An Open Source Based Data Warehouse Architecture to Support Decision Making in the Tourism Sector

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An Open Source Based Data Warehouse Architecture to Support Decision Making in the Tourism Sector

Summary

In this paper an alternative Tourism oriented Data Warehousing architecture is proposed which makes use of the most recent free and open source technologies like Java, Postgresql and XML. Such architecture's aim will be to support the decision making process and giving an integrated view of the whole Tourism reality in an established context (local, regional, national, etc.) without requesting big investments for getting the necessary software.

Keywords: Tourism, Data warehousing architecture

JEL Classification: L83, C81

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Introduction: the actual Scenario

In the era of the Information Technology the impressive masses of data generated by the automatized systems (which contribute to make everyday life easier), the internal (administrative , productive , etc.) enterprise processes and, more generally, by the always more widespread informative network which links all the modern world's sectors (economical, social, cultural) represents today, for the anybody that has to take decisions, a crucial challenge in order to get a leadership position on the market or to efficiently manage resources. Because of such reasons, having an efficient Information System is of vital importance for being fast on perceiving new opportunities, discovering consumers preferences and behaviors, rationalizing the productive process through reducing wastes and optimizing productive and distributive cycles. In other words we can say that the decision making process can (or we should say must) be supported by a statistical system. Such instruments must be able to collect, select, organize and analyze the (usually, but not always) huge amount of data scattered over different operational data sources where, for operational data is intended all atomic and transactional data generated by the enterprises (hotels, campings, etc.) during the ordinary production process. The main purpose of such instruments is to extract information from raw data (which is useless, alone) and to convert it in knowledge that can be helpful for decision making. Those practices, techniques and instruments form a so-called Business Intelligence System. Such systems need to make use of a different platform for storing data because the traditional relational database architecture is not optimized for this kind of tasks. The reason to this relies in the fact that the strategical information needed by the decision maker is obtained by executing very complex queries (a query is a search interrogation on a database) joining different (usually) big tables. Relational databases, which are very good in transaction processing, are not that good for complex and join-intensive queries. During the past years the technology industry had poor results trying to do this type of analytical queries and reporting from their business system often degrading the performances of the system such that it would have stopped or be done after hours.

The Data Warehouse solution

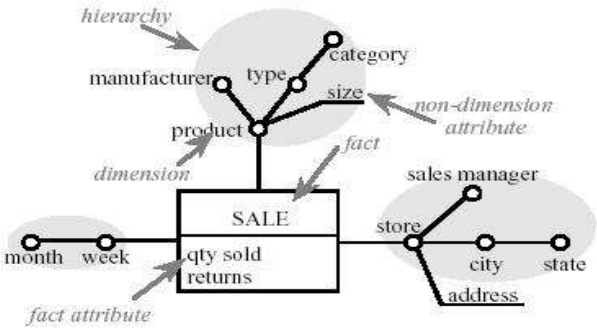
The platform that best fits the needs described before is a Data Warehouse which is a "subject-oriented, integrated, time-variant and non-volatile collection of data in support of management's decision making process" (B. Inmon, 1990) intended in the following way:

- Subject oriented: the data stored in a DW gives information about a particular subject instead of about a company's ongoing operations.
- Integrated: data is gathered into the DW from different heterogeneous sources and is merged into a coherent whole.
- Time-variant: All data in the warehouse is identified with a particular time period. This is a big

difference with the operational systems which store only necessary data for real-time use for the best operational performance and efficiency.

- Non-volatile: data is stable in a warehouse. More data is added but data is never removed. This enables management to gain a consistent picture of the whole business reality.

This definition remained reasonably accurate for almost ten years even if some changes have been made. A Data Warehouse, for instance, can be volatile due to the large amount of storage required (sometimes a DW can reach the size of some terabytes) only a certain amount of history is kept in the repository while the oldest is periodically discharged as soon as new data is loaded. In a Data Warehouse the data coming from the operational sources is processed by the ETL (Extraction, Transformation and Loading) instruments which collect, clean and load them into the repository. Such data is stored in fact and dimension tables where a fact represents a business measure and the dimension tables contain the textual descriptors of the business. It is possible to aggregate and separate data according to a predefined attribute hierarchy for each dimension. An useful instrument for conceptual visualization is the DFM (Dimensional Fact Model) which is shown in next figure.



