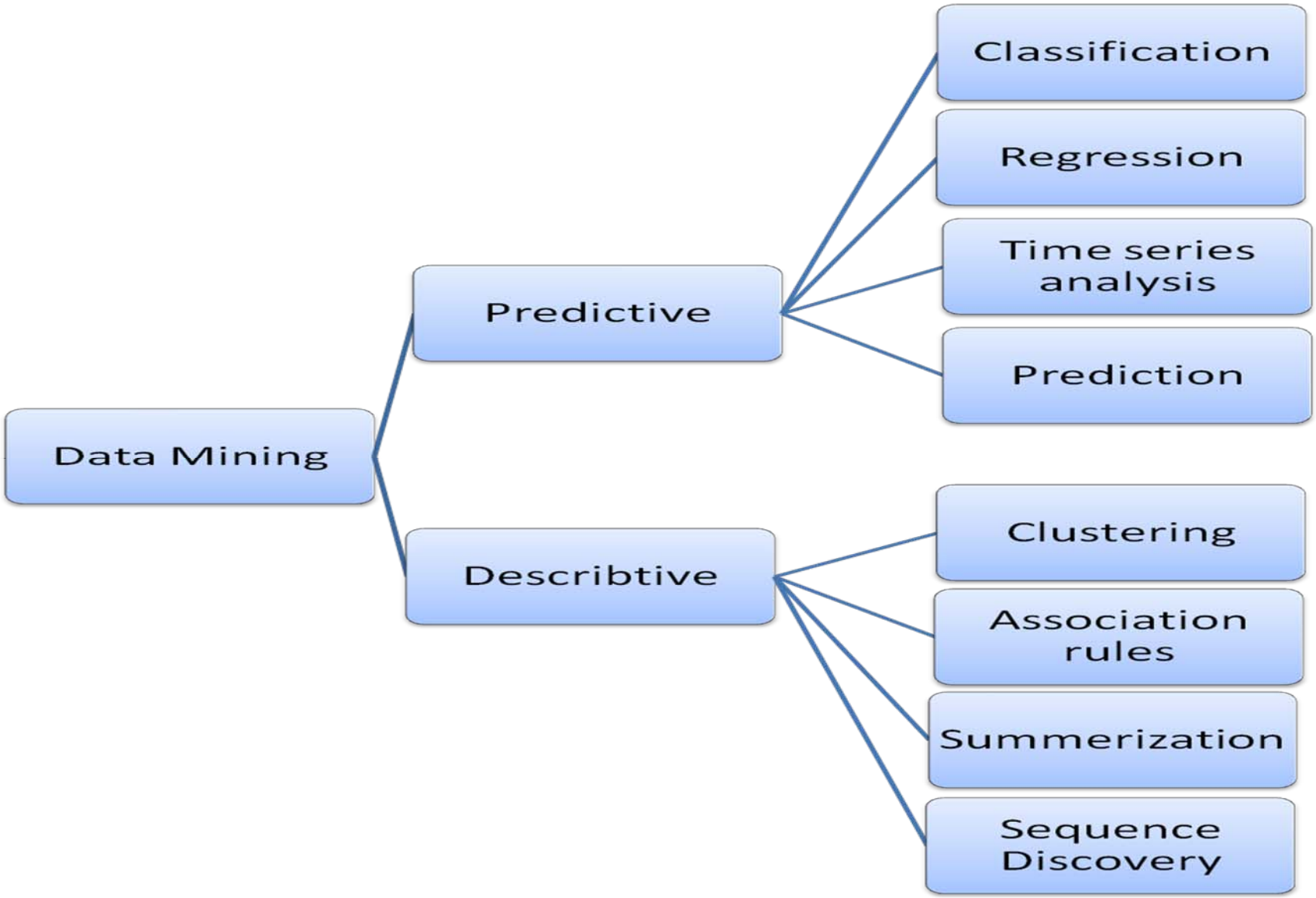
Why Data Mining?!

- The Explosive Growth of Data (from gigabytes to terabytes). The explosion of data caused by:
- Automated data collection tools, database systems, Web, computerized society.
- Abundant data available from various sources:
  - Business: Web, e-commerce, transactions, stocks …
  - Science: Remote sensing, bioinformatics, scientific simulation …
  - Society and everyone: news, digital cameras …
- From the previous discussion we conclude that:
- ***"We are drowning in data, but starving for knowledge!"***
- *"Necessity is the mother of invention"* **Data mining is: Automated analysis of massive data sets.**

What is Data Mining?

- Data mining (knowledge discovery from data) is Extraction of interesting (non-trivial, implicit, previously unknown and potentially useful) patterns or knowledge from huge amount of data.
- Alternative names for Data Mining: Knowledge discovery (mining) in databases (KDD), knowledge extraction, data/pattern analysis, data archeology, data dredging, information harvesting, business intelligence, etc.

Data Mining Functionality (Tasks)



Data Mining Functionality (Tasks)

- ***Classification*** maps data into predefined groups or classes: Supervised learning, Pattern recognition, Prediction
- ***Clustering*** groups similar data together into clusters: Unsupervised learning, Segmentation, Partitioning

Data Mining Functionality (Tasks)

- ***Link Analysis*** uncovers relationships among data: Association Rules, Sequential Analysis determines sequential patterns.
- ***Outlier analysis***
  - Outlier: Data object that does not comply with the general behavior of the data
  - Noise or exception? Useful in fraud detection, rare events analysis

Why Data Mining?—Potential Applications

- Data analysis and decision support
  - Market analysis and management
    - Target marketing, customer relationship management (CRM), market basket analysis, cross selling, market segmentation
  - Risk analysis and management
    - Forecasting, customer retention, improved underwriting, quality control, competitive analysis
  - Fraud detection and detection of unusual patterns (outliers)

Why Data Mining?—Potential Applications

- Other Applications
  - Text mining (news group, email, documents) and Web mining
  - Bioinformatics and bio-data analysis

Example 1: Market Analysis and Management

- Where does the data come from?—Credit card transactions, loyalty cards, discount coupons, customer complaint calls, plus (public) lifestyle studies
- Target marketing
  - Find clusters of “model” customers who share the same characteristics: interest, income level, spending habits, etc.,
  - Determine customer purchasing patterns over time

Example 1: Market Analysis and Management (Cont.)

- Cross-market analysis—Find associations/co-relations between product sales, & predict based on such association
- Customer profiling—What types of customers buy what products (clustering or classification)
- Customer requirement analysis
  - Identify the best products for different customers
  - Predict what factors will attract new customers

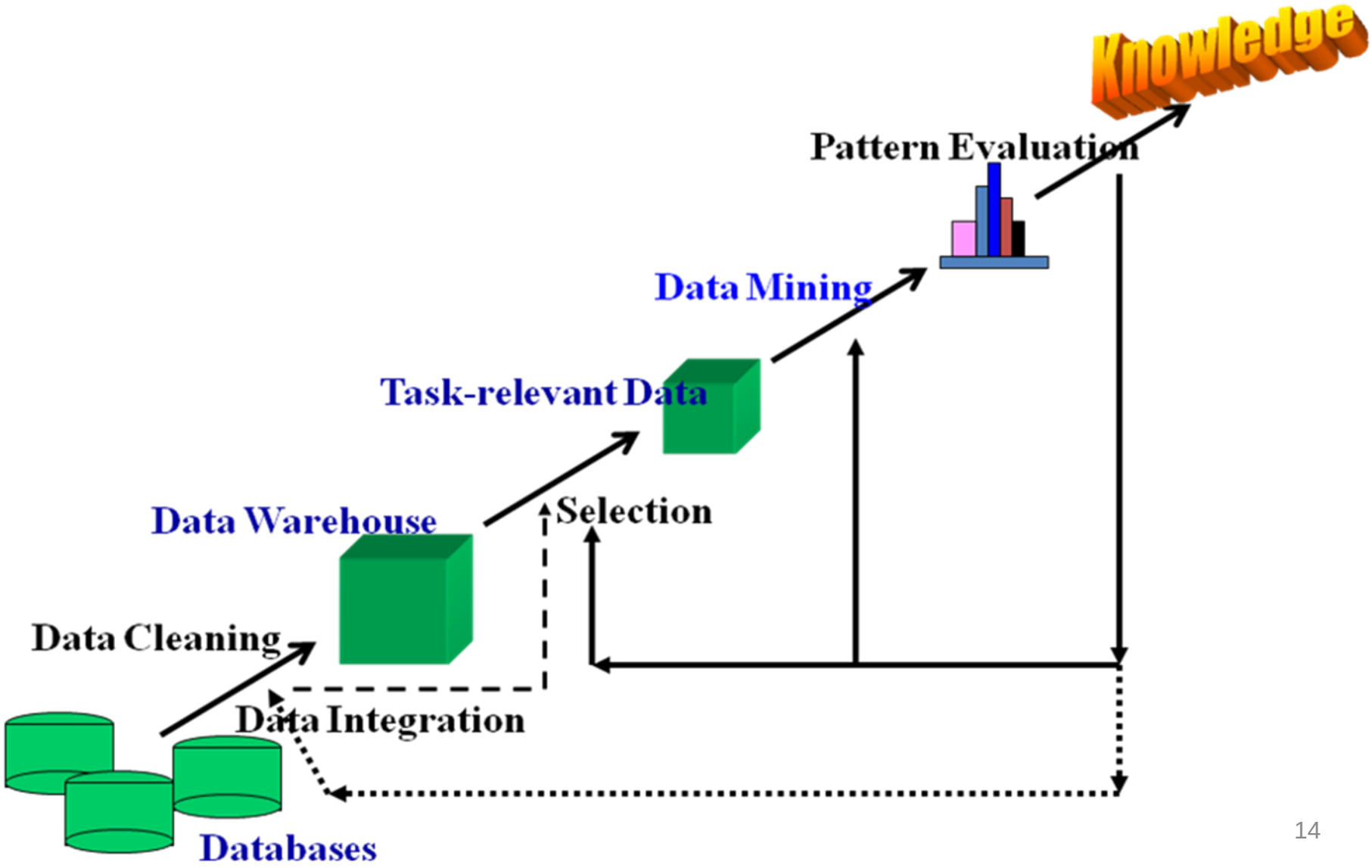
Example 2: Fraud Detection & Mining Unusual Patterns

