Airline Applications of Business Intelligence Systems

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Abstract: Airline industry is characterized by large quantities of complex, unstructured and rapid changing data that can be categorized as big data, requiring specialized analysis tools to explore it with the purpose of obtaining useful knowledge as decision support for companies that need to fundament their activities and improve the processes they are carrying on. In this context, business intelligence tools are valuable instruments that can optimally process airline related data so that the activities that are conducted can be optimized to maximize profits, while meeting customer requirements. An airline company that has access to large volumes of data (stored into conventional or big data repositories) has two options to extract useful decision support information: processing data by using general-purpose business intelligence systems or processing data by using industry specific business intelligence systems. Each of these two options has both advantages and disadvantages for the airline companies that intend to use them. The present paper presents a comparative study of a number of general-purpose and airline industry specific business intelligence systems, together with their main advantages and disadvantages.

Key Words: business intelligence, airline industry, big data, information technology, airline data analysis.

1. BIG DATA IN THE AIRLINE INDUSTRY

Big data is a term that appeared to indicate large collections of data that emerged in the last years, as a consequence of the unprecedented development of the information and communication technologies.

Big data was defined by Gartner, one of the companies acting at a global level on the information technologies area, as "high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making" [9]. Big data is considered to have three properties (Figure 1), also called the 3Vs of big data or the 3V model [10]:

- *Volume* – big data is stored in large quantities, making it impossible to analyze or process it without dedicated computer software and high computational power; big data also requires large storage devices, its quantity being only limited by the capacity of storage on these devices;
- Variety – big data is found in a wide variety of formats; the variety of the big data can pose an important problem for those who develop algorithms to explore or

process it; its variety also makes big data exploration much more challenging than conventional data sources such as structured data warehouses or relational databases.

- Velocity – big data is generated almost continuously from different technological or economic processes, such as those found in the airline industry: data related to air traffic, data coming from sensors in airplanes etc.
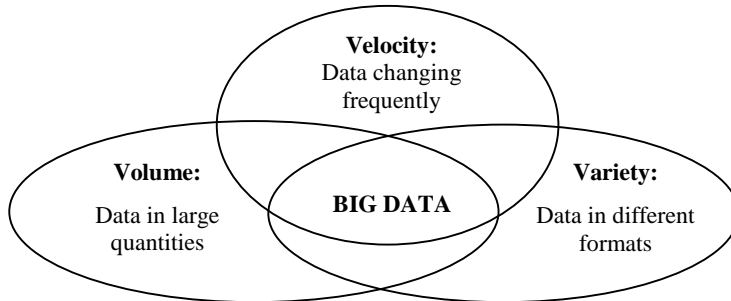

Figure 1. The three properties of big data

Additionally to the three previously mentioned properties of big data, there is a fourth one that can be mentioned: veracity [8]. Veracity refers to the poor quality of bug data. Large quantities of data come from uncertain sources and is unverified (for example data from the internet, like webpages, news etc.). Because of the veracity of data, contradictory results can be obtained during the analysis process with negative consequences regarding perceived reliability of big data analysis products. According to the IBM Big Data & Analytics Hub [8], one out of three business leaders doesn't trust the information used to make decisions and over 3 trillion dollars per year are spent due to inaccurate data. In this context, leveraging unstructured data for enterprise analytics is seen as an important factor [2].

Airline industry, as other similar industries, generates huge quantities of data (that can be considered *big data*, having all the properties previously described), this fact being both an opportunity and, in the same time, a challenge for the companies doing business in this area.

The accumulation of large data volumes in the aviation industry, as in other fields of activity, can be seen as an opportunity to exploit these data through specialized tools, obtaining valuable information that can be used by managers and other people in charge to develop and improve the processes that are carried on by the aviation companies. According to a paper published in 2013, "Airlines, airports, aircraft manufacturers, suppliers, governments and others in the global aviation space depend on data for operational planning and execution. Complex and concurrent data sets create immense technical and human challenges in collecting, sorting, and mining aviation databases. Aviation data sets exceed the capabilities of desktop computing" [1].

Aviation data come in large volumes, having varied formats and continuously, having all the characteristics of *big data*. *Big data* with provenance from the airline industry, according to the paper *Cross-Platform Aviation Analytics Using Big-Data Methods* can have multiple sources: flight tracking data, passenger information, airport operations, aircraft information, weather data, airline information, market information and air safety reports [1].

