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Real time business intelligence in supply chain analytics

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Abstract

Purpose – Rapid innovation and globalization have generated tremendous opportunities and choices in the marketplace for firms and customers. Competitive pressures have led to sourcing and manufacturing on a global scale resulting in a significant increase in products. The paper tries to identify the need for real time business intelligence (BI) in supply chain analytics.

Design/methodology/approach – The paper provides argument and analysis of the advantages and hurdles in BI.

Findings – The paper focuses on the necessity to revisit the traditional BI concept that integrates and consolidates information in an organization in order to support firms that are service oriented and seeking customer loyalty and retention. Enhancing effectiveness and efficiency of supply chain analytics using a BI approach is a critical component in a company's ability to achieve its competitive advantage.

Originality/value – This paper furthers understanding of the issues surrounding the use of BI systems in supply chains.

Keywords Supply chain management, Business analysis, Information systems

Paper type Conceptual paper

1. Introduction

During the last ten years, the approach to business management across the entire globe has deeply changed. The firms have understood the importance of enforcing achievement of the goals defined by their strategy through metrics-driven management. In the twenty-first century, organizations are evolving into new forms based on knowledge and networks in response to an environment characterized by indistinct organizational boundaries and fast-paced change. Researchers Gangadharan and Swamy (2004) identify new and complex changes that are emerging which will force enterprises to operate in entirely new ways. Organizations are experiencing environmental changes characterized by indistinct organizational boundaries and fast-paced change. As a result firms need appropriate decision support infrastructures in order to face these challenges.

Firms are experiencing environmental changes resulting from the new economics of information and the increasingly dynamic and global nature of competition (Evans and Wurster, 2000; D'Aveni, 1994). Therefore, as pointed out by Dijksterhuis *et al.* (1999) organizational survival depends on the construction and integration of knowledge fostering the adaptation to the environment, as well as stimulating environmental changes through the firm's knowledge and practices. The key drivers examined by Doherty *et al.* (2003) for underlining change are the application of information technologies (IT) and systems in any organization. IT now is ubiquitous and increasingly critical part of the fabric of the modern organization, supporting its day-to-day operations and all aspects of the decision making process as well as its strategic position. Gottschalk and Berg (2007) investigated the role and effective use of information systems. As a result, Mahoney (2002) the investments in IT that enable differentiation are of ever-increasing importance.

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Several surveys including those from Gartner and Forrester report that most of the firms are interested in investing in business intelligence (BI) systems. It is to be noted that despite major investments in enterprise resource planning (ERP), supply chain management (SCM) and customer relationship management (CRM) over the last decade businesses are struggling to achieve competitive advantage. This may be due to the information captured, or not captured, by these systems. Any corporation would look forward for one goal called "right access to information quickly". Hence, the firms need to support the analysis and application of information captured in order to make operational decisions. Say for marking seasonal merchandise or providing certain recommendations to customers, firms need right access to information quickly. Implementing smarter business processes is where BI influences and impacts the bottom line and returns value to any firm.

Managing an enterprise requires access to information and efficient data management in order to monitor activities and assess performance of various business processes. It becomes challenging to understand and assess the information about the processes of an organization. This is due to the information systems that collect and process vast amount of data in various forms in organizations.

To survive in the running stream of rapidly changing, increasingly competitive global market and increasingly volatile consumer and market behavior and rapidly shortening product life cycles, business enterprises today need to (Gangadharan and Swamy, 2004) necessarily analyze accurate and timely information. This analysis can be on financial operations, customers, and products using familiar business terms, in order to gain analytical insight into business problems and opportunities. For any enterprises that are maintaining direct contact with large numbers of customers, however, a growing number of novel, channel-oriented applications (e.g. e-commerce support, call center support) create a new challenge of traditional transactional applications that have to be decoupled from channel-oriented applications to allow for sufficient flexibility of assigning access/distribution channels to products/services.

For any firm the cost reduction programs that deliver the promise through value engineering, is challenging. Any firm would look forward to use predictive modeling technique to forecast the probabilities for success in the firms' new product line. But identifying dead or obsolete stock and manage it through product aging strategies is a challenge for supply chain process. Choosing the best strategy for managing returns and making the best economic sense to recycle or refurbish defective products is always challenging for any supply chain process.

Complexities increase as the business or the environment become more dynamic, i.e. where change is a permanent feature and a factor to build into the management of the business. The key question that arises as described by Azvine *et al.* (2007a, b) is how do businesses respond to changes today and, if the nature of the business and the environment is becoming more and more dynamic, what actions can businesses take to predict and prepare for change. To accomplish this, it is essential to have a system for establishing the status of a business at any moment in time in relation to its performance objectives. An important component of this investment is in BI.

This paper analyzes the role of real time BI approach in supply chain analytical. The paper argues that in order to support firms that are service oriented and desperately seeking customer loyalty and retentions, it is necessary to revisit BI concept that integrates and consolidates information in an organization. To support the

argument, the paper presents the role of real time BI in supply chain analytics. The paper also explores the hurdles and benefits using BI. The rest of the paper is organized as follows: Section 2 describes BI and its components. Section 3 given an understanding of real time BI. Section 4 presents supply chain analytics. Section 5 describes real time BI in supply chain analytics. Section 6 concludes the paper.

2. Background: business intelligence

Adelman *et al.* (2002) describe BI as a term that encompasses a broad range of analytical software and solutions for gathering, consolidating, analyzing and providing access to information in a way that is supposed to let an enterprise's users make better business decisions. Malhotra (2000) points out BI benefits that facilitate the connections in the new-form organization, bringing real-time information to centralized repositories and support analytics that can be exploited at every horizontal and vertical level within and outside the firm. Golfareelli *et al.* (2004) brief on BI which includes effective data warehouse and also a reactive component capable of monitoring the time-critical operational processes to allow tactical and operational decision-makers to tune their actions according to the company strategy. Gangadharan and Swamy (2004) define BI as the result of in-depth analysis of detailed business data, including database and application technologies, as well as analysis practices. Gangadharan and Swamy (2004) widen the definition of BI as technically much broader tools, that includes potentially encompassing knowledge management, ERP, decision support systems and data mining.

