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A survey on recent research in business intelligence

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Abstract

Purpose – Business intelligence (BI) has been applied in various domains to take better decisions and it provides different level of information to its stakeholders according to the information needs. The purpose of this paper is to present a literature review on recent works in BI. The two principal aims in this survey are to identify areas lacking in recent research, thereby offering potential opportunities for investigation.

Design/methodology/approach – To simplify the study on BI literature, it is segregated into seven categories according to the usage. Each category of work is analyzed using parameters such as purpose, domain, problem identified, solution applied, benefit and outcome.

Findings – The BI contribution in various domains, ongoing research in BI, the convergence of BI domains, problems and solutions, results of congregated domains, core problems and key solutions. It also outlines BI and its components composition, widely applied BI solutions such as algorithm-based, architecture-based and model-based solutions. Finally, it discusses BI implementation issues and outlines the security and privacy policies adopted in BI environment.

Research limitations/implications – In this survey BI has been discussed in theoretical perspective whereas practical contribution has been given less attention.

Originality/value – A comprehensive survey on BI which identifies areas lacking in recent research and providing potential opportunities for investigation.

Keywords Business intelligence, Business intelligence domains, Business intelligence models, Business intelligence survey, Research opportunities in BI

Paper type Literature review

1. Introduction

Business intelligence (BI) is an integrated set of tools used to support the transformation of data into information to support decision-making. BI analyses the performance of an organization and increases its revenue and competitiveness (Mahdi *et al.*, 2012; Kun-Lin, 2011; Tobias and David, 2011). It also aids in formulating new strategies to increase the profit of the business (Eran and Amir, 2013; Jalileh *et al.*, 2011). To make effective decisions in any business, BI derives information or knowledge from huge volumes of business data using a set of data mining and analytical techniques (Cheung and Li, 2012; Yoichi *et al.*, 2010; Sirawit *et al.*, 2010).

The perspective on BI differs according to the domain in which it is applied (Li *et al.*, 2013; Wingyan and Tzu-Liang (Bill), 2012; Thiagarajan *et al.*, 2012). Though BI has different functionalities according to the domain, commonly it is a data driven decision support system that combines data gathering, data storage and with analysis, to provide input to the decision process (Tanko and Musiliudeen, 2012; Javier *et al.*, 2012). From the perspective of different sources of BI it is understood that BI takes data from

multiple sources, transforms these data into information through people, processes and analytical tools to make better decisions which will improves the performance of the business or an organization. Recently, BI has been applied in various domains to take better decisions and it provides different level of information to its stakeholders according to the information needs (Martin *et al.*, 2014).

BI has been applied in many domains to solve different problems (Fereydoon and Mohammad, 2012; Melody *et al.*, 2010). A huge number of BI applications have been developed to take better decisions (Tobias and David, 2011; John, 2010; Steven *et al.*, 2010; Qiongwei *et al.*, 2010; Jicheng *et al.*, 2008). To improve analytical capabilities of BI applications intelligent techniques have been applied (Wingyan and Tzu-Liang (Bill), 2012; Thiagarajan *et al.*, 2012; Xingsen *et al.*, 2009; Cvitas, 2010). Not only application level development, the data collection strategies of BI have been improved by adding efficient information retrieval techniques.

BI applications have been integrated with other techniques to solve various problems (Tanko and Musiliudeen, 2012; Dien and Douglas, 2010; Long-Wen and Zhang, 2008). Business intelligence models (BIMs) simplifies the development of BI applications developments and BI reference models assists it stakeholders to understand the model before its actual implementation (Cheung and Li, 2012; Liyi and Xiaofan, 2009; Prasanna Venkatesan, 2009; Prasanna Venkatesan and Kuppuswami, 2008). Though many works are available in BI, these works should be evaluated to understand its effectiveness. From the literature it has been found that very limited BI evaluation models have been developed to evaluate and analyze the performance of BI applications (Öyku *et al.*, 2013; Aleš *et al.*, 2012). Another important research scope in BI is to solve the implementation issues in deploying BI applications (Melody *et al.*, 2010; Ming-Kuen and Shih-Ching, 2010).

A comprehensive study on BI can help to gain better understanding of the research works carried out in BI. The detailed understanding of recent works on BI paves a layout to develop effective BI applications. The research opportunities which we identified from this study can create a stronger BI progression.

The rest of the paper is organized as follows: Section 2 describes about a detailed study on BI literature and the various developments established in BI. Section 3 discusses the outcome of BI literature study and describes the research opportunities in BI and finally Section 4 concludes the BI literature review.

2. Literature review

Enterprise users need a technology to access integrated data, to store, to analyze and to make wiser decisions. BI satisfies these needs by applying its wiser components. A typical BI application is made up of many numbers of components such as data warehouse, ETL, data mining, analytical tools, data visualization and analysis, dashboard, score board, CRM, Enterprise Resource Planning (ERP), OLAP and any other related component. According to the business requirement, the BI components may vary from one application to another application (Martin *et al.*, 2011).

BI software not only provides the ability to monitor the performance and operation of business, but it should also assist the business managers and its stakeholders to develop the competitive business strategies. It is a fast developing field and it has been applied to a variety of domains, accordingly many numbers of BI applications have been developed. This survey made analysis on BI works from year 2008 to 2013. In this period even though different kinds of BI work have been carried but a particular

segment of BI work has been given much importance not by any intention in each year which is described in Figure 1.

The year wise contributions in BI are considerably increasing and the growth of BI has been forwarding fast to the future and development of the organization. As BI growing toward its mature stage it is developed with mix of different works. In order to understand the BI works the following parameters are selected (Martin *et al.*, 2012).

To simplify this literature study the various works in BI are segregated into seven categories (Tables II-VIII) according to its usage. The seven category of work have been analyzed from the commonly derived BI parameters which are described in Table I. The categories of BI works are listed below:

2.1 BI and its applications
2.2 Intelligent techniques in BI
2.3 Information extraction in BI
2.4 Integration of BI with other techniques and methods
2.5 Prototypes, Design models and frameworks for BI applications
2.6 Evaluation and performance assessment of BI systems
2.7 Challenges and issues in BI implementation

The BI works have been grouped into seven categories according to its applications. The first category of work discusses about BI applications. The second category discusses about application of intelligent techniques in BI and how the intelligence techniques have been applied to improve the analytical capabilities of BI is described.

Business Intelligence Evolution in Recent Research
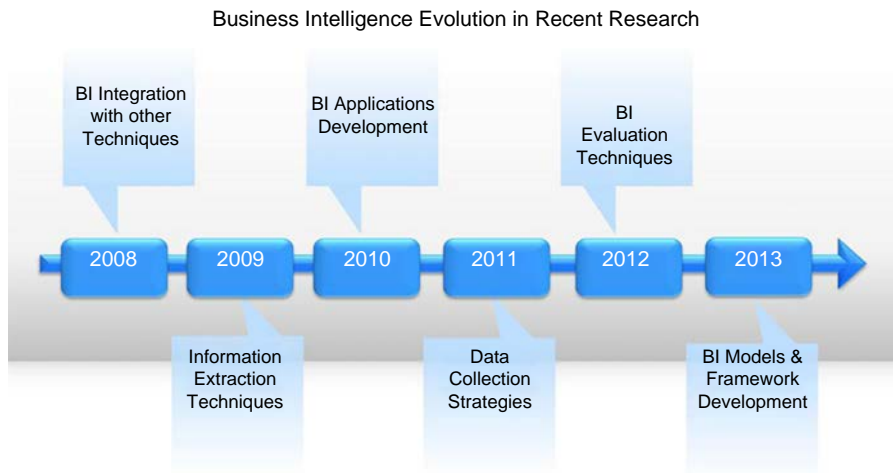
Figure 1.
Evolution in business intelligence

Sl. no.	BI parameters	Description
1.	BI work	Purpose or objective of BI
2.	Domain	Application area or domain in which the BI is applied
3.	Problem identified	Problem description
4.	Solution applied	Solution proposed
5.	Outcome	Contribution of BI work

Table I.
List of parameters to understand the business intelligence

The third category addresses about information extraction techniques, which have been applied in BI to find relevant and accurate information for data collection. Accordingly, this section presents about data collection strategies followed in BI. The fourth category of BI works describes about the integration of BI with other techniques. The BI works which belongs to the fifth category describes about prototypes, design models and frameworks that have been applied in BI applications development.