- Approaches: Clustering & model construction for frauds, outlier analysis
- Applications: Health care, retail, credit card service, telecomm.
  - Auto insurance: detect a group of people who stage accidents to collect on insurance.
  - Money laundering: detect suspicious monetary transactions
  - Medical insurance
    - Professional patients: detect professional patients and ring of doctors and ring of references.
    - Unnecessary or correlated screening tests

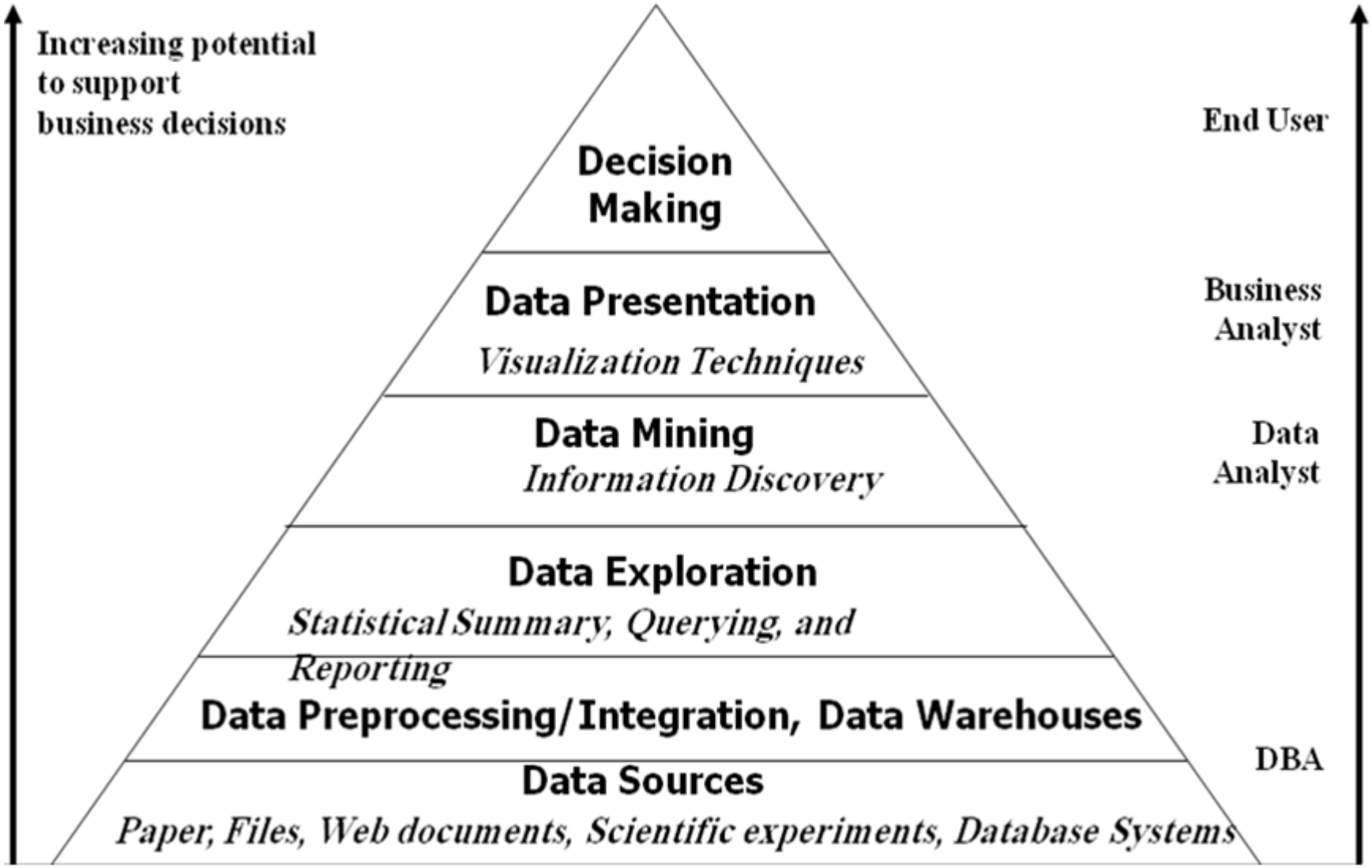
Example 2: Fraud Detection & Mining Unusual Patterns (CONT.)

- Telecommunications: phone-call fraud
  - Phone call model: destination of the call, duration, time of day or week. Analyze patterns that deviate from an expected norm
- Retail industry
  - Analysts estimate that 38% of retail shrink is due to dishonest employees

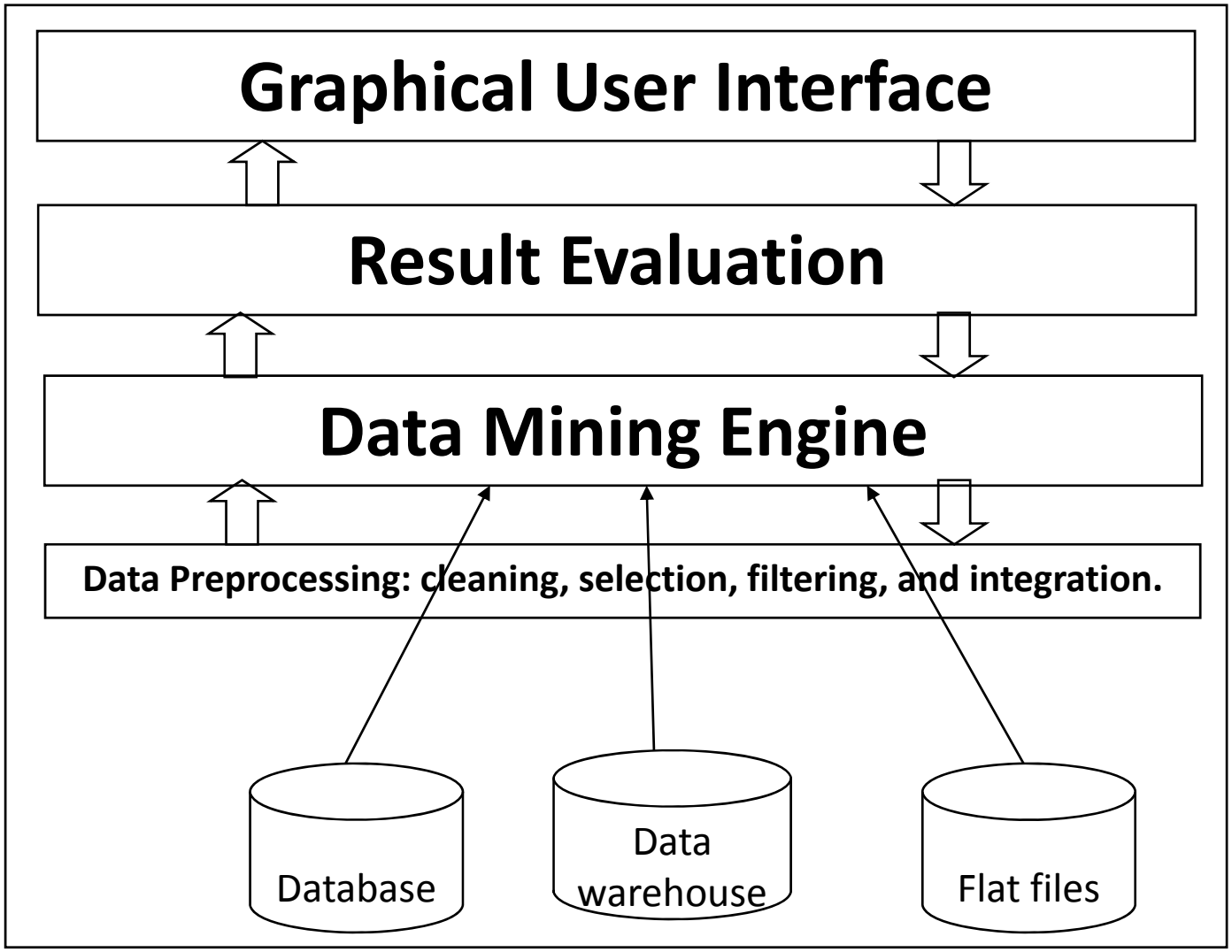
Knowledge Discovery (KDD) Process



Data Mining (DM), Decision Support System (DSS) and Business Intelligence (BI)