BI includes several software for extraction, transformation and loading (ETL), data warehousing, database query and reporting (Berson *et al.*, 2002; Hall, 1999) multidimensional/online analytical processing (OLAP) data analysis, data mining and visualization.

Experts view BI in different ways. Data warehousing experts view BI as supplementary systems and is very new to them. These experts treat BI as technology platform for decision support application. To data mining experts BI is set of advanced decision support systems with data mining techniques and applications of algorithms. To statisticians BI is viewed as a forecasting and multidimensional analysis tool.

The interconnected linkage of supply chains, markets and businesses is posing a new challenge to all enterprises. The path to business insight as pointed out by Shari and Fisher (2003) follows the process of integration of data from disparate internal and external data sources, applying analysis tools and techniques to understand the information within the data, making decisions, and taking actions based on this gained insight. John (2003) argues on businesses that can achieve a true up-to-the-moment view in which the information gleaned is actually current enough to be useful in managing and executing business processes and efficiency is optimized by choosing among the best options available given the circumstances at the time, and the organization is able to respond to its best customers.

Understanding the data, transforming, and shaping the data into networked market places is a key strategy for any organization to achieve competitive advantage. The business success factor for any enterprise is finding ways to bring vast amount of data that is flowing within and across the business processes together and making sense out of the data.

BI denotes on the one hand an analytic process that transforms internal and external data into information about capabilities, market positions, activities, and goals that the

company should pursue in order to stay competitive. On the other hand, BI stands for information system concepts like OLAP, querying and reporting, or data mining that provide different methods for a flexible goal-driven analysis of business data, provided through a central data pool. BI system has emerged from the central part of this strategy for long-term sustainable success.

Traditionally, information systems have been designed to process discrete transactions in order to automate tasks such as order entry or account transactions. These systems are not designed to support users who wish to extract data at different aggregation levels and utilize advanced methods for enterprise wide data analysis. The Figure 1 shows an understanding of BI. A BI system in other words is a combination of data warehousing and decision support systems. The figure also reveals how data from disparate sources can be extracted and stored to be retrieved for analysis. The basic BI approach is shown in Figure 1. Information from supply chain, point of sales and call centers are collected and stored in a data warehouse. Using BI query reporting tools the information is analyzed for hidden useful patterns.

2.1 BI components

BI tools are widely accepted as a new middleware between transactional applications and decision support applications, thereby decoupling systems tailored to an efficient handling of business transactions from systems tailored to an efficient support of business decisions. The capabilities of BI include decision support, OLAP, statistical analysis, forecasting, and data mining.

The following are the major components that constitute BI.

2.1.1 Data warehouse. The data warehouse is the significant component of BI. It is subject oriented, integrated. The data warehouse supports the physical propagation of

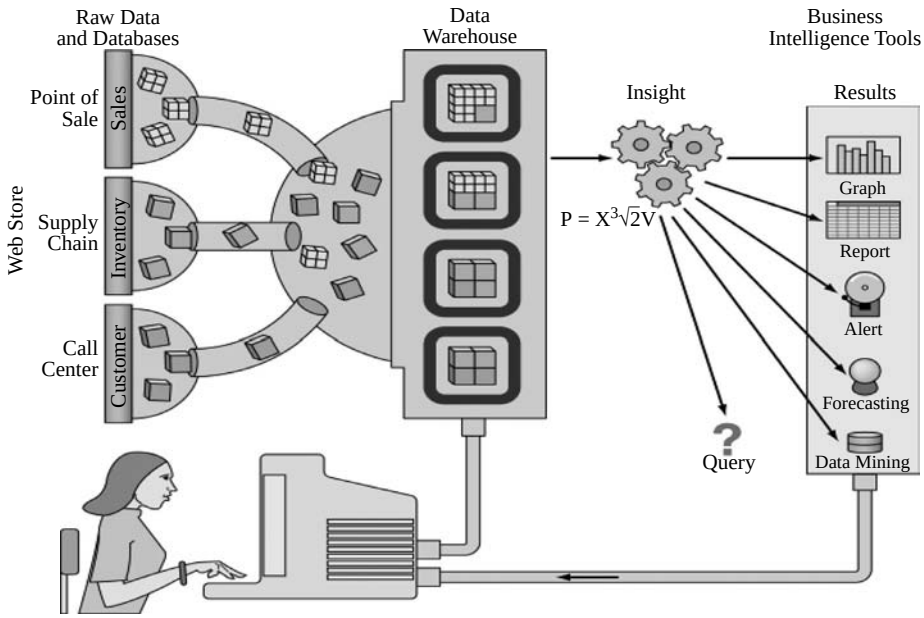


Figure 1.
A basic understanding of BI

data by handling the numerous enterprise records for integration, cleansing, aggregation and query tasks. It can also contain the operational data which can be defined as an updateable set of integrated data used for enterprise wide tactical decision-making of a particular subject area. It contains live data, not snapshots, and retains minimal history.

2.1.2 Data sources. Data sources can be operational databases, historical data, external data for example, from market research companies or from the internet), or information from the already existing data warehouse environment. The data sources can be relational databases or any other data structure that supports the line of business applications. They also can reside on many different platforms and can contain structured information, such as tables or spreadsheets, or unstructured information, such as plaintext files or pictures and other multimedia information.

2.1.3 Data mart. A data mart as described by Inmon (1999) is a collection of subject areas organized for decision support based on the needs of a given department. Finance has their data mart, marketing has theirs, and sales have theirs and so on. And the data mart for marketing only faintly resembles anyone else's data mart. Perhaps, most importantly (Inmon, 1999) the individual departments own the hardware, software, data and programs that constitute the data mart. Each department has its own interpretation of what a data mart should look like and each department's data mart is peculiar to and specific to its own needs. Similar to data warehouses, data marts contain operational data that helps business experts to strategize based on analyses of past trends and experiences. The key difference is that the creation of a data mart is predicated on a specific, predefined need for a certain grouping and configuration of select data. There can be multiple data marts inside an enterprise. A data mart can support a particular business function, business process or business unit.