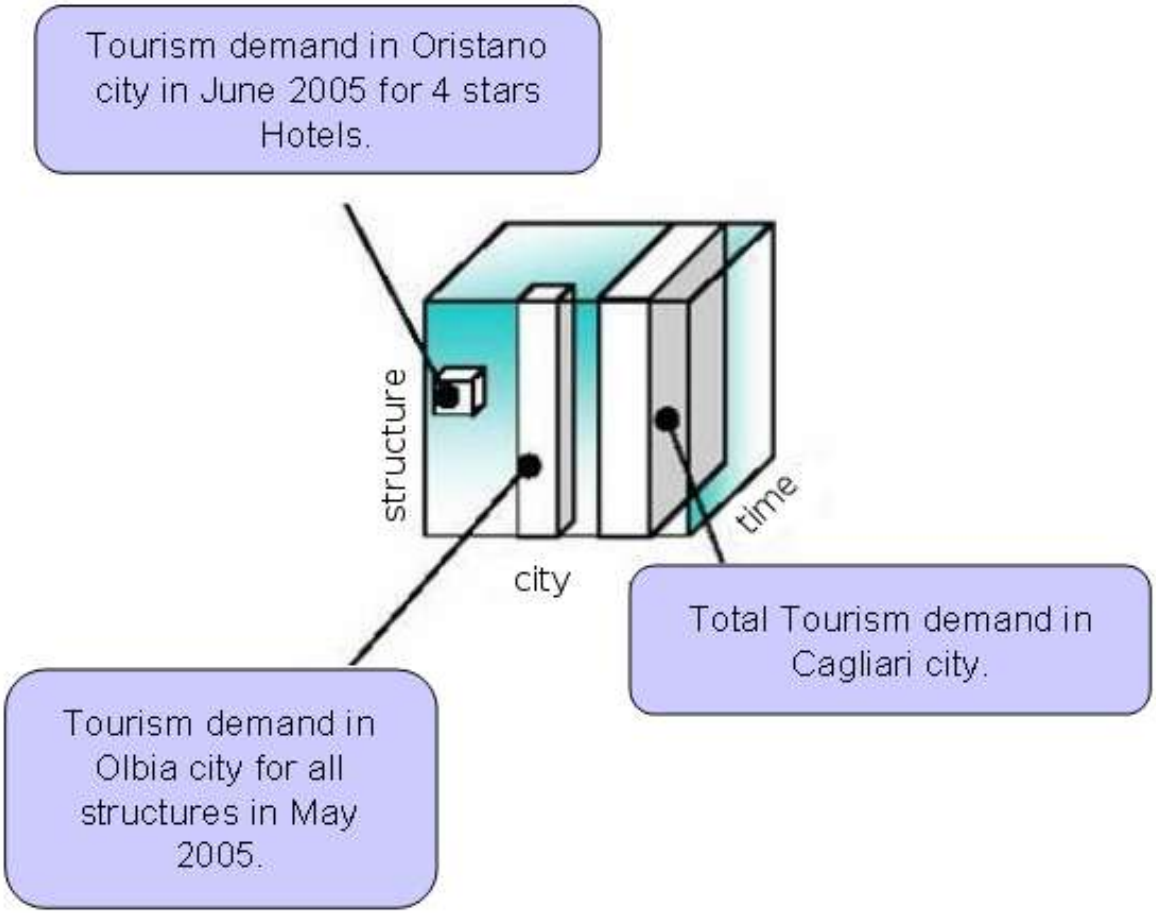
The DW can serve such data for analysis to traditional reporting tools (tables, charts, etc.) and more specific ones like Data Mining applications. The following figure shows the data flow from operational sources to the DW and from the DW to specific applications.