Architecture: Typical Data Mining System



Database vs data mining processing

- **Query:** Well defined (SQL)
- **Data:** Operational data
- **Output:** Precise Subset of database

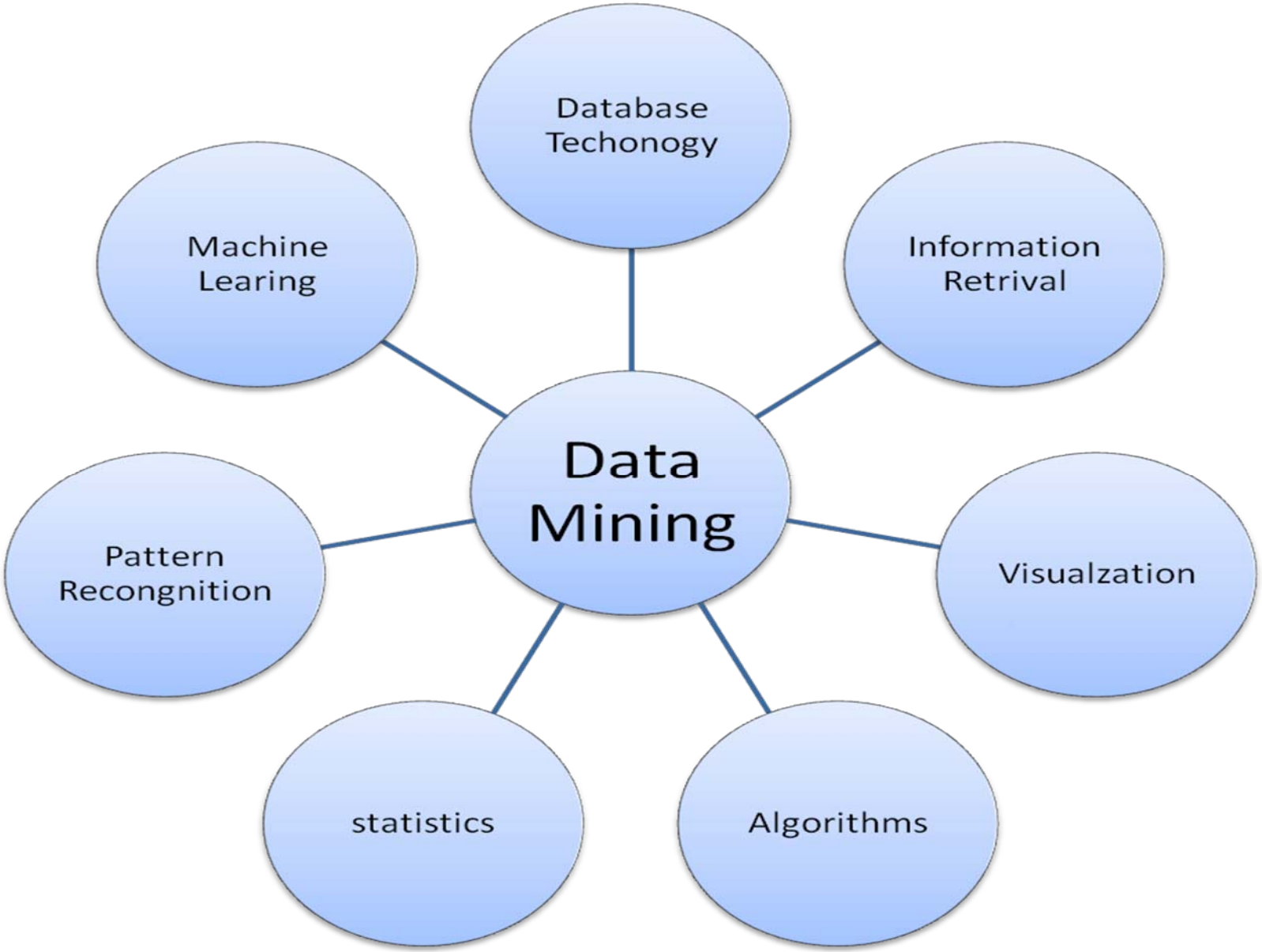
- **Query:** Poorly defined, No precise query language: Data Mining Query Language (DMQL)
- **Data:** Not operational data (warehouses)
- **Output:** Fuzzy, not a subset of database (**knowledge**)

Database vs. data mining processing: An example

- Find all credit applicants with last name of Smith.
- Identify customers who have purchased more than $10,000 in the last month.
- Find all customers who have purchased milk

- Find all credit applicants who are poor credit risks. (Classification).
- Identify customers with similar buying habits. (Clustering).
- Find all items which are frequently purchased with milk. (Association rules).

Data Mining: Confluence of Multiple Disciplines



Some Data Mining tools

- Open Source Data Mining Tools
  - Weka
  - Rapid Miner
- Non-open Source Data Mining Tools
  - SPSS
  - MS SQL 2005 Analytics Service (SSAS)
  - Oracle Data Miner (ODM)

Weka: The Bird

WEKA

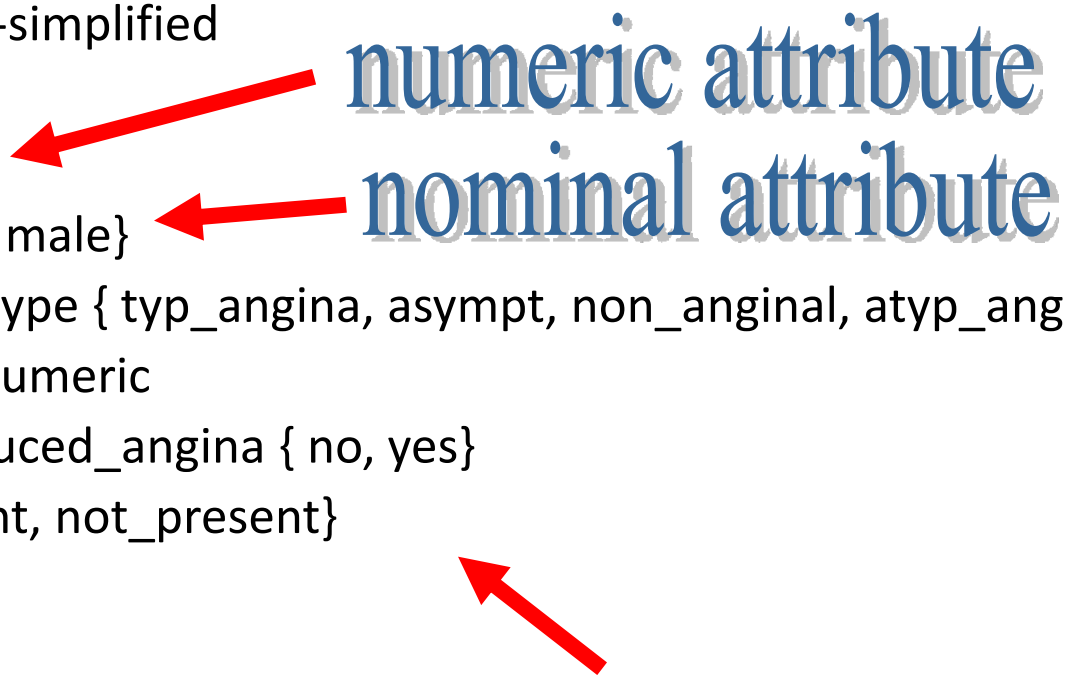
- Machine learning/data mining software written in Java (distributed under the GNU Public License)
- Used for research, education, and applications
- Complements “Data Mining” by Witten & Frank
- Main features:
  - Comprehensive set of data pre-processing tools, learning algorithms and evaluation methods
  - Graphical user interfaces (incl. data visualization)
  - Environment for comparing learning algorithms

WEKA deals with “flat” files

@relation heart-disease-simplified

@attribute age numeric
@attribute sex { female, male}
@attribute chest_pain_type { typ_angina, asympt, non_anginal, atyp_angina}
@attribute cholesterol numeric
@attribute exercise_induced_angina { no, yes}
@attribute class { present, not_present}

@data
63,male,typ_angina,233,no,not_present
67,male,asympt,286,yes,present
67,male,asympt,229,yes,present
38,female,non_anginal,?,no,not_present
...