The next of the category of BI works describes about evaluation and performance assessment methods available in BI. The final category describes about implementation issues in BI. The evolution of BI works have been described in detail in the following sections.

2.1 BI and its applications

BI has been applied in many domains. In most of the domains, BI is applied either to take decisions or to provide input to the decision making. For example, higher education, E-learning, strategy making, crime fighting, financial and other domains it has been applied to take better decisions. The strength of BI is the integration of data at different levels and it provides the right information for decision making at the right time. Table II describes about problem, proposed solutions, benefits and outcome of the BI applications.

Different applications of BI have been described in Table II. The role of BI in all these applications is found to be effective and it paves lot of improvements. A BI application is developed to understand the consumer heterogeneity (Yoichi *et al.*, 2010) in which the customers of an internet service provider industry is divided into groups. In each group, the degree, time and day of usage of the internet by the customers is identified by the BI. This information is very important to the service and sales department to form new strategies in order to raise revenue (Sheng-Tun *et al.*, 2008). The BI-based Student Relationship Management system ensures an effective student-institution relationship in higher education and enhances the teaching-learning process (Maria and Maribel, 2009).

The application of BI in real-time environment has improved the business process (Jalileh *et al.*, 2011; Yang and Simon, 2010; Jun-Jang *et al.*, 2003; Aciar *et al.*, 2009; Vlad *et al.*, 2010). The SOA with BI gives the best performance in the real-time environment (Jalileh *et al.*, 2011). The real-time-BI systems control material and information flow between the suppliers and the end customers by providing pattern discovery, trend detection and visualization (Yang and Simon, 2010). The outcome of BI from the domains is described in Table II.

Outcome:

- Market management – attaining their goals using BI (Mahdi *et al.*, 2012).

- Product/service – quality of service improved (Kun-Lin, 2011).

- Education – monitors and controls the resources (Sirawit *et al.*, 2010).

- Consumer heterogeneity – factors identified for changing behavior (Yoichi *et al.*, 2010).

- Internet service provider – formulate proper marketing strategies (Sheng-Tun *et al.*, 2008).

- Inventory management – delivery reliability is increased (Tobias and David, 2011).

BI applications	Domain	Problem identified	Solution applied	Benefits
The impact of BI systems on stock return volatility (Eran and Amir, 2013)	Stock market	BI role in highly complex environments – case study on BI use in reducing stock return volatility of an organization	Deployment of BI improves information access in turn reduces volatility of stock returns	1. Increase the data sharing 2. Reduces financial risks
BI approach to estimating consumers' consideration probabilities (Hao et al., 2013)	E-commerce	Finding consideration probability (CP) to a consumer after the inspection of a product	A BI approach to estimate CP (two-step estimation approach)	Finds customers' preferences in a both positive and negative manner
Capturing BI required for targeted marketing and driving process improvement (Brian and Margie, 2012)	Library	Impact of library resources in teaching activities with respect to student academic performance and student engagement	A software library cube with data warehouse which contains student's academic marks and electronic resources and a front end which creates tabulated data views	Able to identify learning outcomes of the students between different groups
Mining BI for study at abroad P/S recommendations (Kun-Lin, 2011)	(Product/service)	To improve quality of product/service (P/S) toward studying in abroad	A recommendation expert system (ES) based on mental accounting and an artificial neural network is proposed	Quality and goodwill of this travel agency can be enhanced
Innovation in market management by utilizing BI (Mahdi et al., 2012)	Market mgmt.	To compete in business environment – utilizing modern technologies	Introduction of practical framework using BI to understand market condition	Best practices to be followed to attain their goals by using BI
BI in Thailand's higher educational resources management (Sirawit et al., 2010)	Education	In Thailand, higher education has been developed without sufficient resource and funds	Efficient resource allocation using business intelligence	BI system that monitors and controls the educational resources available at Thailand higher education institutions
BI to understand consumer heterogeneity (Yoichi et al., 2010)	Consumer heterogeneity	More people eat meals outside their homes. So, academic researchers want to investigate the factors that influence eating-out habits	Neural network rule extraction algorithm is applied to discover the factors – Consumers who eat out frequently	Factors have been identified to know change in the eating habit

Table II.
Business intelligence and its applications

Table II.

BI applications	Domain	Problem identified	Solution applied	Benefits
BI to support strategy-making of ISP service management (Sheng-Tun et al., 2008)	Internet service provider	To balance huge investments, Taiwan's ISP industry has to raise revenue, but it lacks the knowledge to develop competitive service management strategies	A BI decision support system to support strategy making	Helps management to formulate proper marketing strategies
BI to enhance the teaching-learning process (Maria and Maribel, 2009)	Education	Student's academic activities are not closely monitored due to lack of appropriate practices and sufficient technological support	Technological infrastructure that has to be integrated into a student relationship management (SRM) system	Ensures an effective student-institution relationship
Business intelligence in E-learning (Mohammad et al., 2010)	E-learning	Problems in conventional e-learning: 1. No tools to evaluate learner's performance. 2. Structure of learning materials is not flexible	To use BI and OLAP to monitor learner's performance in e-learning environments	Provides instructors with detailed report about student's progression
Business intelligence in banks (Muhammad and Syed, 2004)	Banking	Process of obtaining information from a bank is time consuming	A new BI model consisting of OLTP, data extraction, data staging area and user interface layers	Fast and accurate information retrieval
BI to support aircraft and automated test system maintenance (Steven et al., 2010)	Aircraft	Non-commercial off-the-shelf (COTS) BI software tools are very costly	Use of commercial off the shelf business intelligence software tools	Cost effective and readily available
Situation awareness and applying BI to virtual enterprise partner selection (Jicheng et al., 2008)	Partner selection	Partner selection will affect the virtual enterprise's performance and goals	A support model for virtual enterprise partner selection	1. Self-optimization 2. Quickly perceives the situation 3. This model adjusts decisions according to change in environment

BI applications	Domain	Problem identified	Solution applied	Benefits
BI for improving delivery reliability in business networks (Tobias and David, 2011)	Inventory management	Delivery reliability of the supplier is not reached maximum level	A process-centric, collaborative BI will help companies to optimize the reliability of their suppliers	Delivery reliability is increased
BI for the business of crime fighting (John, 2010)	Crime fighting	Accurate, timely intelligence is needed for reducing crime	Analytical BI toolsets are used by police	Delivers right information about crime to right people and reduces crime
BI and financial intelligence (Zhou et al., 2008)	Financial intelligence	How to improve customer service, control financial risks, ensure sustained growth in profits, etc.	To use BI and its derivative financial intelligence	Better decision support and integration of data
BI application in E-business enterprises (Qiongwei et al., 2010)	Pharmaceutical chain enterprise	Chinese enterprises have invested a large amount of money into equipments, technologies and talent introduction. But many of them could not get back their money	Convert enterprise data into high value and accessible information or knowledge	All-win situation for enterprise, partner and client
BI in business performance management (Yan and Xiangjun, 2010)	Business performance	Business performance management (BPM) is a key business initiative to manage performance	Framework to integrate corporate performance management and BI for managing business performance	Provides single integrated view of the enterprise

Table II.