Information and knowledge extraction via OLAP tools

A well-known approach to DW data analysis is called OLAP (On Line Analytic Processing) which consists in obtaining a multidimensional view of the data by preparing a set of queries on the DW in which data can be aggregated and desegregated according to some predefined business categories. A better definition (http://www.olapreport.com) of OLAP applications is: Fast Analysis of Shared Multidimensional Information. The meaning is explained as follows:

- Fast: the system is targeted to deliver most responses to users in real-time (within about five seconds), with the simplest analyzes taking no more than one second and very few taking more than 20 seconds.
- Analysis: the system can cope with any business logic and statistical analysis that is relevant for the application and the user, and keep it easy enough for the target user.
- Shared: the system implements all the security requirements for confidentiality (possibly down to cell level) and, if multiple write access is needed, concurrent update locking at an appropriate level.
- Multidimensional: the system must provide a multidimensional conceptual view of the data, including full support for hierarchies and multiple hierarchies, as this is certainly the most logical way to analyze businesses and organizations.
- Information is all of the data and derived information needed, wherever it is and however much is relevant for the application. The capacity of various products is measured in in terms of how much input data they can handle, not how many Gigabytes they take to store it.

An OLAP application allows the decision maker to navigate through the multidimensional data structure by aggregating and desegregating data in real time on the base of the hierarchical structures of the dimensions. A simple example (just three dimensions for graphical representation) of what kind of queries can be performed with a Tourism oriented OLAP cube is shown in next figure.



Data Mining

Data Mining techniques are also used (by processing the data stored in a Data Warehouse platform) to extract knowledge patterns.
The main Data Mining techniques can be summarized as follows:

- Classification: it is defined a function or a model to assign a unit into one of pre-defined classes;
- Regression: it is defined a regression function or model to describe the dependence relation of a response variable on the basis of various predictors as well as to forecast future behavior and trends of the response;
- Clustering: it is identify an automatic procedure to find a partition of data units into classes on the basis of various characteristics observed on the data.
- Association: it is interesting to identify typological characteristics in the data yielding to find consensus rules or association rules relating various aspects of the phenomenon under analysis.
- Modeling: it is identified a general model to describe the significant relations of the variables by means of graphical tools (such as networks, trees, etc.) or parametric forms that permit the specific use of numerical scale for comparisons and interpretation.
- Analysis of Deviations: it is satisfied the purpose to get the most significant variations in the data with respect to the normative rules as well as past behavior.

Decision Support Systems

A DSS can be defined as an interactive, computer-based system intended to provide support to the decision-makers engaged in solving various semi- or full-structured problems involving multiple attributes, objectives and goals. Typical components of a (model-based) DSS are the transactional database, the user interface and the model management module. However, the methodological and technological developments of DSS are far from being considered mature, since complex, integrated decision-making is still done partially or completely manually. Some technological innovations and recently developed statistical learning tools have enabled far more powerful DSS functionality.
Three main phases are considered in the implementation of a DSS in order to simplify and contribute to decision-making processes:

- Intelligence, by collecting internal and external information to provide a correct and feasible definition of the decision problem.
- Design, by identifying suitable quantitative methodologies aimed to generate various problem-solving alternatives,
- Choice, by evaluating alternatives and selecting the best action on the basis of forecasting and scenario analysis.

The DSS is designed to get four typologies of fundamental operations:

- Reporting, aiming to provide, regularly, several queries to databases, yielding to statistical reports for a graphical analysis of business trends;
- Data mining, that consists in applying specific advanced statistical methodologies yielding to identify trends, pattern recognition, typological characteristics, data segmentation for classification purpose;
- What if analysis, aiming to build up specific scenarios that are useful for satisfying purposes related to planning and forecasting the future market trends;
- OLAP (On Line Analytical Process), leading to get "intelligent" queries (by means of specific operators such as Drill-Down, Roll-Up, Pivot) in real time but also in intuitive matter without taking care of the effective and logical structure of the data.