Weka Explorer: pre-processing the data

- Data can be imported from a file in various formats: ARFF, CSV, C4.5, binary
- Data can also be read from a URL or from an SQL database (using JDBC)
- Pre-processing tools in WEKA are called “filters”
- WEKA contains filters for:
  - Discretization, normalization, resampling, attribute selection, transforming and combining attributes, …

Weka Explorer: building “classifiers”

- Classifiers in WEKA are models for predicting nominal or numeric quantities
- Implemented learning schemes include:
  - Decision trees and lists, instance-based classifiers, support vector machines, multi-layer perceptrons, logistic regression, Bayes’ nets, …
- “Meta”-classifiers include:
  - Bagging, boosting, stacking, error-correcting output codes, locally weighted learning, …

Weka Explorer: clustering data

- WEKA contains “clusterers” for finding groups of similar instances in a dataset
- Implemented schemes are:
  - *k*-Means, EM, Cobweb, *X*-means, FarthestFirst
- Clusters can be visualized and compared to “true” clusters (if given)
- Evaluation based on loglikelihood if clustering scheme produces a probability distribution

Weka Explorer: finding associations

- WEKA contains an implementation of the Apriori algorithm for learning association rules
  - Works only with discrete data
- Can identify statistical dependencies between groups of attributes:
  - milk, butter $\Rightarrow$ bread, eggs (with confidence 0.9 and support 2000)
- Apriori can compute all rules that have a given minimum support and exceed a given confidence

Weka Explorer: attribute selection

- Panel that can be used to investigate which (subsets of) attributes are the most predictive ones
- Attribute selection methods contain two parts:
  - A search method: best-first, forward selection, random, exhaustive, genetic algorithm, ranking
  - An evaluation method: correlation-based, wrapper, information gain, chi-squared, …
- Very flexible: WEKA allows (almost) arbitrary combinations of these two

Weka Explorer: data visualization

- Visualization very useful in practice: e.g. helps to determine difficulty of the learning problem
- WEKA can visualize single attributes (1-d) and pairs of attributes (2-d)
  - To do: rotating 3-d visualizations (Xgobi-style)
- Color-coded class values
- “Jitter” option to deal with nominal attributes (and to detect “hidden” data points)
- “Zoom-in” function

Weka: Performing experiments

- Experimenter makes it easy to compare the performance of different learning schemes
- For classification and regression problems
- Results can be written into file or database
- Evaluation options: cross-validation, learning curve, hold-out
- Can also iterate over different parameter settings
- Significance-testing built in!

Weka The Knowledge Flow GUI

- New graphical user interface for WEKA
- Java-Beans-based interface for setting up and running machine learning experiments
- Data sources, classifiers, etc. are beans and can be connected graphically
- Data “flows” through components: e.g.,

  “data source” -> “filter” -> “classifier” -> “evaluator”
- Layouts can be saved and loaded again later

Weka: try it yourself!

- WEKA is available at

  http://www.cs.waikato.ac.nz/ml/weka

- Also has a list of projects based on WEKA
- WEKA contributors:

  Abdelaziz Mahoui, Alexander K. Seewald, Ashraf M. Kibriya, Bernhard Pfahringer , Brent Martin, Peter Flach, Eibe Frank ,Gabi Schmidberger ,Ian H. Witten , J. Lindgren, Janice Boughton, Jason Wells, Len Trigg, Lucio de Souza Coelho, Malcolm Ware, Mark Hall ,Remco Bouckaert , Richard Kirkby, Shane Butler, Shane Legg, Stuart Inglis, Sylvain Roy, Tony Voyle, Xin Xu, Yong Wang, Zhihai Wang

Rapid Miner

- Rapid Miner (formerly YALE “Yet Another Learning Environment”)
- The world-leading open-source system for knowledge discovery and data mining.
- It is available as a stand-alone application for data analysis and as a data mining engine which can be integrated into own products.

Rapid Miner (Cont.)

- It is available in different flavours:
  - A free open-source version licensed under the GPL, a free version with an improved user interface.
  - Under a developer license (OEM) which allows the integration of RapidMiner as a powerful library even into proprietary products. Enhance your products with adaptability and innovative analytical features.

Rapid Miner: Features

- Freely available **open-source** knowledge discovery environment
- 100% pure **Java** (runs on every major platform and operating system)
- KD processes are modeled as simple **operator trees** which is both intuitive and powerful
- Operator trees or subtrees can be saved as **building blocks** for later re-use

Rapid Miner: Features

- Internal **XML** representation ensures standardized interchange format of data mining experiments
- Simple scripting language allowing for automatic **large-scale** experiments
- **Multi-layered data view concept** ensures efficient and transparent data handling

Rapid Miner: Features

- Flexibility in using RapidMiner:
  - **Graphical user interface** (GUI) for interactive prototyping
  - **Command line mode** (batch mode) for automated large-scale applications
  - **Java API** (application programming interface) to ease usage of RapidMiner from your own programs
- Simple plugin and extension mechanisms, a broad variety of **plugins** already exists and you can easily add your own

Rapid Miner: Features

- powerful plotting facility offering a large set of sophisticated **high-dimensional visualization** techniques for data and models
- **more than 400** machine learning, evaluation, in- and output, pre- and post-processing, and visualization operators plus numerous meta optimization schemes