2.1.4 Query and reporting tools. OLAP provides multidimensional, summarized views of business data and is used for reporting, analysis, modeling and planning for optimizing the business. OLAP techniques and tools can be used to work with data warehouses or data marts designed for sophisticated enterprise intelligence systems. These systems process queries required to discover trends and analyze critical factors. Reporting software generates aggregated views of data to keep the management informed about the state of their business. Other BI tools are used to store and analyze data, such as data mining and data warehouses; decision support systems and forecasting; document warehouses and document management; knowledge management; mapping, information visualization, and dash boarding; management information systems, geographic information systems; trend analysis; software as a service.

2.2 Traditional BI systems

The main key to successful BI system is consolidating data from the many different enterprise operational systems into an enterprise data warehouse. Very few organizations have a full-fledged enterprise data warehouse. This is due to the vast scope of effort towards consolidating the entire enterprise data.

Berson *et al.* (2002) emphasize on emerging highly dynamic business environment and point that only the most competitive enterprises will achieve sustained market success. The organizations will distinguish themselves by the capability to leverage information about their market place, customers, and operations to capitalize on the business opportunities.

Moss and Atre (2003) describe BI as seamless integration of operational front-office applications with operational back-office applications. Gangadharan and Swamy (2004) define BI as an enterprise architecture for an integrated collection of operational as well as decision support applications and databases, which provides the business community easy access to their business data and allows them to make accurate business decisions. The firms can make better decisions, right decisions in particular on their customers, suppliers, employees, logistics, infrastructure and gather, store, access and analyze huge amounts of records only with BI.

Current data warehousing and BI approaches are widely accepted as a middleware layer for state-of-the-art decision support systems (Seufert and Schiefer, 2005). However, they do not provide sufficient support in dealing with the upcoming challenges, such as real-time and closed loop decision making (Seufert and Schiefer, 2005).

There are established research results on decision support systems (Tushman and Nadler, 1978; Eckerson, 1998; Gray and Watson, 1998; Simon, 1960; Sprague, 1980; Weiner, 1948; Silver, 1991) and information processing theory. Davenport (1993) describes various issues on re-engineering in process innovation.

Any new-form organization now a days experience is the value chain-set of primary secondary activities that create value for customers. Denison (1997) examines several critical activities related to value chain. Without effective BI to target process-oriented organizations for supporting is not possible.

Companies have to redesign their business processes for effectively managing and controlling business. It is of great importance resulting for new requirements for decision support. For enabling effective business performance and identifying opportunities for enhancing the business, collecting and reconciling all operational data related to business processes is essential. This operational data from different business processes need to be collected, integrated and prepared for analytical decision-making. This analytical decision-making is essential and required for integration of decision for any management. The components for an effective BI architecture requires a well developed data warehouse, an effective data mart and meta data management, analytical tools like data mining and OLAP and other query reporting tools (Figure 2).

A complete, mission-critical BI technology includes not only BI, data warehouse management, and data integration software, but also a robust hardware foundation

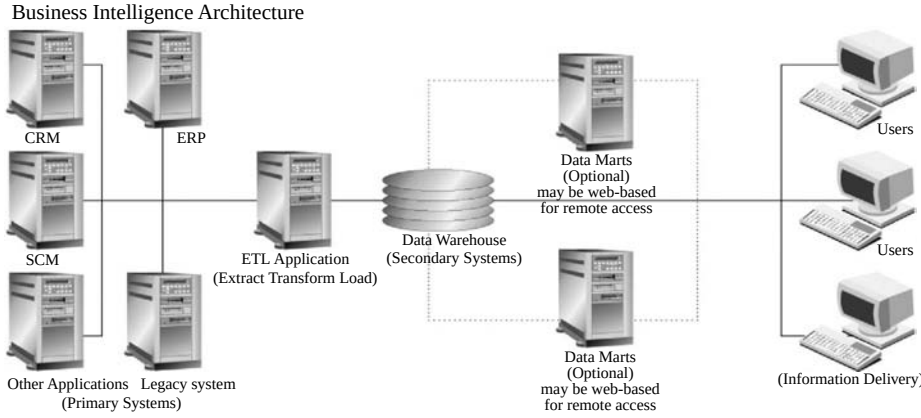


Figure 2.
Traditional BI architecture

that can support scalability both from the data and user perspectives. Information from various sources like ERP, SCM, CRM are collected and loaded through extract transform applications into the data warehouse as a central data repository (Figure 2).

Williams and Williams (2004) stress on achieving business value by using traditional data warehousing and BI tools. Grigoria *et al.* (2004) mention that management information systems are targeted only for traditional reporting and not utilized for measuring the performance of business processes.

Geishecker (2002) and Moncla and Arents-Gregory (2003) explore on providing closed loop support that interlinks strategy formulation, process design and execution for BI. In order to achieve competitive advantage, companies strive towards reducing the time needed to react to relevant business operations. By organizing and deploying BI as per the organization's own characteristics, the complete value of the data stored throughout the enterprise can be unleashed.

2.3 Real time BI

When it comes to extensive data analysis, BI is used to produce the information that is necessary to decide and take appropriate actions. Addressing this, real-time decision support gained great attention. Concepts such as active warehousing, real-time analytics (Brobst and Ballinger, 2000; Raden, 2003) and real-time warehousing became hot topics of interest to firms. Real-time decision support provides suggestions of how to speed up the flow of information in order to achieve competitive advantage. BI systems frequently have been accused by corporates for not getting results to users in a timely manner. This may be due to data-integration problems. However, new BI approaches can process the information quickly enough to make such decisions. For example, in hotel management and information systems, BI can be used to analyze customers' input and make hotel, car rental, and other offers to them when they are on the business' web site or when they visit again in the future.