A case: Australian Tourism Data Warehouse

Data warehouses are not exclusively used for analyzing data but also for offering services. In the tourism field an example is given by the Australian Tourism Data Warehouse(ATDW), which is a joint initiative of the Government tourism organizations from all Australian States and Territories

and the Australian Tourist Commission. With the increased demand for tourism information, the States and Territories identified the need for a comprehensive database of Australian tourism product and destination information from a single "trusted" source. The ATDW has been developed to meet this requirement. Each State and Territory has agreed to integrate their tourism databases into the ATDW, which provides consistent, accurate, and extensive information on Australian tourism products and destinations to the global Internet user (see www.nttc.com.au/nt/nttc/services/atdw.html for details). Such big infrastructure is able to offer, as explained before, a unique and trusted access point to the whole Australian continent for anything which is related to Tourism. It is obvious that such system can also monitor the Tourism phenomenon as a whole and give any kind of statistical information is needed by a decision maker or prepare the right data for any Data Mining analysis. The numbers of that system's dimension are impressive but it is due, of course, to the fact that it stores data referring to a whole continent. Such big dimensionality fully justifies the use of extremely powerful (and expensive) instruments.

The proposed solution

The costs of data warehousing projects are usually very high and one of the reasons lies in the price of the licenses for all the software packages which are necessary to build up the Warehouse. A DW of a big Enterprise would quickly reach huge dimensions so a powerful database engine is needed to manage such big amount of data. Once the database server is on, the manager needs a powerful OLAP tool to analyze the data coming from the DB and the same thing happens when it comes to apply Data Mining techniques by using commercial software, which is usually very expensive. The cost of such software (Oracle, Microsoft Sql Server, IBM DB2, Salford CART, etc.) is usually extremely high so purchasing those tools is affordable (and justified) only for very big enterprises. But also small context (like small and medium enterprises, local Autorities, etc.) need statistical support for decision making because both enterprises are forced to compete (in a dimension whose main keyword is "globalization") with multinational companies and local Authorities are always more often called to constantly monitor the whole behavior of the context of interest (i.e. Tourism) in order to take decisions rapidly in order to correct any situation which is someway "out of control".

In such a scenario, this paper proposes an open-source based statistical decision support system architecture for the Tourism Decision Maker that has the need of analyzing data and formulating strategies. In other words we propose a Business Intelligence System architecture which can be used by Tourism-related local Authorities. Such Authorities requirements are very different from the ones of big enterprises. First of all, small costs are a must for local Authorities, because they don't have the economical availability that a big private enterprise do but, on the other hand, their operational systems tend not to produce the same huge amount of data. Small realities (like regional ones, for instance) won't produce the same mass of data that an international Company would do.

This means that such systems will have the advantage of not being very resources consuming because of the size of the operational systems that would feed such Data Warehouse.