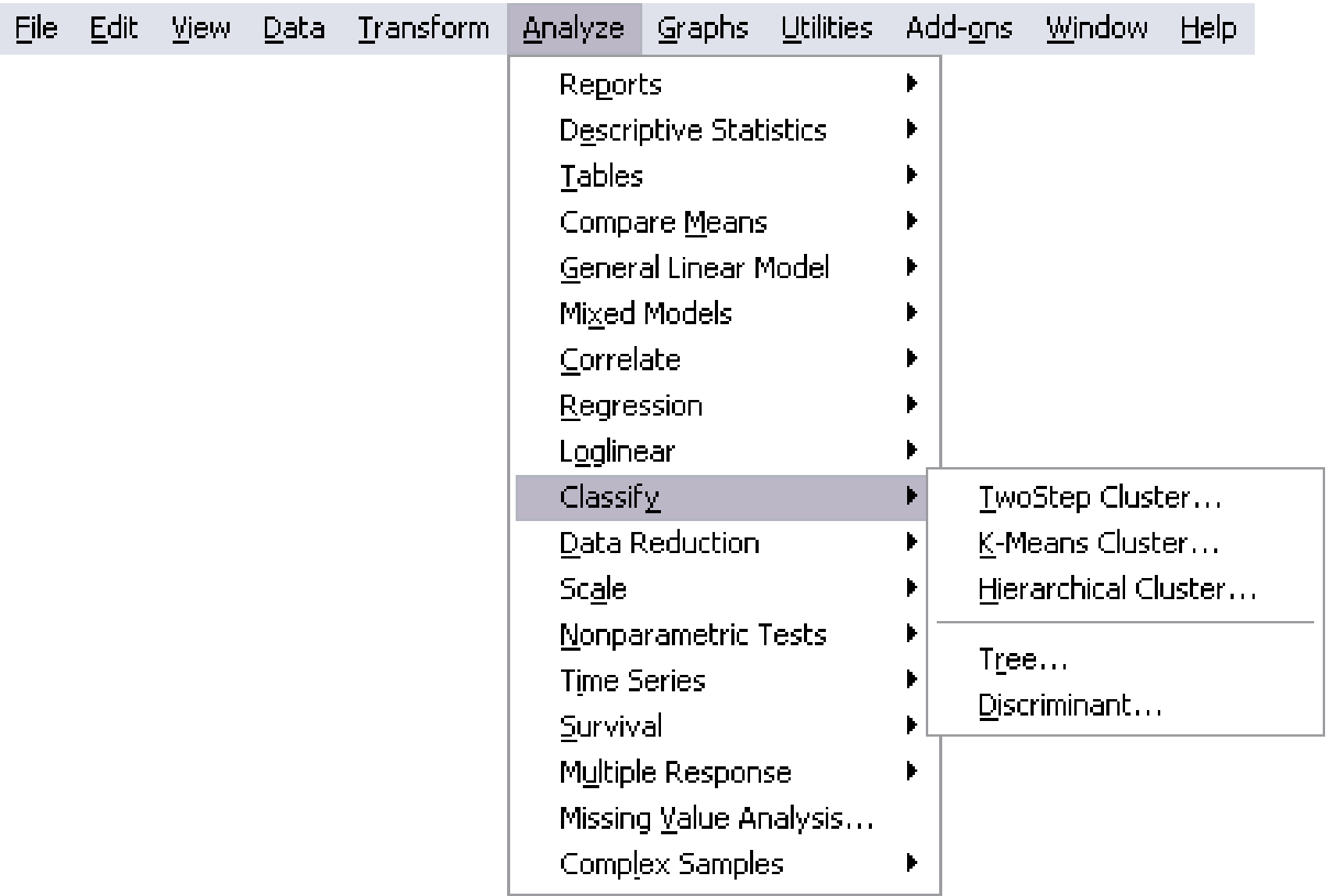
Rapid Miner: Features

- Machine learning library **WEKA** fully integrated
- RapidMiner was successfully applied on a wide range of applications where its rapid prototyping abilities demonstrated their usefulness, including **text mining**, **multimedia mining**, **feature engineering**, **data stream mining** and **tracking drifting concepts**, development of **ensemble methods**, and **distributed data mining**.

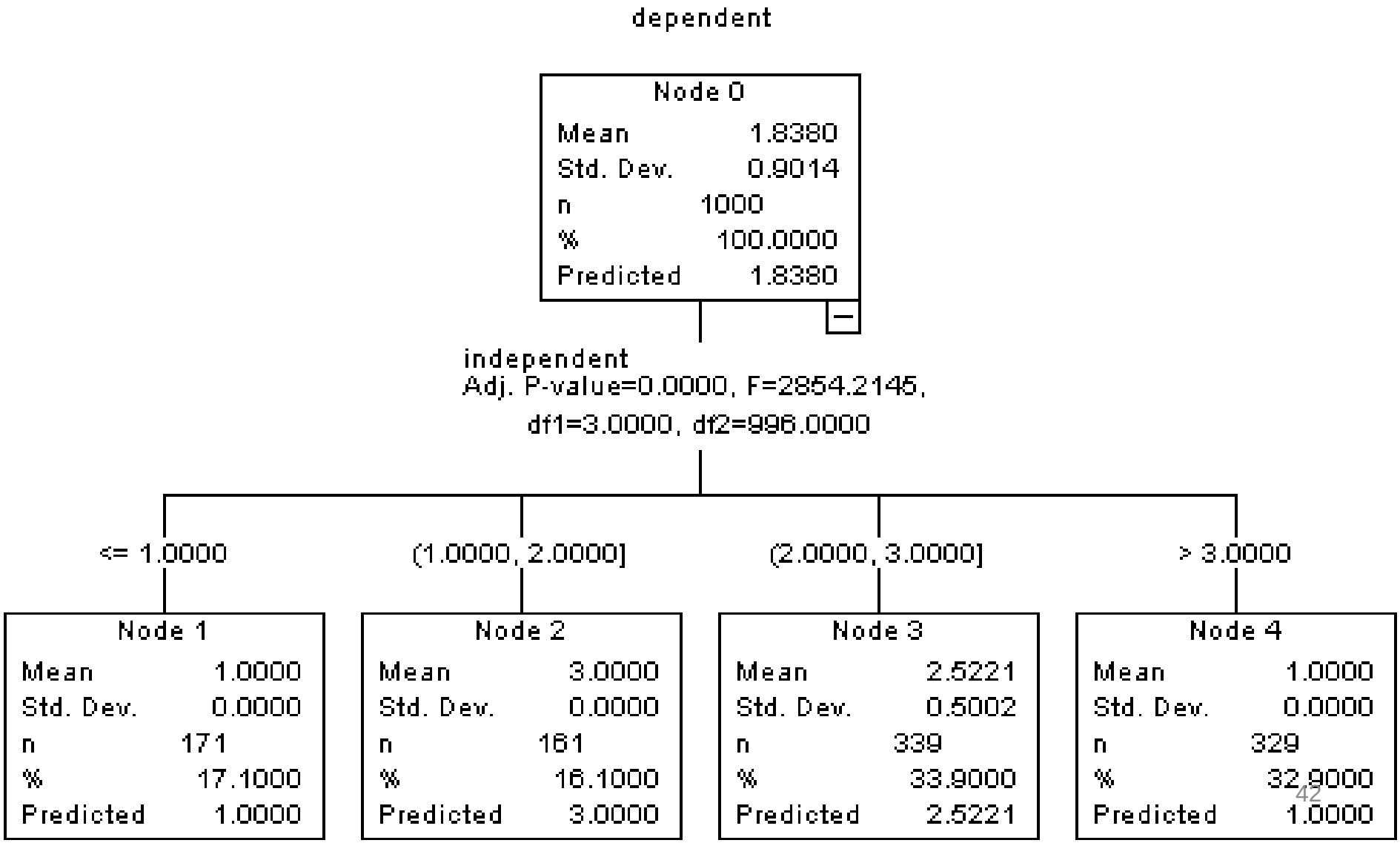
SPSS

- Analytical Software at **SPSS**.com.
- Specializing in **data mining**, customer relationship management, business intelligence and **data** analysis.

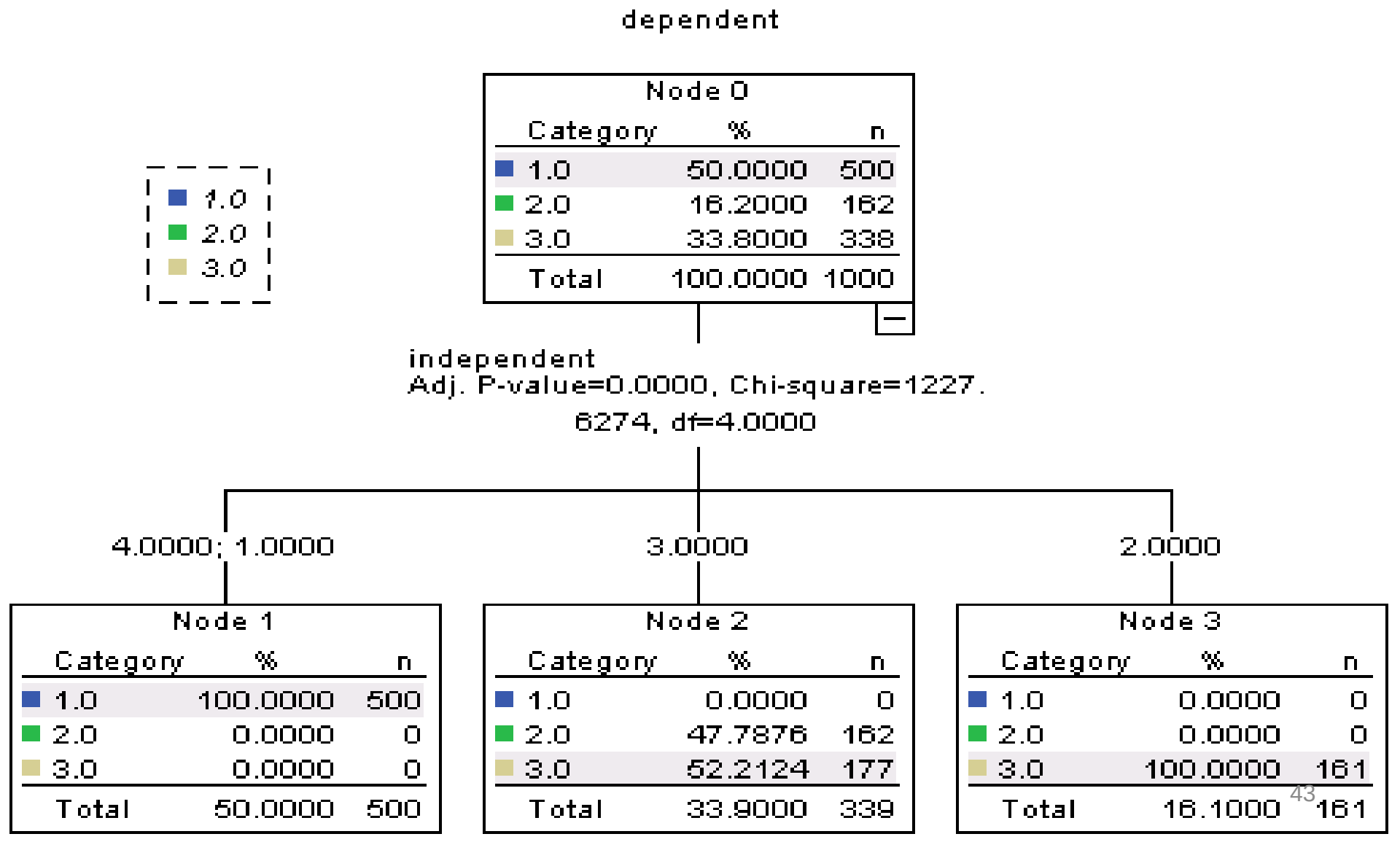
SPSS Classification tree



SPSS Classification tree (CONt.)