The traditional BI discussed in Section 2.2 does not proactively respond to situations and take critical timely business decisions in real time.

Nevertheless, it is becoming essential nowadays that not only is the analysis done on real-time data, but also actions in response to analysis results can be performed in real time and instantaneously change parameters of business processes.

Nguyen Manh *et al.* (2005) introduced an enhanced BI architecture that covers the complete process to sense, interpret, predict, automate and respond to business environments and thereby aims to decrease the reaction time needed for business decisions. Nguyen Manh *et al.* (2005) proposed an event-driven IT infrastructure to operate BI applications which enable real-time analytics across corporate business processes, notifies the business of actionable recommendations or automatically triggers business operations, and effectively closing the gap between BI systems and business processes. Seufert and Schiefer (2005) suggested an architecture for enhanced BI that aims to increase the value of BI by reducing action time and interlinking business processes into decision making.

Azvine *et al.* (2005) discuss the issues and problems of current BI systems and then outlines our vision of future real-time BI. In large organizations, IT departments have had to gather information from multiple databases (heterogeneous data bases) such as those in accounting programs and enterprise-resource-planning applications and normalize it into a single view in a time-consuming, frequently manual process.

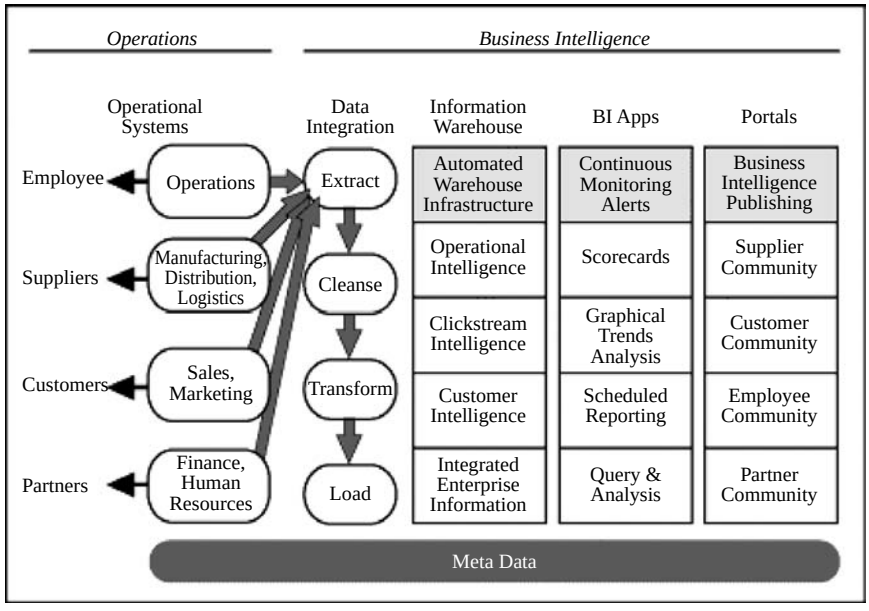
Many operational decisions (e.g. promotion effectiveness, customer retention, key account information) (Schulte, 2000) need actual yet integrated and subject-oriented data in or near real-time. Viitanen and Pirttimaki (2006) examine a case that considers BI as a strategically integrated tool.

The primary goal of real time BI is to meld analytics with management functions so that analytics become an integral part of how managers and employee teams perform their job (Figure 3). Information is collected from several operation systems for data integration. Note the different applications of BI emerging from query analysis to score card management. Hence, successful implementation of real time BI needs to focus first on specific business needs (i.e. SCM, customer churn detection and reduction, etc.).

New service-oriented-architecture tools provide interfaces to various data types, which helps integrate data sources so that multiple applications can read them. BI's real-time capabilities can make it easier for companies to work directly with customers. A customer might be on the phone or an e-commerce web site for only a few minutes, which limits the time and amount of information a company has to make sales-related decisions.

Real time BI system does the process of delivering information about business operations with minimum latency. This means delivering information in a range from milliseconds to a few seconds after the business event. While traditional BI presents historical information to users for analysis, real time BI compares current business events with historical patterns to detect problems or opportunities automatically. This automated analysis capability enables corrective actions to be initiated and or business rules to be adjusted to optimize business processes.

All real time BI systems have some latency, but the goal is to minimize the time from the business event happening to a corrective action or notification being initiated.



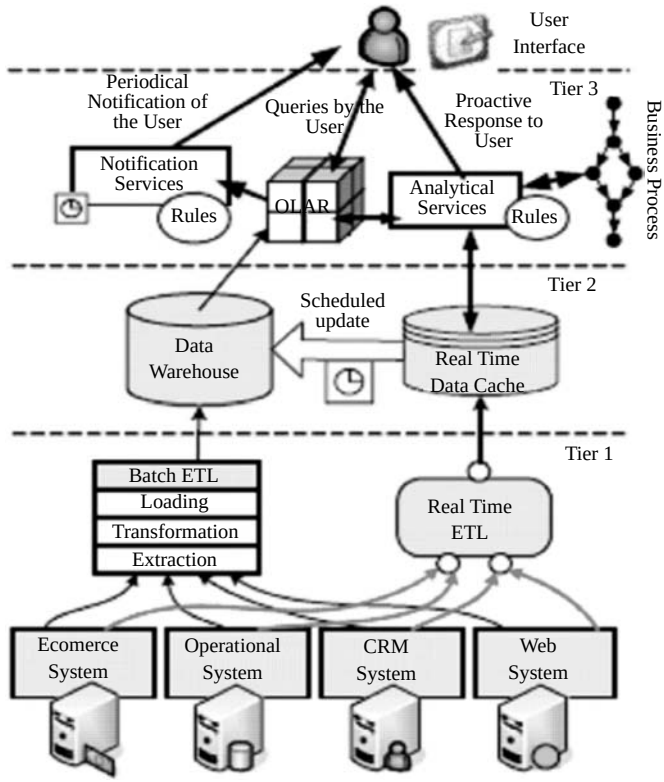
Source: Robinson (2002)

Figure 3.
BI infrastructure

Real time BI technologies are designed to reduce latencies to as close to zero as possible. Traditional BI and business activity monitoring by comparison only seek to reduce data latency and do not address latency since some processes are governed by manual processes.