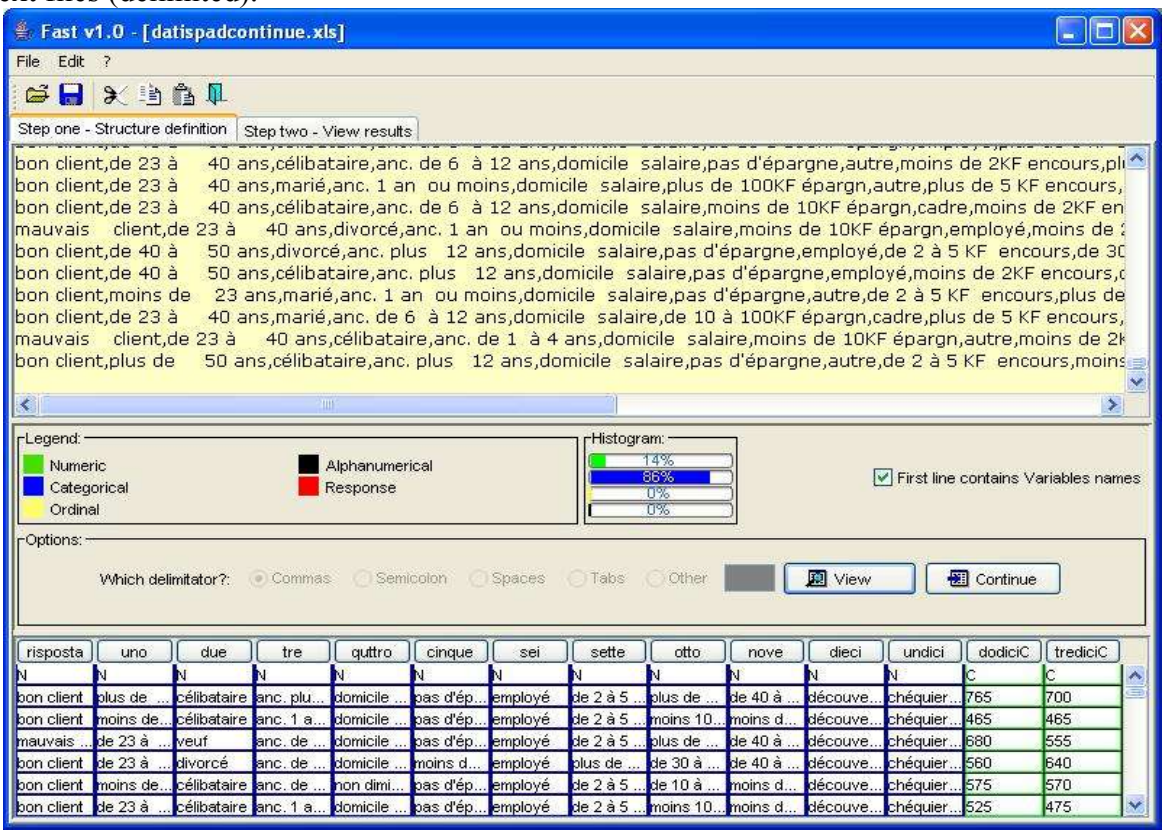
Such system will be designed ad-hoc for the smaller and constrained local Authority reality. The choice of the software architecture will go on open-source instruments which have proved to be valid alternatives (and, some times, competitors) to the very expensive traditional tools for Business Intelligence. By open source software we mean a particular license that states that such software must be given together with its own source code (there are also other specifications, for details see http://www.opensource.org/docs/definition_plain.php). Many open source software are also free to use in the sense that there is no license cost to pay. In particular the MySql and PostGreSql database platforms will be used as DB engines and some ad-hoc Java programs and Php scripts will be written to implement the most important features that the open-source Databases are missing. In order to make all the system usable via the web the well-known Apache web server will be used. It has to be noticed that Java programming language, Php scripting languages and PostGreSql are totally free, even for commercial use, while MySql DB has a very low commercial license fee, so a very big cut in licensing cost has will be done. The open source world has even more to offer: the

Apache http Server, for instance, which is totally free, will allow users to query the DW from a web-based front-end. The high quality level of those open source software is also proved by the fact that Oracle includes, for instance, Apache http Server with his Database Server and uses Java Technology for JDeveloper and Business Intelligence Beans software. In order to allow the decision maker to analyze the data coming out of the DW a rudimentary OLAP interface and some reporting instruments will be written in Java and the queries will be made available through the web using the Apache Http Server.