It has to be noted the fact that, even if the eight types of information previously mentioned are in some way interconnected, none of them can be used independently to form a global image about the airline industry domain. For this reason, we have to use the available information in correlation to obtain reports that are valid and useful for the airline

companies' managers. In this context, integration of available data appears to be the best action before data processing.

In Figure 2 is presented the proposed data circuit, from the provenance of data to their integration and processing through business intelligence systems.
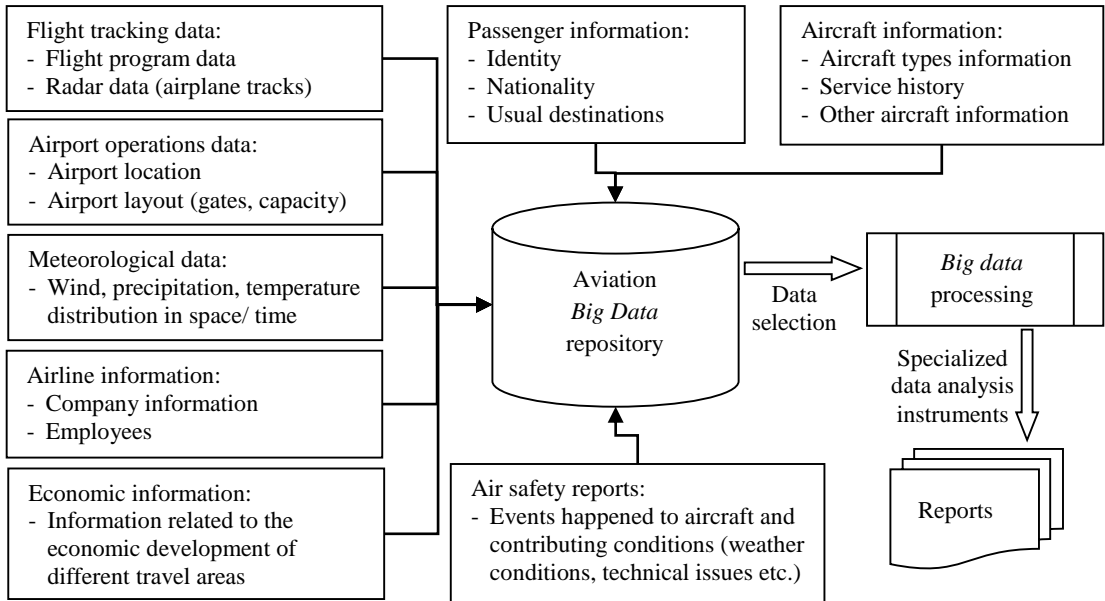

Figure 2. Aviation industry - data sources and processing

As it can be observed from the previous figure, data coming from various sources in the aviation industry are integrated into a common big data repository before they can be analyzed using specialized software.

To explore big data and offer decision support at all levels in a company special software systems have to be used, also known as *business intelligence/ business intelligence type systems*.

2. BUSINESS INTELLIGENCE SYSTEMS, INSTRUMENTS TO EXPLORE BIG DATA FROM THE AIRLINE INDUSTRY

Business intelligence systems received many definitions, some of which are outlined in the present section. As will be seen, business intelligence instruments can be applied to extract useful business information from the big data repositories associated with the airline industry. According to the book "*Business Intelligence Success Factors: Tools for Your Business in the Global Aligning Economy*" published in 2009, business intelligence (BI) is "a set of methodologies, theories, architectures and technologies that are used to transform raw data into useful information necessary for organizations to improve the economic activities that they are carrying" [5].

Chaudhuri and Narasayya define business intelligence as "a collection of decision support technologies for the enterprise aimed at enabling knowledge workers such as executives, managers and analysts to make better and faster decisions" [4].

Business intelligence is defined as "providing accurate information to the right people at the right time. The term means also the capability to transform existing data into information

that everyone in the organization can trust and which they can use to adopt effective decisions" [6].

Howson Cindi, in *Successful Business Intelligence* published in 2013, gives another definition to the concept of business intelligence. According to the author, business intelligence is a technology that allows people from all levels of an organization to access, interact and process data for an enterprise's management, to improve its performance, to discover new opportunities and to work more efficiently [7].