Robinson (2002) evaluated the completeness and adequacy of BI infrastructures based on the information available from: effective data integration process, continuous monitoring processes, automated information delivery process, fully automated warehouse administration infrastructure, availability of information on standardized dimension such as customer, product and geography, higher end-user acceptance. The BI infrastructure adopted from (Robinson, 2002) is presented as a three tier frame in Figure 4. Real time ETL tools collects the operational data from different heterogeneous sources for centralized data integration in real time. The business rules are analyzed in tier 3 through query and reporting tools in real time.

Nguyen Manh *et al.* (2005) proposed an approach to real time BI based on service-oriented architecture (Figure 4). As organizations seek to incorporate intelligence into business operations, a robust infrastructure is necessary to meet mission-critical requirements for high scalability, availability, and performance (Nguyen Manh *et al.*, 2005). Azvine *et al.* (2007a, b) proposed a real time BI architecture for an adaptive enterprise.



Source: Nguyen Manh *et al.* (2005)

Figure 4.
Real time BI architecture

The concept of service-oriented architecture has been the buzz in the business technology area. These service-oriented architecture tools provide various interfaces to various heterogeneous types of data in any organization and integrate various data sources so that multiple applications can have access to these data. Several service-oriented architecture adapters and interfaces have been developed for integrating and accessing various heterogeneous data sources. Lawton (2006) provides information on these type of adapters that enables Google One-Box search appliance to tract in real time data stored in more than 85 types of data bases and generated by more than 150 transaction types. Lawton (2006) further adds that vendors like Cognos, Information Builders, and SAS are working with Google to use the Google One Box with real time BI systems.

3. Supply chain analytics

The concept of supply chain analytics promise to extract and generate meaningful information for decision makers in the enterprise from the enormous amounts of data generated and captured by supply chain systems.

For configuring supply chain functions data collected across the supply chain is crunched, numbers are analyzed, and information is generated for decision makers. Technologies ranging from mainframe-based multidimensional spreadsheets to PC-based statistical analysis tools are used for supply chain systems' analysis. The biggest challenge any enterprises face today is building these supply chain-based analysis of aggregating data from multiple sources.

Limited ability to raise prices, high-customer expectations and low levels of loyalty have led to increased challenges in already competitive market for all retail organizations (Taylor *et al.*, 2004). The retailers are looking forward to supply chain analytics to reduce cost and improve customer service. The retail organizations can expect a better and effective supply chain analytic only by defining the analytical needs of enterprise and a well-defined key metrics for organizational strategy.

The hype surrounding both ERP, SCM and CRM have led many firms to believe that these systems improve business processes and customer services and also provide enterprise reporting and analytics. But the fact is ERP and CRM systems are integrated across enterprise information infrastructure and functions on their respective modules. Both the systems do not follow the integrated business rules and definitions and function in their individual domains. The traditional transactional systems are not designed to support efficient enterprise reporting and business analytics. Hence, it is well understood that SCM alone cannot deliver the expected value at right time in an organization. Clearly a BI systems needs to draw information from all operational systems. Hence, BI and SCM requirements need to be developed simultaneously.

Taylor *et al.* (2004) explore the issues on SCM and BI in an organization. Many retailers are now turning towards advanced SCM systems in an attempt to reduce costs and improve customer service. Taylor *et al.* (2004) describe that SCM sells on the promise of just in time (JIT), demand driven supply, providing the functionality to plan and monitor inventory levels, track orders and shipments and manage warehouse and distribution facilities.

Supply chain analytics provides a broad view of an entire supply chain to reveal full product and component. It is implemented for strategic decision making. It reveals opportunities for cost reduction and stimulates revenue growth. It generally maintains historical data and enables an understanding of total cost. Drill down and roll up

operations yield figures to reveal what caused the performance level. Ordering products, global outsourcing, and web-based buying and selling, JIT manufacturing are the major key business drivers for supply chain analytics.

Lee and Kim (2007) proposed a methodology for the development of new business based on technical systems. Sivakumar, 2006 discusses on supply chain intelligence in organizations to derive better operational efficiency by giving key performance indicators (KPI) for supply chain managed firm. Kumar and Deshmukh (2005) explore the business value of BI through supply chain analytics.

Several vendors like SAS, business objects provide supply chain analytical solutions. Heydock (2003) point out on supply chain intelligence which reveals opportunities to reduce costs and stimulate revenue growth by enabling companies to understand the entire supply chain from the customer's perspective.

Heydock (2003) describes this new initiative for providing the capability to extract sense and analyze information about a supply chain. Supply chain using BI enhances an executive's ability to reason through business outcomes. Supply chain analytics include planning sourcing, making and delivery of supply using analytics.

Supply chain analytics provides a single view across supply chain and includes prepackaged KPI, analytics. It also helps an organization on the primary drivers behind supply chain processes-planning, procurement, manufacturing, logistics, and returns. An organization therefore can analyze and act to increase the supply chain efficiency. Supply chain analytics addresses measuring supply chain performance against goals and over time, identifies opportunities to reduce costs, improves supplier management, increases manufacturing efficiency and optimizes delivery.

For storing pre-aggregated information, controlling end-user access to the information, providing fast access into information and representing the end-user view and multi dimensional view of the supply chain system is essential.

Both vendors and users of supply chain have become enamored with operational BI. The real time BI can be pushed to enhance supply chains. BI analysis will be in line to a business process such as identifying unusual supplier activity that might require a change in pricing or manufacturing schedules or noting higher than expected sales activity of lower margin products that may indicate a problem in sales or distribution. Several vendors foresee BI as powerful engine that hooks into all sorts of processes and work flows to monitor anomalies and changes in trends in supply chain. BI is foreseen to automate adjustments in stead of alerting people. In other words BI can be treated as a layer that sits across all application layers. This can be interpreted as adding BI functionality to all applications that require attention to the results of the processes executed. There is no ERP report to roll up a cross process for viewing customer profitability. Applications that monitor certain processes may be immediately useful for certain managers who use these SCM applications but these processes also need to be monitored by BI tools that works across multiple platforms.