- Pharmaceutical – all-win situation for enterprise (Qiongwei *et al.*, 2010).
- Business performance – integrated view of the enterprise (Yan and Xiangjun, 2010).
- Best real-time architecture using BI and SOA (Jalileh *et al.*, 2011).
- Real-time + BI systems – controlled information flow (Yang and Simon, 2010).
- Reduced cost by using open negotiable environment (Aciar *et al.*, 2009).

Thus, the impact of BI in various domains makes it an efficient system. The next section describes about intelligent techniques which are applied in BI.

2.2 Intelligent techniques in BI
The basic advantage of using BI is effective decision making. To further enhance the performance of the BI, intelligent techniques have been applied. Table III describes about the BI applications which use intelligent techniques.

The observations made from Table III on the BI application with intelligence techniques have been discussed. BI with artificial intelligence techniques provides better and efficient performance in decision making (Maria and Abdel-Badeeh, 2010). The analytical functionality of the traditional BI system is enhanced and information overloading has been reduced (Li *et al.*, 2007) using analytical techniques. The important outcome of this study is as follows:

Outcome:

- Computational intelligence + BI = Better decision-making ability.
- Cognitive orientation + traditional BI = Improvements in analytical functionality.
- Artificial intelligent techniques + BI = Improved performance and better decision-making ability.
- Ontology-based framework + BI = knowledge-based BI systems.

The next section discusses about various information extraction techniques which are applied in BI.

2.3 Information extraction in BI
The web is an information repository which contains an enormous amount of data. To find exact or relevant information, BI provides different number of information extraction techniques. Table IV describes various information extraction techniques and methods which are applied in BI applications.

In BI, information extraction techniques play a key role in finding relevant information to arrive an effective decision making. In order to find relevant information, different type of information extraction techniques have been applied in various BI applications which are described in Table IV.

The study of factors influencing BI data collection strategies helps to have a better understanding about the success factors associated with collecting vast quantities of data required for BI (Thiagarajan *et al.*, 2012). In information extraction, systematic information collection method improves the intelligence level of BI and finds more knowledge by transformation. It generates strategies to solve contradiction problems

BI and intelligent techniques	Problem identified	Solution applied	Benefits
A cognitive BI system (Li et al., 2013)	Enhancing decision making by incorporating situation awareness	Improving traditional information systems (FACETS) by incorporating various cognitive models	BI environments with cognition-driven decision process
Intelligent techniques for BI in healthcare (Maria and Abdel-Badeeh, 2010)	Efficient intelligent techniques are needed for the healthcare based BI systems	Use of expert systems, data mining and grid computing techniques	Resource optimization in planning, budgeting and forecasting
Exploratory cognitive BI system (Li et al., 2007)	Analytical functionality of traditional BI system has to be extended	Extend the traditional BI systems on cognitive orientation	Reduces information overload
BI and knowledge management (Zhao et al., 2010)	Relationship between KM and BI has to be studied	Business intelligence describes the relationship between BI and KM	KM and BI together results in more effective solutions
Computational intelligence based intelligent BI system (Jui-Yu, 2010)	Existing BI tools have several limitations like lacking data analysis and visualization capabilities	To increase the data analysis capability of BI tools	Better decision making in BI applications
Knowledge-based BI systems (Alexander & Babis, 2010)	Information management is a complicated task	Ontology makes it as semantically rich knowledge base	Provides insight of the problems and challenges related with BI

Table III.
Intelligent techniques and business intelligence applications

BI and information extraction techniques	Problem identified	Solution applied	Benefits/outcome
Discovering BI from online product reviews (Wingyan and Tzu-Liang (Bill), 2012)	Online product reviews – difficult to extract information from reviews' rich expressions and the customer ratings	Develop a framework using rough set theory, inductive rule learning, and information retrieval methods	Market sentiment analysis and e-commerce reputation management can be improved
Factors influencing BI data collection strategies (Thiagarajan et al., 2012)	Data collection strategy is very important for BI success	Develop a research model for data collection strategy	Success factors associated with collecting data required for BI
Systematic information collection method for BI (Xingsen et al., 2009)	No structured information collection method is available for BI	Design of structured information collection method based on extenics theory	Improves information extraction level of business intelligence
Information extraction in BI systems (Cvitas, 2010)	It is difficult to select an information extraction technique because each one has its own pros and cons	To use ETL and information extraction to all data in a single place	Simplifies information extraction process for BI applications
Relation extraction from text documents (Cvitas, 2011)	BI has to be combined with the information extraction methods	To extract relation from text documents (unstructured data)	Provides better result in information extraction
Mining comparative opinions from customer reviews for BI (Kaiquan et al., 2011)	Identifying the comparative relations from customer review on product comparisons gives business opportunities	A novel graphical model to extract and visualize the interdependencies among relations	Enterprise risk management from the review comments of consumer
BI from voice of customer (VOC) (Venkata et al., 2009)	BI model must account for the unstructured information from VOC	To derive business intelligence from the analysis of the voice of customer	Reduced response time in fulfilling customer queries (customer support)
Enhanced BI using EROCS (Bhide et al., 2008)	Unstructured Information lacks content on which the analysis to be applied	Use of OLAP tools to analyze structured and unstructured data in consolidated manner	Provides consolidated analysis of structured and unstructured information

Table IV.
Information extraction techniques in business intelligence

using the extension theory (Xingsen *et al.*, 2009). The important outcome on the study of information extraction techniques are as follows:

Outcome:

(1) BI data collection strategies:

- Comprehensive data collection strategy (Thiagarajan *et al.*, 2012).

- Problem driven data collection strategy (Thiagarajan *et al.*, 2012).

(2) Factors that influences BI data collection strategies:

- Institutional isomorphism and competitive pressure (Thiagarajan *et al.*, 2012).

- Insight into its business processes, strategies and operations (Xingsen *et al.*, 2009).

- To discover new business opportunities (Wingyan and Tzu-Liang (Bill), 2012).

- Risky situations (Kaiquan *et al.*, 2011).

(3) Information extraction leads to:

- Improved market sentiment analysis (Wingyan and Tzu-Liang (Bill), 2012).

- Simplified and enriched information extraction process (Cvitas, 2010; Cvitas, 2011; Bhide *et al.*, 2008).

- Enterprise risk management from review comments (Kaiquan *et al.*, 2011).

- Immediate response to customer queries (Venkata *et al.*, 2009).

In BI two kinds of data collection strategy have been followed in which comprehensive data collection strategy is traditional, time consuming and very expensive whereas problem driven data collection strategy is rapid and it is developed based on the competitive pressure faced by the organization. The next section describes about the integration of BI with other techniques.

2.4 Integration of BI with other techniques and methods
A BI system can be integrated with other techniques. At present, there are many researches which integrate BI with SOA, CRM, ERP, Mobile BI and socio-environmental indicators. Table V describes about BI applications which are integrated with other techniques.

When BI is integrated with ERP the time taken for decision making is minimized and the utilization rate of the resources is maximized (Long-Wen and Zhang, 2008). CRM with BI increases the customer satisfaction and customer relations (Dien and Douglas, 2010). BI has been customized to integrate with social environmental indicators for the organizational sustainable development (Maria and Maribel, 2009). The important outcome of this study is as follows:

Outcome:

- BI + SOA = Service Oriented Business Intelligence architecture prototype developed and evaluated (Tanko and Musiliudeen, 2012).

- BI + CRM = Customer relations and customer satisfaction are improved (Dien and Douglas, 2010).