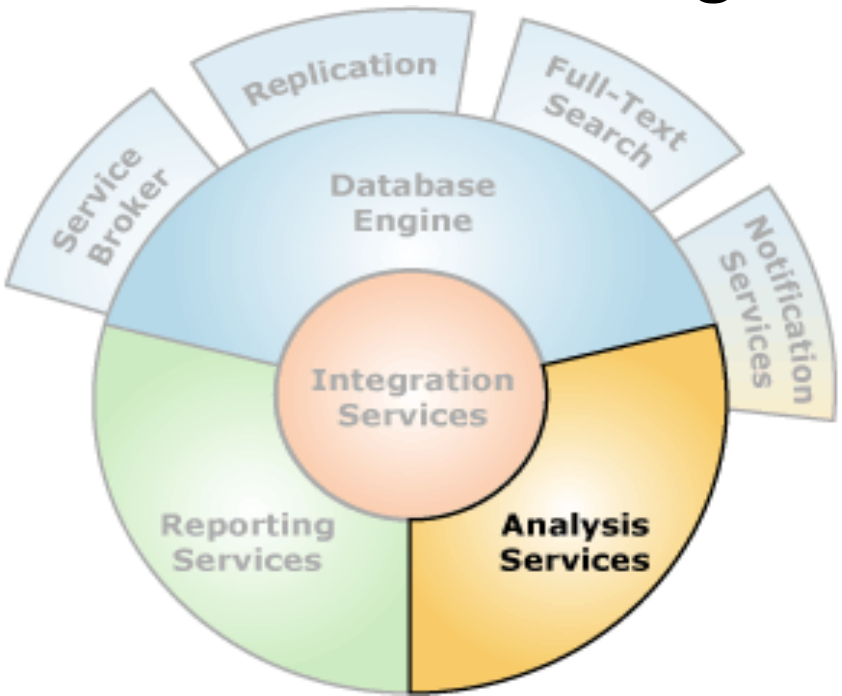


SPSS Classification tree (CONt.)



MS SQL 2005 Analytics Service (SSAS)

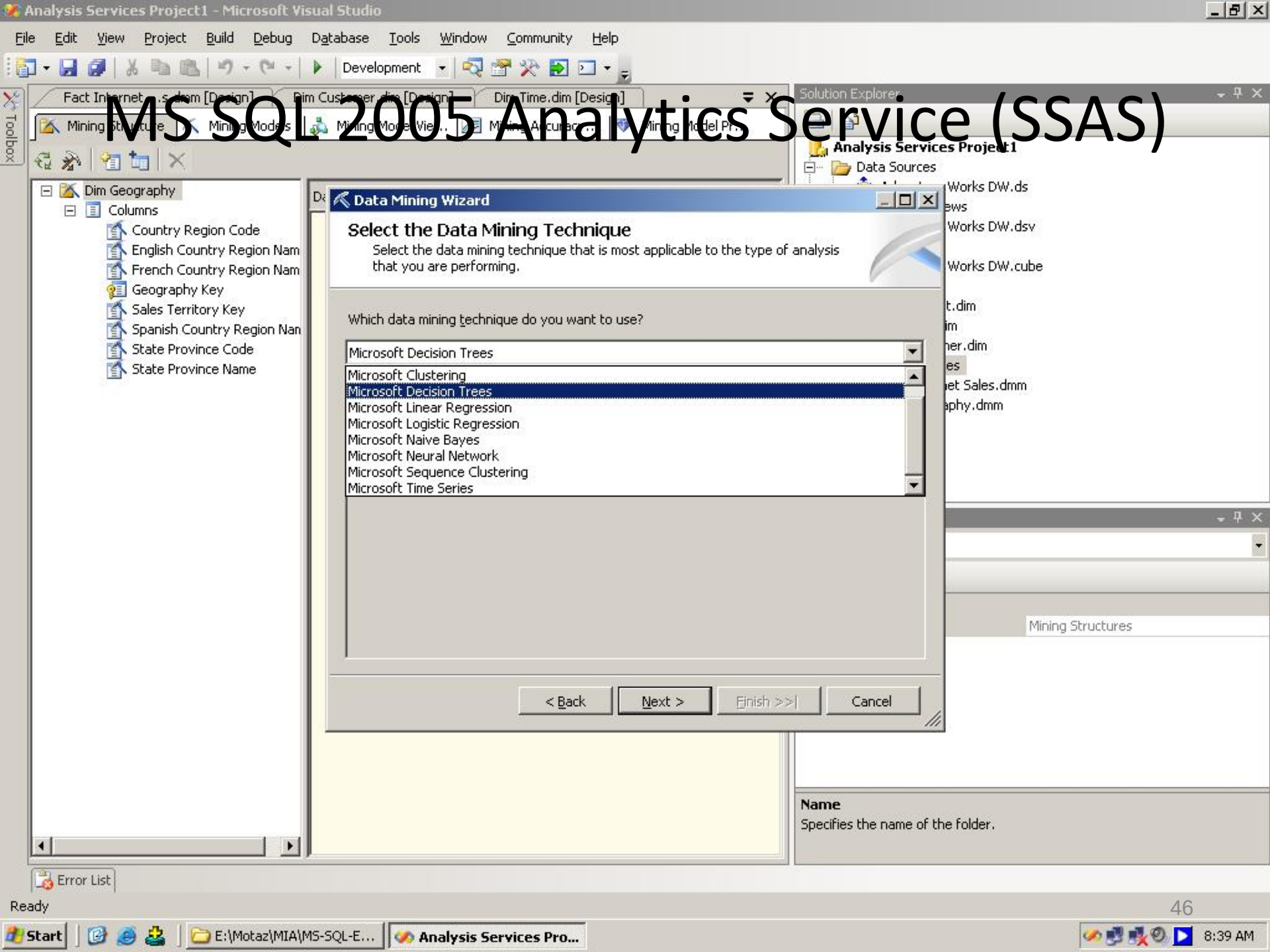
- Microsoft SQL Server 2005 Analysis Services (SSAS) delivers online analytical processing (OLAP) and data mining functionality for business intelligence applications.



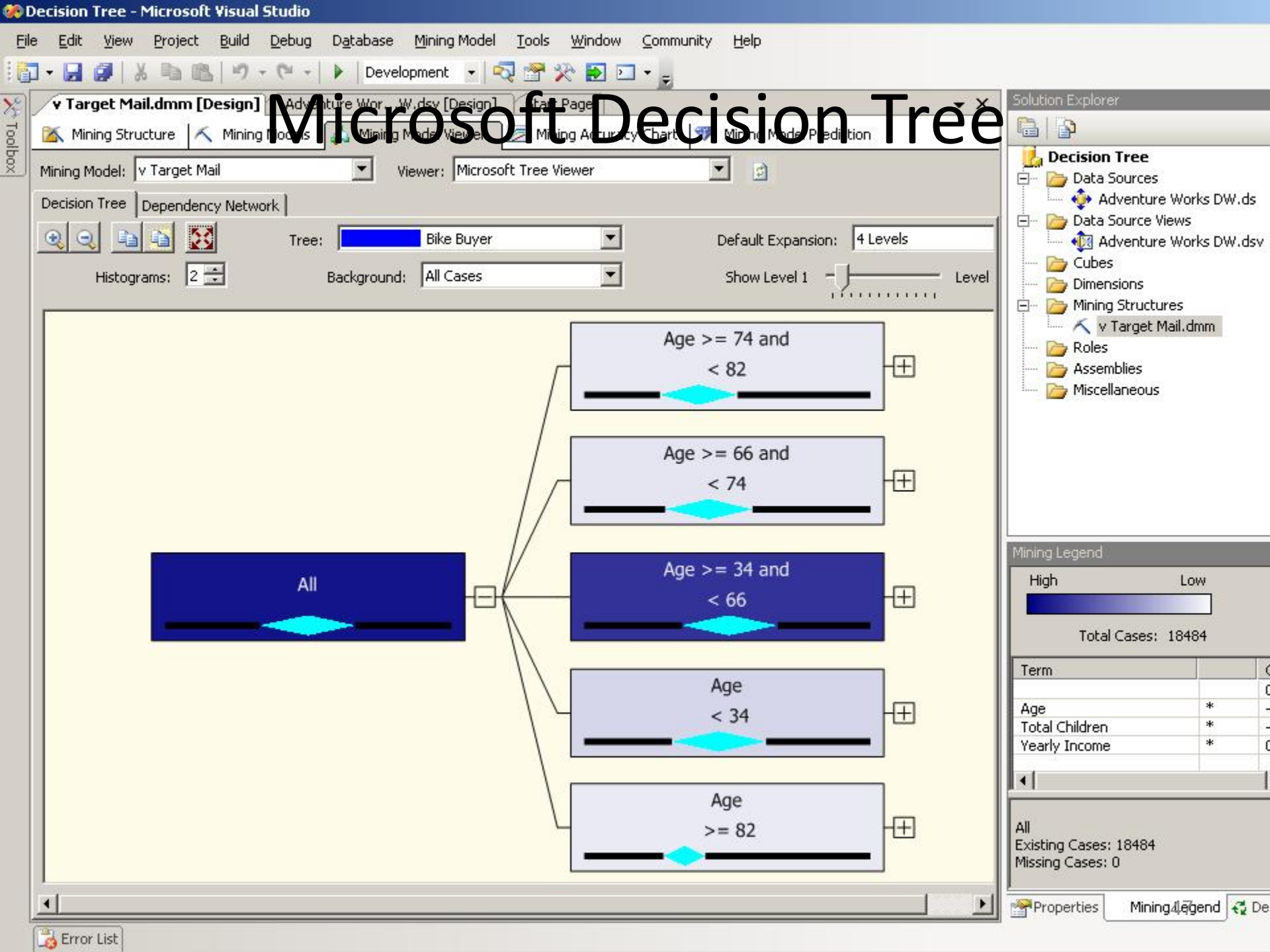
MS SQL 2005 Analytics Service (SSAS)