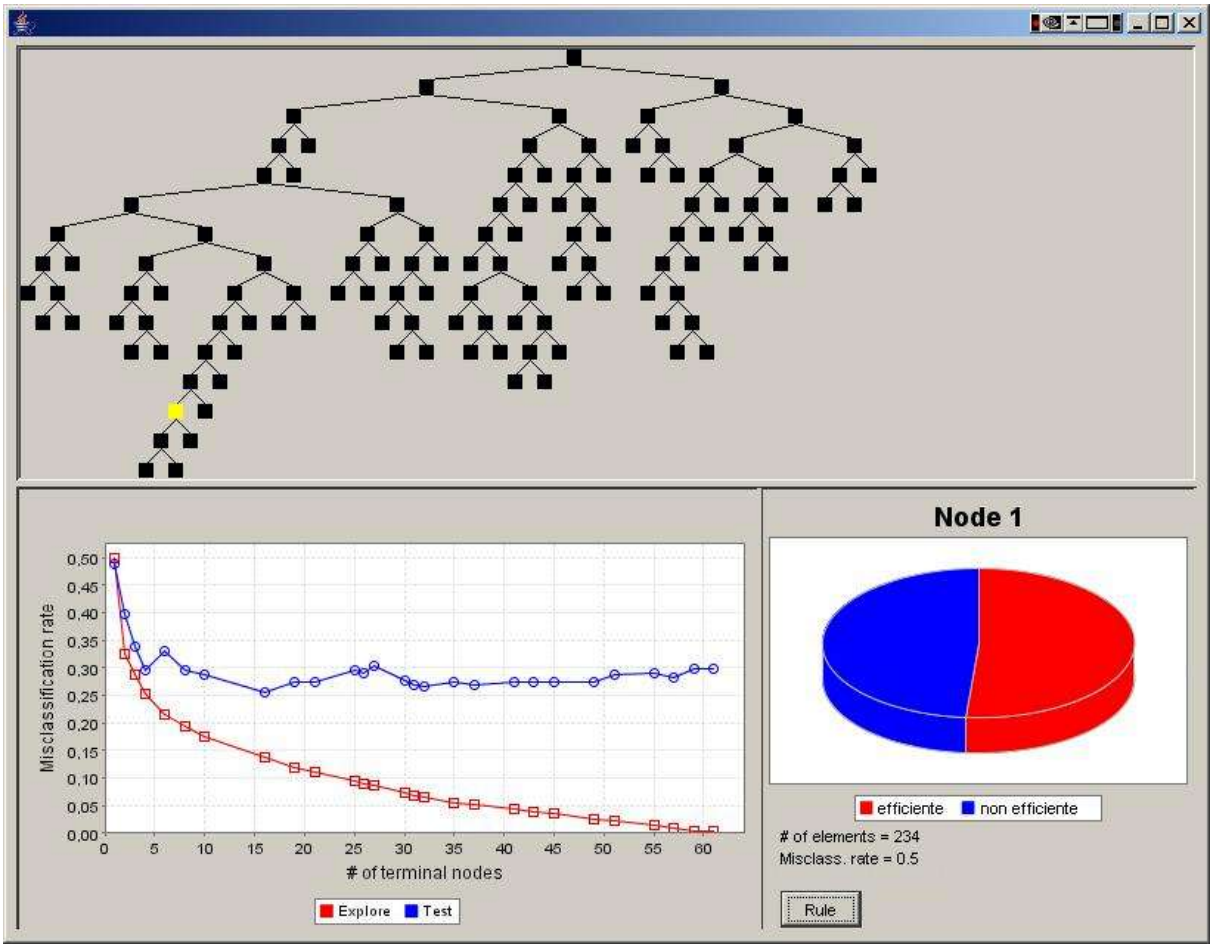
Data Mining with free tools

The strong interoperability between the various chosen platform (PostGreSql and MySql provide native JDBC driver that allow direct connection between the DB and a Java program) and the use of the XML language will grant communication between all the layers of the whole architecture and make it possible to easily plug other free Data Mining software like J-FAST (Miele, Mola and Siciliano, 2005), a Java-based program for building Classification and Regression Trees. J-FAST can easily connect (via the JDBC drivers) to all of the aforementioned databases engines (also to many others and the commercial ones). The next figure shows the interactive Data Import GUI of the J-FAST software. The plugin for letting J-FAST connect to the following sources are already available:

- Oracle DB.
- Mysql DB.
- PostGreSql DB.
- Excel files.
- Text files (delimited).



All the necessary ETL (Extraction, Transformation and Loading) can thus be written by making use of the Java and PHP languages. The J-FAST program builds Classification and Regression Trees, which are powerful Data Mining tools used for complex exploratory and predictive analysis (See Breiman et al., 1984, for further details). The next figure shows the J-FAST interactive GUI for browsing the results of an analysis.



Further developments: Heuristic Algorithms

Once a Data Warehousing system is active it will quickly collect very big amounts of data, and this makes another problem rise. Such problem lies in the fact that actual Data Mining procedures have problems to analyze very big datasets, so that just very some statistical techniques could be applied (univariate and bivariate statistics, time series modeling, etc). This would lead to have very big repository that "hide" information and knowledge which is not possible to perceive completely.
New modern procedures, which are based on the use of particular optimization techniques called Heuristic Algorithms, are being developed for treating datasets which are not analyzable by making use of classical Data Mining procedures (see Mola and Miele, 2005). The use of such techniques could be the answer to an actually crucial question about Data Mining about data dimensionality and computational performance.

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(lxxvii) This paper was presented at the Workshop on Infectious Diseases: Ecological and Economic Approaches held in Trieste on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics.
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