BI and its integration	Domain	Problem identified	Solution applied	Benefits
A SOA approach to BI in Telecoms industry (Tanko and Musiliudeen, 2012)	SOA – Telecom	To integrate data from heterogeneous data sources of the organization using SOA and BI. To find a suitable customer tariff plan, ensures satisfaction to customer	Development of prototype which will integrate SOA and BI that leads to Service Oriented BI (SOBI) architecture	A prototype was developed which integrates SOA and BI. Due to prototype limitation, right product to right customer is not implemented
BI system for catalogue and online retailers (Dien and Douglas, 2010)	Online retail	Business suffered with great losses	Renewed emphasis on CRM and BI systems	Profit increased. Key success factors are identified
Integrative structure of BI and ERP (Long-Wen and Zhang, 2008)	ERP	ERP has deficiencies like analysis and decision support	BI is used along with ERP to overcome these deficiencies	Reduces processing time and increases resource utilization rate
Mobile BI tool (MBIT) (Sajjad et al., 2009)	SOA	Corporate executives need to access real-time business information from anywhere	Development of Mobile Business Intelligence Tool	Easy integration with any other BI module
BI with socio-environmental indicators for sustainability (Maira and Marlei, 2009)	Business strategy	To implement and monitor sustainable and socially responsible business practices	To manage sustainability using business intelligence solutions	Socio-environmental indicators and financial indicators are combined and integrated into business strategies and practices

Table V.
Business intelligence and its integration with other techniques

- BI + ERP = Time taken for decision making is minimized and the utilization rate of the resources is maximized (Long-Wen and Zhang, 2008).

- BI + Socio-environmental indicators = Managing sustainability with the support of BI (Maria and Maribel, 2009).

Integration of BI with other techniques leads to rapid evolution in business process. The next section discusses about prototypes, design models and frameworks which are followed for BI applications development.

2.5 Prototypes, design models and frameworks for BI

Many authors have proposed different design models for BI and these models have been applied to design and structure BI applications. Table VI describes about BI design models.

To develop any BI application, an underlying architecture is essential. Table VI describes the BIMs which are applied for BI application development. Data mining techniques have been applied widely as analytical component in BI (Cheung and Li, 2012; Javier *et al.*, 2012). A reference model for BI has been developed and this model helps to monitor the information flow promptly (Liyi and Xiaofan, 2009). BI systems are not affordable by all organizations due to its huge cost. Therefore, an efficient but less cost BI system has been introduced (Yong *et al.*, 2010).

The studies on BI design model have described the BIMs that are applied in various business domains. In all these design models, three components are very common. They are data storage model, data analysis model and data visualization techniques for reporting. The outcome of BI design has been described below:

Outcome:

- Correlation coefficient sales data mining system – higher predictive power (Cheung and Li, 2012).

- Multi-agent based BI system – better understanding of internal functioning of BI systems (Javier *et al.*, 2012).

- Feasible enterprise BI design model – reference system for BI applications (Liyi and Xiaofan, 2009).

- Framework for BI systems – adoptable for small and medium size enterprises (Zhang and Zhou, 2010).

- Low-cost BI system based on multi-agent – low cost BI systems (Yong *et al.*, 2010).

- BI tools – implementation of BI design models.

The next section discusses about various performance assessment methods available for BI applications.

2.6 Evaluation and performance assessment of BI systems

BI systems should be evaluated and assessed to know their level of functioning and thereby sustainability of BI systems can be upgraded. Table VII describes the various assessment methods applied to assess the performance of BI systems.

In BI, accessing the performance of BI applications is very important and it gives self-review about the BI systems. Selecting the best suitable BI systems is a prime

BI design models	Problem identified	Solution applied	Benefits
Quantitative correlation coefficient mining method for BI (Cheung and Li, 2012)	Traditional data mining methods may be inadequate in completely uncovering the hidden patterns of sales based on transaction records	Correlation coefficient sales data mining system (CCSDMS) has been developed – uncovering hidden patterns	Possess higher accuracy, better computational effectiveness and higher predictive power
BI system for web-based risk management (Javier et al., 2012)	Innovative BI tools are required to predict risky situations and manage inefficient activities	Predictions based on previous experience using multi-agent system through reasoning capabilities	Better understanding of internal functioning of the business to reduce risk
Feasible enterprise BI design model (Liyi and Xiaofan, 2009)	Lack of reference and lack of prototype for BI application for enterprises	To build a reference system for BI applications to apply in enterprises	Prompt monitoring of information using BI applications
Design of the low cost BI system based on multi-agent (Yong et al., 2010)	Due to the high cost of BI, its development and popularization is limited	To propose a low-cost business intelligence system based on multi-agent	Reduces cost and improves decision making
Enterprise BI maturity model (EBIMM) (Min-Hooi, 2010)	There is only limited research of CMM applied in Enterprise BI (EBI) domain	To develop a model that help firms to elevate their BI to higher levels of maturity	Helps firms to elevate their BI to higher levels of maturity
Parallel architecture of the data mining for BI applications (He Yue and Ding, 2009)	To develop a parallel data mining architecture to BI applications	Enhancement in BI applications to add parallel processing of data mining	Adopting parallel architecture of data mining to BI applications
Constructing a BI solution with MS SQL Server 2005 (Zhijun, 2010)	BI lacks integration	To provide Microsoft SQL Server 2005 which is an integrated BI platform	Rapid development of BI applications
Developing a framework for BI systems (Zhang & Zhou, 2010)	Small and medium size enterprises (SMEs) of manufacturing industry in China – need sharing and exchanging information	A generic conceptual framework using BI for manufacturing information system	SMEs can solve their complex project tasks and participate in projects exceeding their individual capabilities
BI for CIMS system model (Liu and Zhou, 2010)	To develop existing CIMS with latest AI technology, and information processing technology to achieve a continuous production process	CIMS as integrated management of industrial production system using BI techniques	BI helps to take effective decision making

Table VI.
Prototypes, design models and frameworks for business intelligence applications

BI evaluation	Problem identified	Solution applied	Benefits
Evaluating the effectiveness of BI systems (BIS) (Aleš et al., 2012)	How information systems (IS) and BIS dimensions are related and limited. Examine the success of IS and BIS	A model has been developed to know the impact on information access quality and information content quality	Decision-making culture using BIS depends on information access quality and content of the information
Evaluation model for BIS using fuzzy TOPSIS (Saeed et al., 2012)	Evaluation of BIS to suit enterprise decision support environment. (Assistance to design, select, evaluate and buying of enterprise systems)	34 BI evaluation criteria identified and fuzzy TOPSIS technique was applied to compute evaluation scores and ranking	1. Better BI systems can be selected by considering BI evaluation criteria's 2. Identifies suitable intelligence that support managers decisional tasks
BI system usage and individual performance (Chung-Kuang, 2012)	The success of BI system depends on end user computing satisfaction (EUCS) and system usage	Identifies relationship between EUCS, system usage and individual performance using structural equation modeling approach	EUCS leads to increased BI system usage in turn it improves higher levels of individual performance
Performance assessment model for BI systems using analytical network process (ANP) (Yu-Hsin et al., 2009)	Assessment method to evaluate the performance of the BI systems is needed	Performance assessment model for BI systems based on ANP	It is an effective assessment model for assessing BI applications
Evaluation of BI system based on BP neural network (Su-Li et al., 2012)	Existing BIS evaluation system does not support large-scale evaluation and its evaluation indicators give less accuracy in evaluation	Systematic study and analysis on present situation of comprehensive evaluation of BIS	BP neural network method has a strong applicability in overall evaluation of BIS
A generic construct based workload model for BI benchmark (Jia-Lang and Chiu, 2011)	Benchmarks are not accurate to measure system performance when the user domain differs from the standard problem domain	A domain independent and workload independent benchmark methods are proposed	Scalable, portable and simple benchmark assessment has been made

Table VII.
Evaluation and performance assessment of business intelligence systems

objective of an organization. To evaluate a BI system, 34 criteria have been considered and TOPSIS technique is applied to find the best suitable BI system (Saeed *et al.*, 2012). The success of any BI system depends on two factors namely information access quality and information content quality. All other abilities such as processes, technologies, tools, applications, data, databases, dashboards, scorecards and OLAP enables BI (Aleš *et al.*, 2012). Outcome based on the evaluation and the performance assessment of BI systems is as follows:

Outcome:

- Effectiveness of BIS – depends on information access quality and information content quality (Aleš *et al.*, 2012).