Techopedia [11] presents the main characteristics of *business intelligence* systems, defined as software used to collect data from separate data warehouses or data collections, which are in the same time connected in a stack type architecture with the purpose of processing and using them for solving different business problems. According to Techopedia, the essential functionalities of *business intelligence* systems are:

- Business processes performance and objectives achievement measurement (having benchmarking purposes) – for example measuring the process performances of an airline company related to the others, with the opportunity to improve one's processes in accordance to the best practices available at the moment;
- Quantitative analysis by predictive analytics, predictive modeling, business process modeling, statistical analysis – for example, by making predictions related to the passengers habits of travel, an airline company can optimize the schedule of aircraft, service intervals, stocks etc.;
- Reporting at department level or enterprise level through various techniques – an essential feature for any company, regardless of its domain of activity;
- Ability to use different tools to enable both entities inside and outside of the company to work through electronic data interchange (EDI) or by data sharing;
- Using knowledge management software to identify information within the company and make them available to those interested – mainly the managers of the company who can adopt informed decisions according to the results offered by the system;
- Using specific methodologies and procedures for implementing interactive information gathering techniques.

Big data poses new requirements to business intelligence tools. In this context, "traditional techniques, models, and methods must be redefined to provide decision makers with service of data analysis through the cloud and from big data" [3].

Taking into account the facts previously presented, it can be concluded that *business intelligence* systems for the airline companies are designed to optimally process airline related data so that the activities that are conducted can be optimized to maximize profits, while meeting customer requirements.

3. COMPARATIVE STUDY OF BUSINESS INTELLIGENCE SYSTEMS USED BY THE AIRLINE INDUSTRY

A company that has access to large volumes of data (stored into big data repositories) has two options to extract useful decision support information:

- Processing data by using general purpose *business intelligence* systems;
- Processing data by using industry specific *business intelligence* systems.

The general purpose business intelligence systems have the advantage that they are usually the most advanced systems on the market, with functionalities that make them suitable for analyzing big airline related data in a timely manner, having interactive

interfaces for presenting the analysis results. These types of business intelligence systems are the most flexible on the market, their functionalities being designed to fit a wide variety of companies. However, the specialized business intelligence systems may need to be customized on the data available to the airline companies and to their individual needs.

On the other hand, the specialized business intelligence systems designed for companies carrying on activities in the airline industry are designed around the necessities of airline companies. They have functionalities that enable them to offer answers to specific problems, being more specialized tools.

General-purpose business intelligence tools

Some of the best known *business intelligence* software products will be analyzed in the present section with the purpose of making a comparison between them and outlining the advantages and disadvantages of using such tools in the airline industry.

Table 1 presents some general-purpose business intelligence tools, together with their advantages and disadvantages. The advantages and disadvantages presented are synthetized after consulting several dedicated websites with users' opinions.

Table 1. General-purpose *business intelligence* products

No.	Business intelligence software product	Advantages	Disadvantages

1.	IBM Cognos Business Intelligence Software	• Multiple analysis tools:
		  o What if analysis;
		  o Trend analysis;
		  o Advanced analysis;
		  o Analytical reporting;
		• Self-service functionality – enables working offline or on mobile devices;
		• Interactive dashboard, friendly user interfaces;
		• Interactive operation for multiple users;
		• Integration with other APIs;
			• Relatively high entry cost compared to other similar software products;
			• Not designed for beginner or inexperienced users;
			• Difficult error tracking as error messages contain little useful information;
			• Large installer compared to other similar software products;

2.	Birst Software	• Compatible with a wide array of data sources; • Refines multiple heterogeneous data into a uniform business data tier; • Assures accuracy and consistency of data; • Interactive dashboard, friendly user interfaces; • Works on both cloud and local data; • Easy to integrate with other products;	• Administration operations are more difficult than on other similar software products; • Needs good system resources to offer results in a timely manner; • Some users complain about the user interface which they say is a bit confusing; • High cost for small companies;

3.	SAP Business Objects business	• Multiple analysis tools:
		  o Ad-hoc analysis;
		  o OLAP;
			• The software interface is not very user friendly according to some users;