4. Real time BI in supply chain analytics

There are various proven research results on supply chain framework (Kinder, 2003), supply chain performance (Li *et al.*, 1997), supplier selections (Lee *et al.*, 2001; Kraljic, 1983; Choi and Hartley, 1996) supplier evaluations (Ghodsypour and O'Brien, 1998; Hausman, 2003), supply chain practices (Kinder, 2003; Cavinato, 2002; Sarkis and Talluri, 2002; Sabath and Fontanella, 2002).

As mentioned in Section 2.3, The hype surrounding both ERP, SCM and CRM have led many firms to believe that these systems improve business processes and customer services and also provide enterprise reporting and analytics. But the fact is ERP and CRM systems are integrated across enterprise information infrastructure and functions on their respective modules. Hence, it is well understood that SCM alone cannot deliver the expected value at right time in an organization. Clearly a BI systems needs to draw information from all operational systems.

Data have been critical to decision support. Rapid innovation and globalization have generated tremendous opportunities and choices in the market places for consumers and companies alike. Competitive pressures have led to sourcing and manufacturing on a global scale resulting in a significant increase in product offerings. When businesses grow more complex so do the supply chains. The managers need tools that generate the insight that leads to smarter.

The term BI comprises OLAP, data mining, data warehousing, visualization and query reporting tools. A decade ago BI used to monitor changes in source systems, extract the changed data, perform necessary transformation and put the data for loading in the warehouse. Note that not all data were real time. But real time analysis of data helps firms move to what is called as "zero latency" or real time enterprise. Though real time BI involves changes in various technologies what really makes different and significant is how the scope and importance of BI is viewed at. Real time BI impacts current business decisions and current business processes.

Traditional BI systems consist of a back-end database, a front-end-user interface, software that processes the information to produce the BI itself, and a reporting system. Several varied sectors like manufacturers, electronic commence businesses, telecommunication providers, airlines, retailers, health systems, financial services, bioinformatics and hotels use BI for customer support, market research, segmenting, product profitability, inventory and distribution analysis, statistical analysis, multi-dimensional reports, detecting fraud detection, etc.

Robinson (2002) evaluated the completeness and adequacy of BI infrastructures based on the information available from effective data integration process, continuous monitoring processes, automated information delivery process, fully automated warehouse administration infrastructure, availability of information on standardized dimension such as customer, product and geography, higher end-user acceptance.

Companies still fee that BI has technology-related complexities and usable only by technically savvy specialists. They also feel that BI is expensive. BI takes a long time to yield correct analysis. The firms want these analyses in real time for short-term projects. The tradition BI may not do this but a real time BI environment certainly comes into rescue.

The focus of SCM systems is to provide operational and transactional efficiencies in the fields of manufacturing, sourcing and distribution within an organization and across its supply chain. Applying the concepts of BI to data from SCM systems, supply chain analytics seek to provide strategic information to decision makers in organizations. Information categories range from what-if scenarios (Reddy, 2003) for reconfiguring key functions in sourcing, manufacturing, and distribution to measuring the ability of a supply chain to produce cost-effective products.

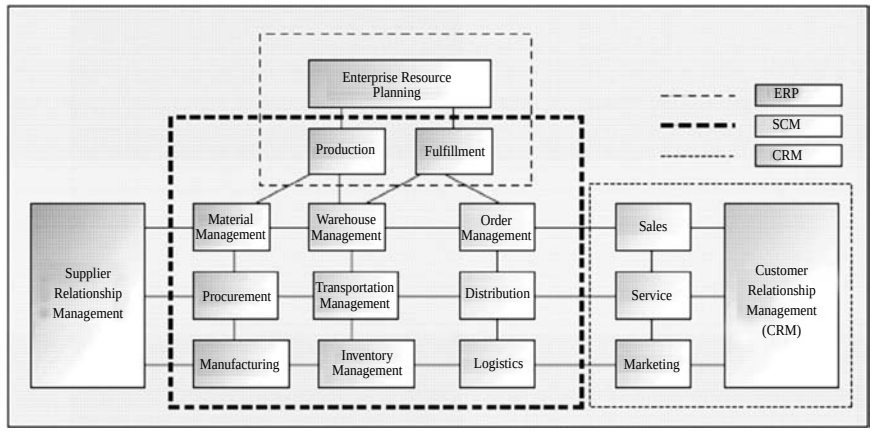
The SCM sells on the promise of JIT, demand driven supply, providing the functionality to plan and monitor inventory levels, track orders and shipments and

manage warehouse and distribution facilities (Taylor *et al.*, 2004). But SCM systems have to ensure that right items are in stock always so that inventory levels can be reduced. The existing SCM, ERP and CRM systems' attempts to have enhanced enterprise reporting and analytics for improved return on investment (ROI) did not result in anticipated way. This paved way for supply chain analytics in real time.

Real time BI in SCM requires the ability to analyze products, processes, components, and materials. This demands a data integration infrastructure. Supply chain analytics analyses the products, processes, components and materials. Hence, an integrated infrastructure that extracts, transforms and loads the data from multiple sources like ERP, SCM, CRM, customer data, supplier data, product data, manufacturing data, quality management data, shop floor manufacturing data, legacy system data, online web-based SCM data, demographic market places-based data and marketing data from third party data suppliers is required for a successful supply chain analytics.

Figure 5 shows an understanding of the role of ERP, SCM and CRM in any enterprise. The data sources can be from like ERP, SCM, CRM, customer, supplier, product manufacturing/testing, quality management, shop floor manufacturing, legacy system, data from online industry trading exchanges, market places and auction, demographics and marketing data purchased from third party data suppliers, etc. Real time BI in SCM requires tighter integration of manufacturing into analytics. And, information resulting from the integration is critical to the identification of design issues and costs through out the product life cycle.