- Evaluation model of BI – better BI systems can be selected – 34 BI evaluation criteria considered (Saeed *et al.*, 2012).

- BI system usage and individual performance: EUCS → BI system usage → higher levels of individual performance (Chung-Kuang, 2012).

- Performance assessment model for BI systems – effective model for assessing the BI (Yu-Hsin *et al.*, 2009).

- Evaluation of BI System – analysis on current situation of comprehensive evaluation of BIS (Su-Li *et al.*, 2012).

- BI benchmark – scalable, portable and simple benchmark assessment (Jia-Lang and Chiu, 2011).

The next section discusses the challenges and issues in BI system implementation.

2.7 Challenges and issues in BI implementation
Table VIII describes about various challenges and issues associated with BI applications implementation.

The process of implementing BI involves many steps. The value of BI to an organization and strategies to be followed should be opened before implementing BI to an organization (Fereydoon and Mohammad, 2012). BI implementation for an organization is challenging and it takes longer period of time. To resolve these issues, vernacular knowledge and organizational methodology should be followed (Melody *et al.*, 2010). However, strong, dedicated and adaptive leadership style can implement BI irrespective of any challenges (Melody *et al.*, 2010). The outcome of challenges in implementing BI is described below:

Outcome:

- Process of implementing BI – BI values and strategies described (Fereydoon and Mohammad, 2012).

- Resolving challenges in BI implementation – strong, dedicated and adaptive leadership style (Melody *et al.*, 2010).

- To develop global BI – combines qualitative research and quantitative analysis for firms planning strategy (Ming-Kuen and Shih-Ching, 2010).

BI implementation issues have been described only in limited papers and more research should be conducted to addresses the practical difficulties and issues involved in BI implementation. The next section discusses the findings of the survey.

BI implementation	Problem identified	Solution applied	Benefits
The roles of BI capabilities and decision environments (Öyku et al., 2013)	Factors that are required to improve BI capabilities irrespective of decision environment	BI success depends upon data quality, user access and the integration of BI with other systems	1. Factors that influencing BI success 2. Technological capabilities directly influences BI success
Role of BI in the development of organizations (Fereydoon and Mohammad, 2012)	To keep the organization in high level	Steps to implement business intelligence	BI helps managers to take good decisions and in turn improves performance and productivity
Indigenous leadership in implementing a BIS (Melody et al., 2010)	Difficulties in implementing BI to Chinese firms. Major cause – employee resistance and change management	Vernacular knowledge and organizational methods – Strong, dedicated and adaptive leadership style	This study outlines most efficient and successful strategies to implement BI
To develop global BI for information service firms (Ming-Kuen and Shih-Ching, 2010)	Handling exact business information for BI System and to take better business decisions	1. A framework with specific business elements 2. Adjustment of business strategy with six performance indices	Quantitative and qualitative analysis yields better business decisions

Table VIII.
Challenges and issues in business intelligence implementation

3. Findings of the survey

In this literature review different kinds of BI evolutions and its applications have been described in different perspectives. The outcome of this survey has been described in this section.

3.1 BI and its applications

BI has been applied in numerous domains and many numbers of applications have been developed in each domain to make better decisions. Table IX lists out the applications which are developed using BI.

The contributions of BI in terms of its applicability in various domains have been described in Table IX. The potential of BI has been explored in the domains mentioned in Tables II and IX. Although BI is applied in various domains, the quantity of work established in each domain is very limited. In all these applications a new strategy or progressive methodology has been applied for the development of the organization.

In business organizations piece meals of technologies, for example data warehouse, ETL, OLAP, OLTP, data mining, Dash board and data visualization techniques has been applied previously for decision making (Inmon, 2013; Power, 2013; Gangadharan and Swami, 2004). BI has brought all these technologies into a single umbrella (Saxena and Anand, 2013). It makes BI as a strong business tool which can be applied to cross domains to make better decisions (Ren *et al.*, 2013). The next section explores the various ongoing researches in BI.

3.2 Ongoing researches in BI

From the BI works which are described in Tables II-VIII, the ongoing researches in BI have been derived as shown in Table X.

Business intelligence applications in various domains			
Telecom (Tanko and Musiliudeen, 2012)	Banking (Martin *et al.*, 2014)	Pharmaceutical (Qiongwei *et al.*, 2010)	E-learning (Mohammad *et al.*, 2010)
Education (Maria and Maribel, 2009)	Aircraft (Steven *et al.*, 2010)	Healthcare (Maria and Abdel-Badeeh, 2010)	Analysis on impact of library resources in teaching (Brian and Margie, 2012)
Market management (Mahdi *et al.*, 2012)	Partner selection (Jicheng *et al.*, 2008)	Real time environment (Jalileh *et al.*, 2011)	Risk mgmt. (Javier *et al.*, 2012)
Information exchange (Liyi and Xiaofan, 2009)	Inventory management (Tobias and David, 2011)	Forensic computing (John, 2010)	Performance mgmt. (Yan and Xiangjun, 2010)
Catalogue and online retail (Dien and Douglas, 2010)	Managing sustainability (Maira and Marlei, 2009)	Voice of customer (Venkata *et al.*, 2009)	Financial intelligence (Zhou *et al.*, 2008)
Consumer heterogeneity (Yoichi *et al.*, 2010)	Stock market (Eran and Amir, 2013)	Service firms (Kun-Lin, 2011)	Manufacturing industry (Zhang and Zhou, 2010)
Internet service provider (Sheng-Tun *et al.*, 2008)	Analysis from unstructured text (Cvitas, 2011)	Online reviews (Kaiquan *et al.*, 2011)	Business data collection strategies (Thiagarajan *et al.*, 2012)

Table IX.
List of business intelligence applications

Sl. no.	Ongoing researches in BI	Description
1.	Business intelligence and its applications (ABI)	To improve the performance of business
2.	Intelligence techniques in BI (IBI)	To enhance the analytical capabilities of BI
3.	Information extraction techniques in BI (EBI)	To access relevant information
4.	Integration of business intelligence with other techniques and methods (OBI)	Integrating BI with other techniques
5.	Prototypes, design models and Frameworks for BI (DBI)	To develop cost effective design models for BI applications development
6.	Evaluation and performance assessment of BI systems (PBI)	To enhance the functionality and performance of business intelligence systems
7.	Challenges and issues in BI implementation (CBI)	Difficulties in implementing BI

Table X.
Ongoing research in
business intelligence

From the research work considered for the literature study has been analyzed from which seven kinds of ongoing research opportunity has been found. The contribution on each research area is depicted in Figure 2.

The ongoing research in BI is depicted in Figure 2. The research on applying BI (ABI) in various domains is high when it compared to all the other research. The information extraction techniques (EBI), business intelligence integration (OBI) and evaluation and performance assessment of BI systems (PBI) have limited number of contributions. In the ongoing research analysis, the information extraction (EBI) and DBI have relatively equal number of contributions. The CBI has very less contribution when it compared to the researches. The lesser contribution in CBI indicates that it has wide opening and the issues present in this CBI has to be explored.

3.3 BI domains, problems and solutions – a prospective convergence
BI has been applied in many domains and this section analyses the relationship between BI domains, problems and solutions which are depicted in Figure 3.