- Analysis Services supports OLAP by letting you design, create, and manage multidimensional structures that contain data aggregated from other data sources, such as relational databases.
- For data mining applications, Analysis Services lets you design, create, and visualize data mining models that are constructed from other data sources by using a wide variety of industry-standard data mining algorithms.

MS SQL 2005 Analytics Service (SSAS)



Microsoft Decision Tree



Oracle Data Miner

- Oracle Data Mining (ODM)
- An option to Oracle Database 10*g* Enterprise Edition
- Enables you to produce actionable predictive information and build integrated business intelligence applications.
- Using data mining functionality embedded in Oracle Database 10*g*, you can find patterns and insights hidden in your data.

Oracle Data Miner

- Application developers and integrators can quickly automate the distribution of new business intelligence—predictions, patterns and discoveries—throughout your organization.
- Oracle Data Mining enables business decision makers, data analysts, integrators, and IT to extract greater value from corporate data resulting in better informed business decisions that address a wide range of business problems.

Oracle Data Miner

Oracle Data Miner - View : MINING_DATA_BUILD_V

File View Data Activity Tools Help

Navigator

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Activity Tasks

Name

Activities Server

New Activity Wizard - Step 1 of 5: Model Type

Select Mining Activity Type

Choose a model function type and algorithm. Review the descriptions to be sure you have picked the most appropriate selections. Click the Help button for additional details.

Function Type: Anomaly Detection

Algorithm:

Description:

- Anomaly Detection
- Association Rules
- Attribute Importance
- Classification
- Clustering
- Feature Extraction
- Regression

- Maximum prediction accuracy that avoids overfit.
- Supports sparse transactional data.
- Supports text data.

Usage:

Standard binary supervised classification algorithms require the presence of both positive and negative examples (counterexamples) of a target class. Anomaly Detection requires only the presence of examples of a single target class. In outlier detection, typical examples in a distribution are separated from the atypical (outlier) examples.

Help < Back Next > Finish Cancel

101534	M	38	Married	Argentina	E: 90,000 - 1...	Assoc-A	Other	3	4
101535	F	33	NeverM	United State...	L: 300,000 a...	Bach.	Prof.	2	4
101536	M	59	Married	United State...	E: 90,000 - 1...	10th	Crafts	3	6
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101538	M	39	Married	Germany	I: 170,000 - 1...	Assoc-A	Crafts	3	6

Start | Oracle Data Miner ... | Clustering.JPG - Paint | Clustering Models.txt... | My Documents | E:\Motaz\MIA\ODM | 8:37 AM

Oracle Data Miner: Decision Tree

Result Viewer: MINING_DATA_B25773_DT

File Publish Help

Tree | Results | Build Settings | Task

Nodes ☐ Show Leaves Only — Show Levels: 3

Node ID	Predicate	Predicted Value	Confidence	Cases	Support
⊟0	true	M	0.6955	890	1.0000
⊟1	HOUSEHOLD_SIZE is in { 3 6-8 }	M	0.9882	422	0.4742
5	AGE <= 26.5	M	0.8148	27	0.0303
6	AGE > 26.5	M	1.0000	395	0.4438
⊟2	HOUSEHOLD_SIZE is in { 1 2 4-5 9+ }	F	0.5684	468	0.5258
⊟3	OCCUPATION is in { Armed-F Crafts Farming Handl...	M	0.8495	93	0.1045
7	AGE <= 27.5	M	1.0000	31	0.0348
8	AGE > 27.5	M	0.7742	62	0.0697
⊟4	OCCUPATION is in { ? Cleric. Exec. House-s Machin...	F	0.6720	375	0.4213
9	HOUSEHOLD_SIZE is in { 1 2 }	F	0.5512	254	0.2854
10	HOUSEHOLD_SIZE is in { 4-5 9+ }	F	0.9256	121	0.1360

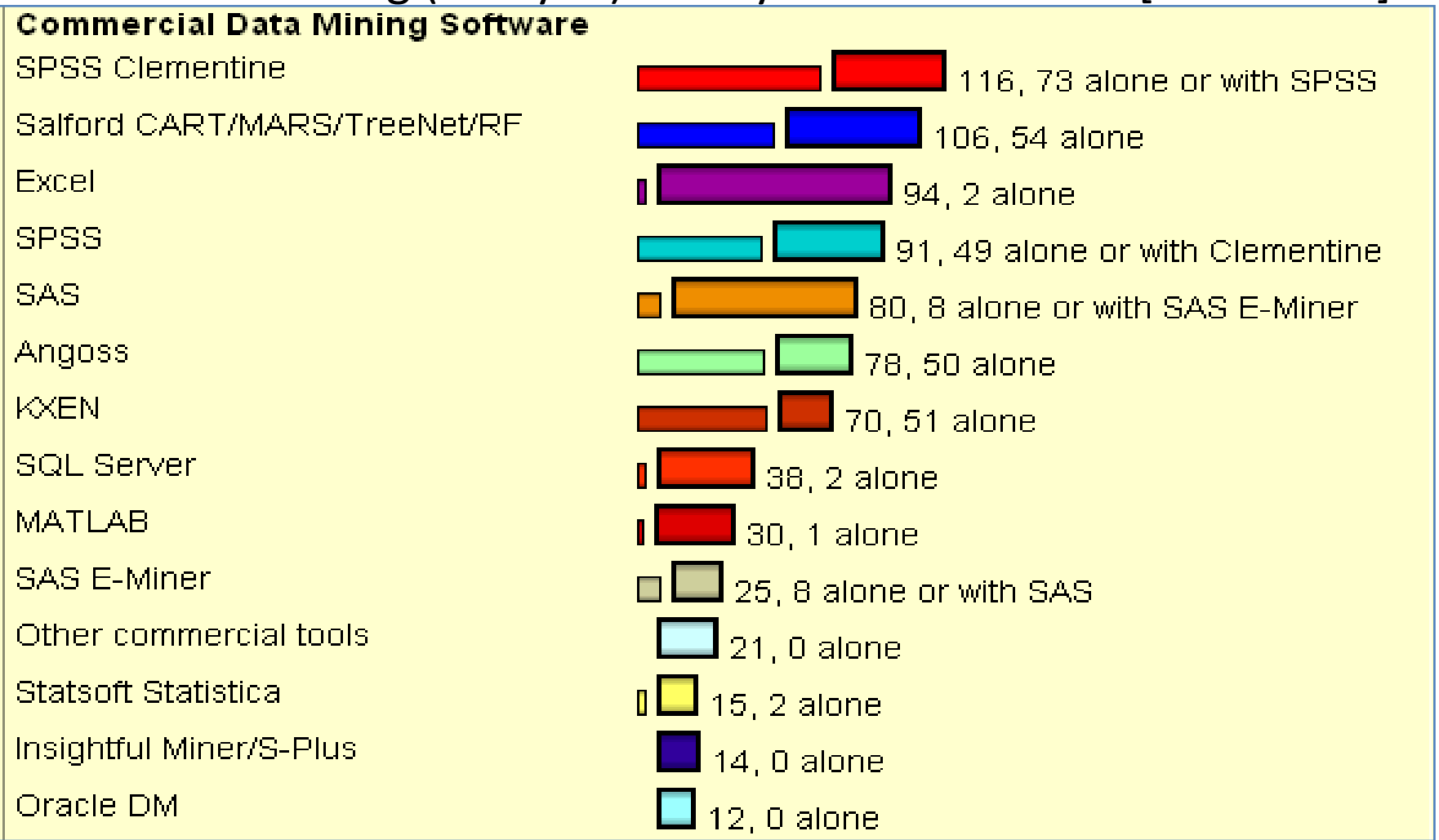
Predicted Target Value: M
Support: 0.0303
Confidence 0.8148
Cases: 27
Level: 2