	intelligence	○ Predictive analysis; ○ Trend indicators; • Works on both on premises and cloud data; • Users can easily retrieve their own data without technical support; • Mobile device compatible; • SAP offers training for the users;	• Users need to have minimal tech knowledge to use this software; • Confusing licensing for the customers; • Maintenance costs have to be considered;
4.	Oracle Business Intelligence Foundation Suite 11g	• Multiple analysis tools: ○ Ad-hoc analysis; ○ OLAP; ○ Predictive analysis; ○ Profit analysis; • Ideal to both small and large users; • Works on both on premises and cloud data; • Works on both traditional data sources and big data; • Users can easily retrieve their own data without technical support; • Accessible cost for small companies; • Includes eight dedicated platforms;	• Difficult and costly customization for a company's needs; • Upgrade a little difficult as reported by a number of users; • Complex interface for the users;
5.	Tableau business intelligence	• Multiple analysis tools: ○ Ad-hoc analysis; ○ OLAP; ○ Predictive analysis; ○ Trend indicators; • Can handle local or cloud data but intended mainly for cloud data; • Simple to use intuitive interface; • Fast operating platform; • Mobile devices compatibility;	• Costly for small to medium businesses; • Some users complain about OLAP functionalities being relatively slow; • The great complexity of the product makes it confusing to novice users;
6.	Microsoft SharePoint business intelligence	• Microsoft Office compatibility (MS Excel, MS PowerPoint etc.); • Web based application – easily accessible to different people; • Multiple analysis tools: ○ Ad-hoc analysis; ○ Predictive analysis;	• Does not work on all mobile devices; • Requires some tech knowledge from users; • May require additional technical support inside the company.

Airline companies can use with success any of the business intelligence software products described in the previous table. As airlines are usually large companies, they have to choose business intelligence software that best suits their needs, offering business solutions at all company levels.

Airline specific business intelligence products

Over the last years, some business intelligence systems specific to the airline industry were developed. These systems are optimized to operate on data specific to the airline industry as presented in the first part of the present paper.

Two of the most used airline industry specific business intelligence products are presented in Table 2, with their main characteristics as advertised on the official websites.

Table 2. Airline industry specific business intelligence products

No.	Business intelligence software product	Main characteristics
1.	Teradata Airline Decisions	- Passenger management functionalities that helps airlines to maximize airplane usage while avoiding overbooking; - Shows passenger trends/ behavior according to the available data; - Offers insight into the causes of trends that are observed; - Multiple analysis tools: - Ad-hoc analysis; - Exception alerts;
2.	IATA Business Intelligence & Statistics Services	- Multiple tools designed for the airline industry; - Is different from other business intelligence software providers through the fact that it also offers access to industry specific data; - Access to airline specific databases (AirportIS database); - Benchmarking tools related to customer satisfaction (AirSAT); - Different reports related to the airline industry (cargo, market analysis etc.); - Is useful not only to airline companies, but also to other agents operating in the transportation domain; - Offered at a global level, with globally gathered data;

It can be observed that airline industry specific *business intelligence* tools come with some facilities that are essential for the companies acting in this field of activity. The availability of airline specific data is a big advantage for such companies, a known fact being that the results obtained through such software products cannot be better than the available data.

4. CONCLUSIONS

Airline industry, as other similar industries, generates huge quantities of data (that can be considered big data, having properties like high volume, velocity and variety), this fact being both an opportunity and, in the same time, a challenge for the companies doing business in this area. The accumulation of large data volumes in the aviation industry, as in other fields of activity, can be seen as an opportunity to exploit these data through specialized tools, obtaining valuable information that can be used by managers and other people in charge to develop and improve the processes that are carried on by aviation companies.

In the presented context, data coming from various sources in the aviation industry has to be integrated into a common big data repository before being analyzed by means of specialized software. To explore big data and offer decision support at all levels in a company, special software systems have to be used, also known as *business intelligence/ business intelligence type systems*.

Business intelligence systems for the airline companies are designed to optimally process airline related data so that the activities that are conducted can be optimized to maximize profits, while meeting customer requirements.

Analyzing the different business intelligence tools available on the market, it was concluded that a company that has access to large volumes of data has two options to extract useful decision support information: processing data by using general purpose *business intelligence* systems or processing data by using industry specific *business intelligence* systems. After presenting both the general-purpose and airline industry specific *business intelligence* tools, it was concluded that the former offer to companies more flexibility and a wider range of instruments, but, in the same time, they are not as adapted to the needs of airline companies as the latter. On the other hand, dedicated airline industry *business intelligence* systems offer solutions to specific problems that airline companies are facing, offering even access to specific data interesting to such companies. Dedicated airline industry *business intelligence* systems are not only useful to airline companies, but also to others involved in related businesses.

Further research can be conducted regarding the possibility to integrate into a common platform the advantages of both general purpose and dedicated business intelligence systems (flexibility, performance, multiple functionalities, access to industry specific data).

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