Figure 3 describes the convergence of BI domains, problems and solutions. To find the technological convergence on BI we have applied divide and conquer approach to
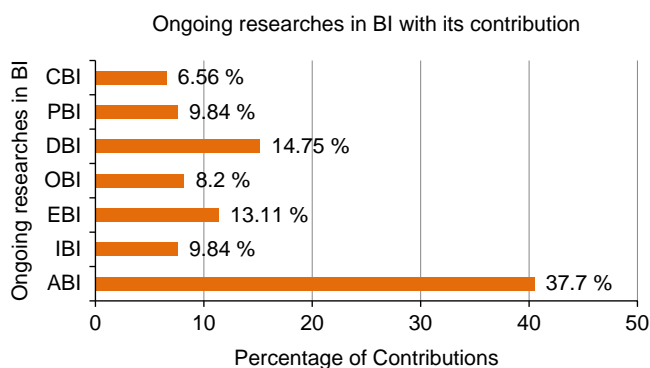

Figure 2.
Ongoing researches in
business intelligence

divide the domains into congregated domains, problems into core problems and solutions into key solutions. BI domains have been identified from the BI works and these domains have been segregated into congregated domains. The problems which are found in these congregated domains are grouped, and from this group we have identified the core problems. BI solutions which are applied to these core problems are grouped and from these solutions we have formulated the key solutions.

3.3.1 BI domains and congregated BI domains. In the first step of convergence, each research work has been segregated into different domains according to the identified problem. The domains are identified based on following questions:

(1) What kind of application it is?

(2) Where it can be applied?

(3) Which field is best suited for it?

This section groups the BI works that has high similarity in comparison to one another. The domain of the BI works belongs to Section 2.1-2.7 has been studied and it is segregated into different groups according to the nature of the domain. Table XI describes the segregation of BI work into congregated domain for the category "Business Intelligence and its Applications," "Intelligent Techniques in Business Intelligence" and "BI models and frameworks."

Table XI describes the segregation of BI domains into congregated domains. Similarly, the same procedure is applied to other categories and segregated into congregated domains. In this analysis, totally 56 domains have been found and these domains are segregated into congregated BI domains such as customer satisfaction, market management, knowledge management, business performance and other similar congregated domains. In this process 12 kinds of congregated BI domains have been found which are described in Table XII.

Among these 12 congregated domains the domains which are less relevance such as education, medical, forensic computing, banking and aircraft are omitted and domains which are related to general issues has been selected. The complete set of the congregated domains which are relevant to each other are depicted in Figure 4.

The percentage of contributions in each of these congregated domains has been described in Figure 5.

In this congregated BI domain, the domain: BI infrastructure has the highest number of contribution whereas the domains: customer satisfaction, knowledge management, information management and risk management have limited contributions.
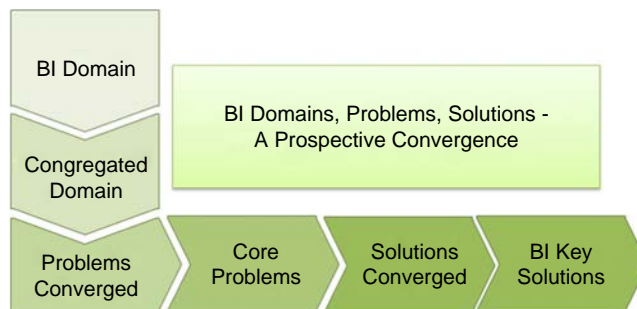

Figure 3.
Business intelligence domains, problems and solutions – a prospective convergence

Ongoing research in BI	BI work	Congregated domain	BI work	Congregated domain
Business Intelligence and its Applications	Mining BI to study abroad P/S recommendations	Customer satisfaction	BI to understand consumer heterogeneity	Customer satisfaction
	Innovation in market management by utilizing BI	Market management	BI to support strategy-making of ISP service management	Market management
	BI in Thailand's higher educational resources management	Education	BI to enhance the teaching-learning process	Education
	Business intelligence in E-learning	Education	Situation awareness and BI to virtual enterprise partner selection	Business context analysis
	Business intelligence in banks	Business performance	BI for improving delivery reliability in business networks	Market management
	BI to support aircraft and automated test system maintenance	Business performance	BI for the business of crime fighting	Forensic computing
	BI application in E-business enterprises	Business performance	BI in business performance management	Business performance
	BI and financial intelligence	Risk management	Agent-based architecture for real-time enterprises	Business performance
	Real-time BI system architecture with stream mining	BI infrastructure	Distributed approach to BI systems synchronization	BI infrastructure
Intelligent Techniques in Business Intelligence	Intelligent techniques for BI in healthcare	Medical	Computational intelligence-based intelligent BI system	Knowledge management
	Exploratory cognitive BI system	Business context analysis	Knowledge-based business intelligence systems	Knowledge management
	BI and knowledge management	Knowledge management	Architecture for cognitive business intelligence system	BI infrastructure

(*continued*)

Table XI.
Congregated BI domains

Table XI.

Ongoing research in BI	BI work	Congregated domain	BI work	Congregated domain
Prototypes, Design Models and Frameworks for Business Intelligence	Enterprise BI maturity model	BI infrastructure	Parallel architecture of the data mining for BI applications	BI infrastructure
	Quantitative correlation coefficient mining method for BI	Risk management	Constructing a BI solution with MS SQL Server 2005	BI infrastructure
	Feasible enterprise BI design model	BI infrastructure	Developing a framework for BI systems	BI infrastructure
	Design of the low cost BI system based on multi-agent	BI infrastructure	Business intelligence for CIMS system model	Business performance

3.3.2 Congregated BI domains and its core problems. The fundamental or the most important part which address the functional issues of the system is called as core problem. In this literature each BI work has addressed a problem. An analysis has been made to identify the core problems which are very important and affects the functionality of the system. To identify the core problems the problems which are found commonly in BI considered in this literature survey are listed:

- innovations required to improve customer satisfaction;

- competitive technology to find new strategies;

Congregated business intelligence domains (CBID) with its contributions

Customer satisfaction (CS) (3)	Market management (MM) (8)	Education (ED) (3)
Knowledge management (KM) (3)	Context-based BI (CB) (9)	Forensic computing (FC) (1)
Medical (MD) (2)	Business performance (BP) (8)	BI infrastructure (BF) (12)
Information management (IM) (4)	Banking (BA) (1)	Risk management (RM) (4)

Table XII.
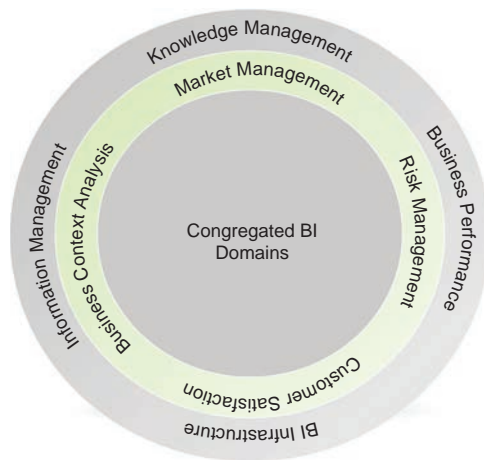Congregated business intelligence domains

Figure 4.
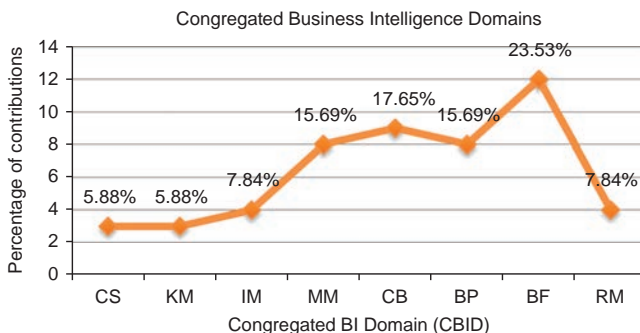Congregated business intelligence domains

Figure 5.
Congregated BI domains with its contributions

- best analytical tools to find new business patterns;

- BI tools to control the financial risk;

- strategic framework to implement BI for an organization;

- adaptability analysis to meet sudden requirements;

- decision support and risk management;

- data collection strategies to find relevant information; and

- mining of new business opportunities from huge volumes of data using relation extraction techniques.