Split Rules: (•) Full Rule ( ) Surrogate

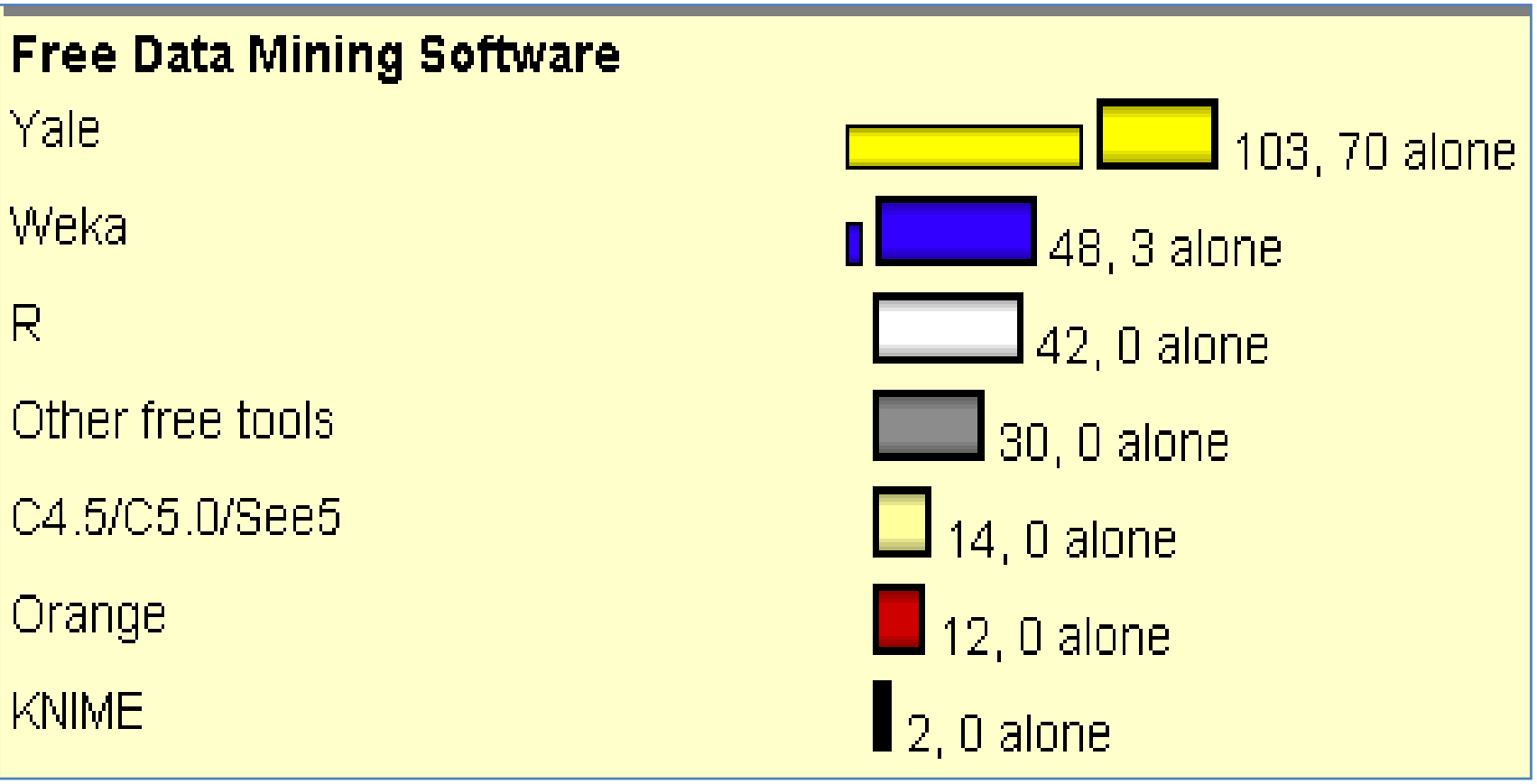
AGE <= 26.5 AND
HOUSEHOLD_SIZE is in { 3 6-8 }

Dnuggets.com Poll : Data Mining / Analytic Software Tools (May 2007)

- Data Mining (Analytic) tools you used in 2007: [534 voters]

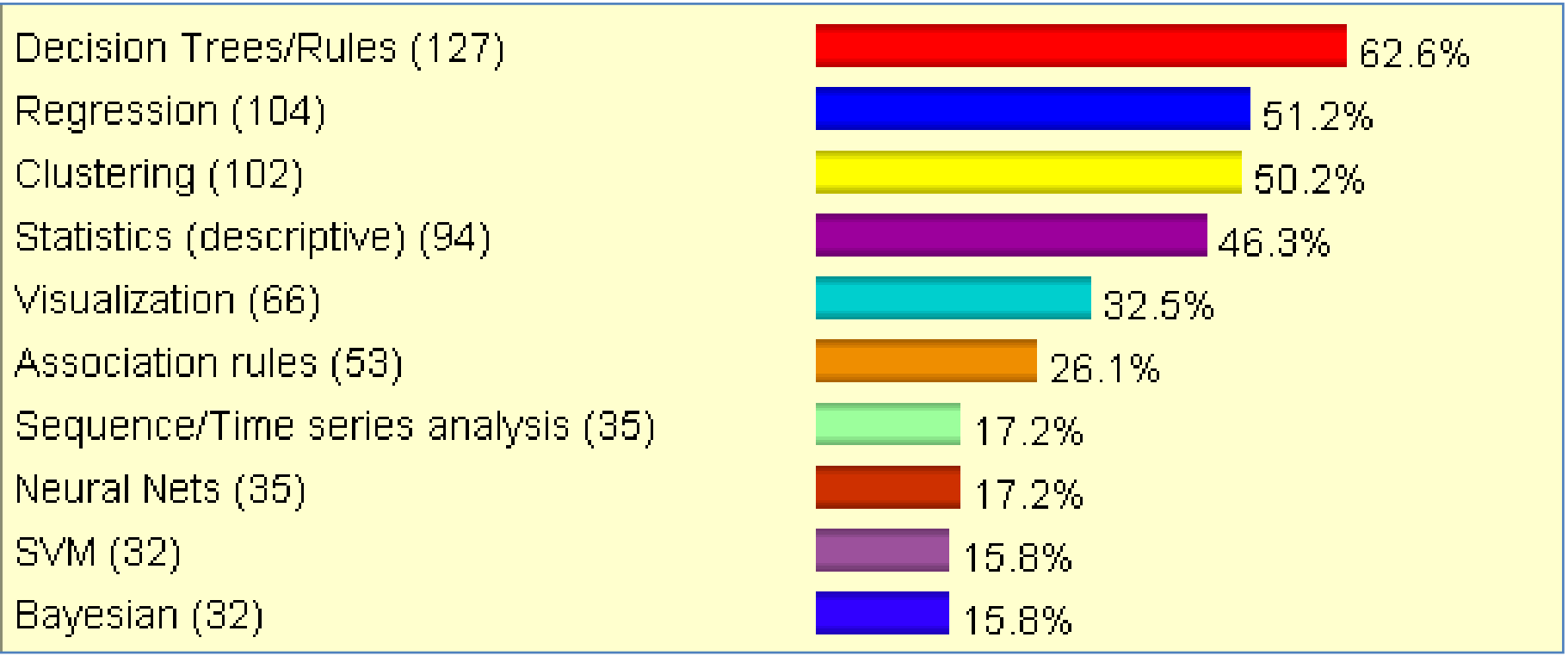


Dnuggets.com Poll : Data Mining / Analytic open source Software Tools (May 2007)



Kdnuggets.com Poll : Data Mining Methods (Mar 2007)

- **Data mining/analytic methods you used frequently in the past 12 months: [203 voters]**



Thank you: Q & A ?!