As more and more customers look for web-based purchases, the transactions representing these business activities become accessible readily to the business for improved analytics and better business decisions. Customer loyalty is driven by product quality and price and as well as new set of criteria such as product choice, service quality and ease of access. Every one is aware that the business decisions are growing at an unprecedented pace. The complexity of these decisions also increases as the diversity and volume of data grow. Customer demographic data, business transactions, seasonal ebbs and flows, supplier data and inventory levels all have to be carefully coordinated to enable real time business decisions.



Source: Krishnamurthy (2006)

Figure 5.
Data sources integrated for real time BI

To build real time BI in SCM application, it requires many data sources to be integrated (Figure 5). The data sources that companies are integrating to support their real time BI in SCM, ERP, data from suppliers, legacy systems, SCM systems, and CRM systems (Figure 5) data from shop floor systems and product manufacturing/testing applications is also vital for feeding real time BI. The companies are not using data from online industry exchanges and marketplaces widely.

There fore, the bottom line is that real time BI in supply chain requires a data integration architecture that will support supply chain analytics applications with the ability to extract, transform, cleanse, and integrate data from a variety of data sources. Many of these sources can be difficult to reach; while everyone now knows the difficulty associated with retrieving ERP and legacy systems data, other sources can be even more difficult to access. For instance, shop floor manufacturing data can be especially difficult to collect because many of these systems use proprietary application interfaces and data formats. Figure 6 shows the role of BI in an enterprise. The traditional data life cycle includes data warehouses and data marts.

An example: consider a firm ABC that manufactures broad range of products. It wants to track the resellers and retail sales channels. The company incorporates mobile devices, bar code scanners to store the information for every item about its location and status of current method of transportation. This enhances better monitoring, synchronizes and optimizes the process flows. The real time BI continuously analyses the data and calculates the key critical indicators that provide value. The key business drivers for this corporate is meeting the reporting requirements over a large geographically dispersed users database, tracking customer orders and replacing multiple non integrated legacy applications. The company requires a standard format in real time to improve the data quality and resolve conflicting terminology because

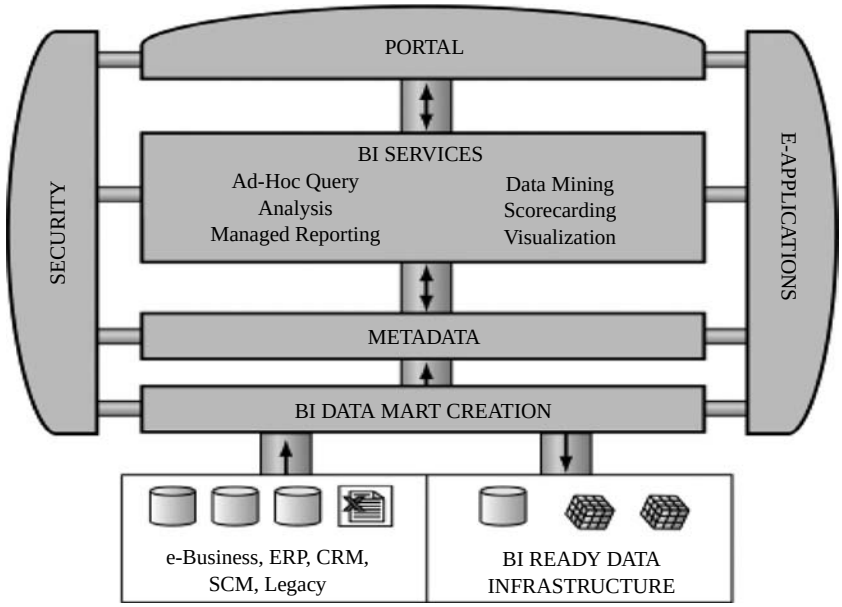


Figure 6.
BI services in real time in an enterprise

there are several business conflicting rules for reporting and analysis across region. The real time data warehouse refreshes minute to minute and seconds to seconds. The documentation for the existing reporting solutions in gathering requirements for key process indicators is essential. Here, real time BI comes to rescue.

The real time BI continuously analyses the data and calculates the key critical indicators that provide value. The value can be interpretation of essential business information such as current transportation time for shipping, transportation cost, utilization of any transportation vehicle, etc. In addition, real time BI detects early situations for planning and coordination of the logistics such as delay of freight or loading the freight into a wrong container. In such critical cases BI makes arrangements in order to deliver the goods timely by changing the transportation route or changing the method of transportation. The route can be choosing a more direct transportation route to the customer and or through express-transport services. In case of failure of delivery, the real time BI automatically sends the notification to the customer with an estimate of delay in shipping.

In this example, the real time BI reacts in near real time to changes in the business environment. Events from various sources (vehicles, distribution centers, contractors, customers) are received and unified (event transformation) in order to assess the current state of the business environment. Certain event patterns describe a business situation (e.g. a truck is stuck in a traffic jam) that is automatically discovered by real time BI (situation discovery). A business situation triggers the invocation of analytical services in order to forecast whether a shipment is going to be late (analytical processing). Based on the analytical results a rule decides (decision making) whether the transportation route should be adjusted, or whether the customers should be notified about the shipment delay. The real time BI instantaneously initiates and executes the appropriate actions (response management) based on the outcome of the decision rule.

A global real time data warehouse, real time data mart for storing historical and summary data at different levels is required. An efficient OLAP interface with secured real time architecture is necessary. The reports are refreshed every minute in various time zones. This enhances the real time reporting for supply chain analytics. The enterprise can have real time based 360-degree view of its reseller business. For planning and forecasting based on product distribution, optimizing sales distribution, analyzing key inventory measures real time BI in supply chain analytics is necessary. This paves for a centralized data base for reporting data and accommodating rapid delivery of solution enhancements. The end-users will benefit from improved analytical flexibility and better performance for creating, delivering and viewing supply chain analytics.