The problems which are found in the literature have been grouped according to the congregated domain. A sample of the congregated BI domains and the group of problems addressed in the respective congregated domain are described in Table XIII.

Similarly, core problems have found from each of the congregated domain. There are totally nine kinds of core problems are identified. The total percentages of the core problem found in the congregated domain are described in Figure 6.

The different kinds of core problems are described in Figure 6 with its level of contribution. The core problems and its impact are analyzed to find the solution.

3.3.3 BI key solutions. An analysis made to find key BI solutions from the literature to the core problems. In this analysis process the solutions which are widely in BI are listed below:

- applying a BI framework/an BI architecture/a BIM to implement BI;

- relation or information extraction to find relevant data;

- to select an appropriate BI solution using evaluation methods;

- improving the analytical abilities of the BI using artificial intelligence and data mining techniques;

- best practices for information management to get better results;

- information access quality and content of the information;

- quantitative and qualitative analysis for better business decisions;

Business performance (CBID)	Business context analysis (CBID)
Quick retrieval of information	Virtual enterprise partner selection
Cost effective business tools	Enhancing analytical functionality of BI
No revenue irrespective of huge investment	Discovering review rich expressions
Framework to integrate information	Mining comparative opinions
Handling real time business information	Analysis of structure and unstructured information
Real time analytics for decision making	Design of low cost BI using agents
Socially responsible business practices	End user computing satisfaction and BI usage
Continuous production process using BI	Evaluation of BI system
Information management (CBID)	*Risk management (CBID)*
Efficient data collection strategy for BI	Controlling of financial risk using BI
Structured information collection method	Predicting risk situation using BI
Simplified extraction methods	Successful strategies to implement BI
Extract relations from text documents	Better business decision-making techniques

Table XIII.
Congregated BI domains and core problems

Figure 6.
Core problems converged
in business intelligence

- BI and knowledge management to enhance the analysis process; and

- adopting different kinds of BI implementation practices.

The obtained BI solutions have been grouped and termed as key solutions which are
depicted in Figure 7. Based on this classification we derived the key solutions for the
core problems.

The derived key solutions have been applied to solve the core problems. The BI key
solutions can be applied to solve different kind of problems in various domains.

Figure 7.
Key solutions of
business intelligence

Most of the BI solutions propose a new strategy, a new framework or applying a BI architecture. To find new information or knowledge the BI solutions such as BI data collection strategies, information extraction techniques with information management techniques might be considered. Thus, the convergence of BI domains, problems and solutions, provides key BI solutions to any domain. The next section discusses about component composition in BI.

3.4 Component composition in BI

A typical BI application consists of many parts or components such as a data source, data storage and filtering techniques, analytical process and reporting. Application development using the component-based approach helps to develop efficient BI applications. From the literature, it is found that BI applications have been developed using a diverse number of components. However, well-organized usage of components facilitates the development of efficient BI applications. This literature study helps to identify components that have been widely applied for the development of BI applications. The identified components with their examples have been depicted in Figure 8.

Figure 8 depicts the widely applied BI components with examples from the literature survey. While developing BI applications, the required BI components can be selected from the given set of widely applied components. The explosive growth of BI has dramatically expanded the variety and size of components that are relevant to decision making. The next section describes about widely applied BI solutions.

3.5 A detailed discussion on BI solutions

BI offers different solutions in which the widely applied solutions are algorithm-based solutions, architecture-based solutions and model-based solutions, which are described below.
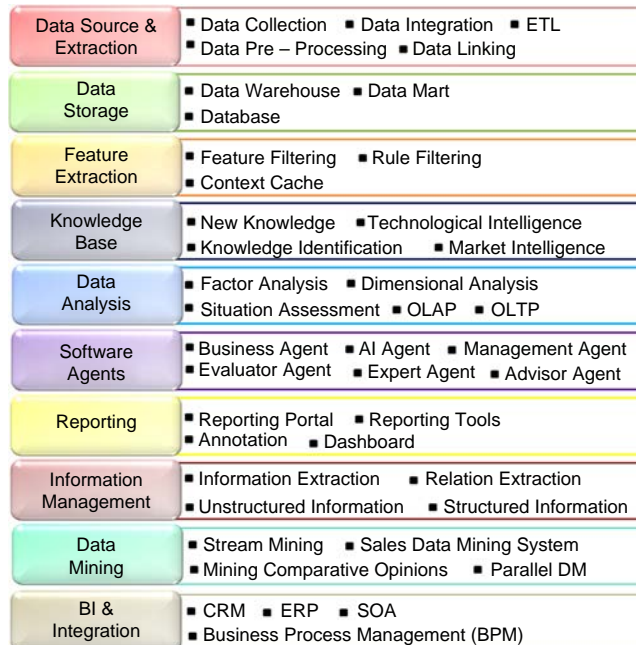

Figure 8.
Business intelligence components with examples

3.5.1 Algorithm-based BI solutions. In BI in the process of analysis various techniques and algorithm have been applied to find the required information and knowledge. Table XIV describes algorithms and techniques which are applied recently in BI for analysis.

In BI different kinds of algorithms and techniques have been applied to conduct analysis. According to the domain and application the appropriate algorithms has been chosen to perform the analysis. Information extraction and business process analysis are the two major places where the BI algorithms and techniques are very essentially required. To improve the effectiveness of information extraction techniques semantic web intelligence has been applied. Finding the relevant information with meaningful search is an objective of semantic web.

BI has been merged with semantic web such that new trends and realistic knowledge can be discovered using BI applications (Alexander and Babis, 2010; Kim *et al.*, 2013). In Section 4, Table IV has described a different number of information extraction techniques to access both structured and unstructured data. These information access techniques efficiently find relevant information with fast access. BI has a lot of scope in this area to identify the required structured and unstructured data. The effectiveness of BI information extraction can be improved by adopting the latest techniques as well as semantic web intelligence techniques.

3.5.2 Architecture-based BI solutions. A successful BI system should translate the business requirement into high level BI architecture (William and Andy, 2010). Organizations must consider two important aspects when constructing BI architecture: integration of large heterogeneous data sources and provision of analytical capabilities to analyze that data (Aleš *et al.*, 2012). Generally, a BI architecture consists of data transformation (ETL), data warehouse, data analysis (OLAP) and reporting (Mounire *et al.*, 2013). Table XV describes BI architectures which are applied in various domains.