5. Real time BI: benefits and hurdles

BI is a boon to any enterprise as BI pulls together large quantities of real time information from disparate heterogeneous systems and distills them into focused views of the business. BI's new real-time capabilities can even make it easier for companies to work directly with customers. A customer might be on the phone or an e-commerce web site for only a few minutes, which limits the time and amount of information a company has to make sales-related decisions. However, new BI approaches can process the information quickly enough to make such decisions.

Any organizations who successfully integrate BI into a business process can achieve a significant return on investment. This is the most arguable statement. Some organizations may view it differently. The cost of deploying a large data warehouse to support a BI system is still high for many organizations. Now calculating BI systems' return on investment is difficult because BI provide business-related insights rather than direct links to sales or cost savings. What will happen to those firms with tight budgets? Such firms might decide to cutback on such expenditures.

A study reports (Eastwood *et al.*, 2005) that a BI implementation generates a median five-year return on investment (ROI) of 112 percent with a mean payback of 1.6 years on average costs of $4.5 million. Of the organizations included in the study, 54 percent had an ROI of 101 percent or more. The largest class of benefit was due to "business process enhancement," where BI was applied to operational decisions in areas such as logistics (Eastwood *et al.*, 2005) call centers, fraud detection, and marketing campaign management.

Yet BI benefits do not come without effort. From an organizational perspective, the business units affected by the BI project must be intimately involved and committed to the project. Likewise, management must have an in-depth understanding of its business processes and a clearly defined set of goals to be achieved. Finally, the technology platform for BI must be capable of delivering information on demand, at the point of an operational decision, in a cost-effective manner. The real payback for BI applications as pointed out by Gangadharan and Swamy (2004) comes from the BI hidden in the organization's data, which can only be discovered with data mining tools. In addition, the success of BI depends on training and support on BI tools.

Firms are of thought that BI does not integrate with their CRM and ERP applications. Vendors also used to offer BI systems only as stand-alone products that did not always integrate well with other corporate software such as CRM and financial applications (Lawton, 2006). Owing to this, firms are denied the opportunity to analyze the valuable information in these applications.

The author is of opinion that ERP integrates information pertaining to firm's internal processes while SCM processes and monitors firm's external information. Integrating them and giving a correct relevant business decision based on bundles of very large volumes of both internal and external data is possible only with BI.

Nevertheless, BI faces numerous ongoing challenges to future success, such as implementation cost and complexity. BI systems frequently consist of multiple elements that do not integrate well together, including best of-breed components from different vendors. Organizations want BI systems that are cheap, fast, easy to install and use, low maintenance, sated with help functions, and keeps the users happy and off the back of IT. It is very difficult to find such one.

The biggest challenge is the users' ability to determine how to take action based on the results of BI analysis in an organization.

The author also feels that there are no such widely implemented benchmarked BI standards for any firm. This exacerbated limitation has caused firms to consider BI as complex systems. Traditional BI has been slow at gathering and analyzing data. This makes the short-term and day-to-day decision making unsuitable. BI products and their interfaces have also been more complex than most applications need and require too much technical sophistication for most employees to set up and use effectively. Most of the tools have rich functionality that is only appropriate for about 5 percent of a company's employees.

Data integration, defining business and end-user requirements, and organizational issues (e.g. getting different departments and groups to function/collaborate cohesively based on related metrics, etc.) are (Sivakumar, 2006) the three most difficult issues companies are experiencing with supply chain analytical application development.

Another shortcoming in BI is the data marts required to store the amounts of data that is necessary for BI operations are too expensive for most firms. A terabyte-sized data mart cost $5 million five years ago. But today the use of inexpensive open source software as well as proprietary software and hardware that are less costly than in the past has reduced data marts' prices (Lawton, 2006).

A BI system might not be able to make informed decisions based on the information but can present users with organized, analyzed data. For example, knowing that older males buy more of a product does not necessarily tell the vendor what it must do to increase sales.

Although BI tools are easier to use, companies still need a technically savvy team to deploy the data warehouse that integrates all their information into one place. The team also must create applications to access the information and decide which data sets within the warehouse will be most useful.

BI technology will always entail complex deployment and data preparation and is not easy to link directly to either reducing costs or increasing revenue. Any firm should not expect a tool to produce value on its own, it may be difficult for that to happen at least in case of BI.

Real time BI for supply chain analytics reduce decision cycle processes. It responds to market and customer demand in hours and in minutes not in weeks. Measuring and monitoring supply chain activities interactively to respond to timely decision are possible in real time BI.

The companies should use their general enterprise real time data warehouse for their supply chain analytics. According to a Gartner report, 57 percent of companies said their organizations were using their general corporate or enterprise data warehouses (Sivakumar, 2006) to support their supply chain analytical applications, as opposed to 43 percent who were using a separate data warehouse intended specifically for supply chain analytics.

Using real time data warehouse will allow consolidation of all supply chain-related information with all other corporate data. This consolidated view offers the optimum capabilities for enterprise data analysis and reporting. The drawback to this approach is that it typically requires a considerable undertaking in which redesigning the enterprise data warehouse to incorporate supply chain models and reporting processes is essential.

6. Conclusion

BI refers to the use of technology to collect and effectively use information to improve business potency. An ideal BI system gives an organization's employees, partners, and suppliers easy access to the information they need to effectively do their jobs, and the ability to analyze and easily share this information with others. BI provides critical insight that helps organizations make informed decisions. It facilitates scrutinizing every aspect of business operations to find new revenue or squeeze out additional cost savings by supplying decision support information.

Business transactions, customer demographics, seasonal flows, supplier data and inventory levels all have to be carefully coordinated to enable real time BI enabled

supply chain solutions. We have presented in this paper real time and traditional BI. The approach to real time BI in supply chain analytics is described. The advantages of real time BI is also discussed. We believe that supply chain analytics using real time BI in organizations will derive better operational efficiency and KPI for any organization in SCM.

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