Domain	Problem identified	Algorithm/technique applied
Semantic BI (Kim *et al.*, 2013)	Mobile BI service based on adaptive recognition of user intention and usage patterns	Text mining and semantic web technologies
E-commerce (Hao *et al.*, 2013)	Finding consideration probability (CP) to a consumer after the inspection of a product	A BI approach to estimate CP (two-step estimation approach)
(Product/service) (Kun-Lin, 2011)	To improve quality of product/service (P/S) toward studying in abroad	Mental accounting and an artificial neural network
Consumer heterogeneity (Yoichi *et al.*, 2010)	Factors influence eating-out habits	Neural network
Cognitive BI (Li *et al.*, 2013)	Enhancing decision making by incorporating situation awareness	Incorporating cognitive models
Marketing management (Cheung and Li, 2012)	Uncovering hidden sales patterns	Correlation coefficient sales data mining system
Risk management (Javier *et al.*, 2012)	Predict risky situations and manage inefficient activities	Predictions based on previous experience using multi-agent system through reasoning capabilities

Table XIV.
List of algorithm-based BI solutions

Domain	Proposed BI architecture	Outcome
IT service management (Marin Ortega *et al.*, 2014)	BI architecture for the integration of business and technological domains	New BI architecture to support IT service
BI interpretation (Givens *et al.*, 2013)	A BI architecture to capture knowledge of employees carrying out the interpretation of BI output	Improvement of BI interpretation
Chemical industry (Carvalho and Jose Sassi, 2013)	Push BI architecture	Usage of BI during the critical crisis moment
Healthcare (Meimei, 2013)	Top down scalable BI architecture	Different from traditional BI (rapid, consistent and scalable)
Cognitive decision support (Li *et al.*, 2013)	Architecture for cognitive business intelligence system	Cognitive decision support in ill-structured decision situations.
Multi-criteria decision making (Ayman, 2013)	Multi-criteria business intelligence architecture	To develop a course treatment for chronic liver disease
Education (Kun-Lin, 2011)	An BI-based recommendation expert system architecture	Successful designing and positioning product/service
Product relation network (Cheung and Li, 2012)	An BI architecture for correlation coefficient sales data mining system	Improved quality and awareness of product relations
Risk management (Yong *et al.*, 2010)	BI with multi-agent system architecture	Detecting potential risk situations

Table XV.
List of architecture-based BI solutions

Different kind of BI architecture has been proposed to apply BI in various domains. To apply BI in ill-structured decision situations, cognitive BI system architecture has been developed. Similarly, to improve quality and awareness of product relations, correlation coefficient sales data mining architecture has been developed. According the nature of the problem the architecture for BI has been designed. From the literature it has found that different authors have proposed different BI architectures but there is no BI architecture patterns have been identified. From all these proposed architectures architectural pattern to be identified and it would be reused for other domains to develop BI applications quickly.

3.5.3 Model-based BI solutions. In BI to design an application, models and framework have been applied. BIM provides a set of constructs for modeling and analyzing a business context consisting of intentions, situations, processes, actors, influences, key performance indicators and more. It is intended to support the modeling and analysis of a business organization at both a strategic and a tactical level. A framework is a reusable architecture that provides structure and behavior common to all applications of same domain. Frameworks are partially completed software systems that may be targeted at a specific type of application (Johnson, 1997). Hence, frameworks are generally hybrid of architecture level information and implementation. The frameworks and models which are applied in BI have been described in Table XVI.

In BI, two kinds of design methodologies such as BI frameworks (Wingyan and Tzu-Liang (Bill), 2012; Lee *et al.*, 2009; Ayman, 2013; Yeoh *et al.*, 2013) and BIMs (Dien and Douglas, 2010; Tanko and Musiliudeen, 2012; Oyko and Mary, 2013) have been followed to develop BI applications. Domain-specific BI frameworks (Wingyan and

Domain	Requirement	Approach	Outcome	Nature of design
Online product reviews (Wingyan and Tzu-Liang (Bill), 2012)	Discovering BI from customer ratings and their reviews	Pattern recognition and information retrieval techniques	Framework	Implemented
Procurement (Lee et al., 2009)	To improve the existing procurement process using BI	Agent-based procurement system with BI module (OLAP)	Framework	Implemented
Medical – liver disease (Ayman, 2013)	BI framework to treat the chronic liver disease	Architecture of multi-criteria BI approach	Framework	Implemented
Manufacturing (Rausch et al., 2013)	To close the gap between IT support for mgmt. and production	Operational BI	Framework	Conceptual
Manufacturing (Zhang and Zhou, 2010)	Sharing and exchanging of information	Based on the basic model of the manufacturing information system (MIS)	Framework	Conceptual
Market management (Mahdi et al., 2012)	To acquire correct and well-timed understanding of marketing condition	Based on business, organizational and IT skills	Framework	Conceptual
Online product reviews (Wingyan and Tzu-Liang (Bill), 2012)	Discovering BI from customer ratings and their reviews	Pattern recognition and information retrieval techniques	Framework	Implemented
Domain independent (Liyi and Xiaofan, 2009)	Lack of prototype for BI for enterprises	Based on the analysis of enterprise data model structures	Framework	Conceptual
Domain independent (Yong et al., 2010)	To reduce developmental cost of BI systems	Multi-agent technology	Framework	Conceptual
Domain independent (Yeoh et al., 2013)	Relationships between BI competency, absorptive capacity and assimilation	Based on BI competency	Framework	Conceptual
Online retailers (Dien and Douglas, 2010)	To incorporate customer satisfaction and relationships	Integration of BI and CRM	BI model	Implemented
Telecom (Tanko and Musiliudeen, 2012)	SOA approach to BI for customer satisfaction	From the review of existing models and architectures	BI model	Implemented
Domain independent (Oyko and Mary, 2013)	Role of decision environment in BI success	Based on technological BI, organizational BI and decision environment	BI research model	Implemented

Table XVI.
List of BI models and framework

Tzu-Liang (Bill), 2012) and generic BI framework (Yeoh *et al.*, 2013) has been designed to implement BI applications. Most of the BI frameworks which are considered in the literature survey have not been matured to implementation level. The conceptual details of framework are available whereas its implementation details are not available. Similarly, generic frameworks have been developed suitable to all domains. However, it has been matured to conceptual level. Despite these developments some of the BI frameworks do not have complete conceptual details (Yong *et al.*, 2010; Liyi and Xiaofan, 2009).

BIM has been implemented in domains such as online retail (Dien and Douglas, 2010) and telecom (Tanko and Musiliudeen, 2012). Generic BIM has been developed to justify the role of decision environment in BI success (Oyko and Mary, 2013). Both of these design methodologies have limited contribution moreover, BIM has very limited contribution. This analysis shows that most of BI applications have matured to implementation level despite any design model guidance. These kinds of developments obstruct the reusability of BI to be applied in other domains.

3.5.3.1 Development of BIMs. BI applications have been developed to address various issues in different domains. These BI applications have not followed any model by their contributors knowingly or unknowingly for its development (Liyi and Xiaofan, 2009; Mahdi *et al.*, 2012). The study which we made on BIMs and framework clearly state the need of BIMs. The observation from Tables II-VII depicts the availability of BI applications and developments happened in BI. In all these BI works, there is no reference model or standard model has been followed to develop BI applications. To address the BI design issues, a generic BIM is required which would be tailored to suit any domain. Development of a BIM can simplify BI application development and reduces the development period.

From the literature we have found different components which are applied in various BI applications described in Figure 7. The proposed generic BIM may take the components from BI components collection. Recently, information delivery model has been developed which is applied in banking (Martin *et al.*, 2014). The basic concept behind this model is delivering the right information to right user at right time. In normal reporting, the information is presented as reports to users independent of their requirements of the information. In most of the cases, users receive information that is not of their interest. Finding the user's current context and providing them information accordingly, could be a challenging task.

Reporting is very important in the enterprise information processes and is very much essential in decision making. While presenting to the user, the information that is of his interest alone will be sufficient. This is nothing but delivering the right information to the right user through right channel. It also prevents inappropriate use of information by unauthorized users. This information delivery model delivers customized reporting which is tailored to meet requirements of a particular user or user group. This information delivery model further enhanced to suit other domains according to the BI applications which are considered in this literature study.

3.6 Development and implementation cost of BI applications

The development cost of BI software tools are very high (Steven *et al.*, 2010) and low cost BI system using multi-agent has been proposed (Yong *et al.*, 2010) to cut the cost in developing the BI applications. The size of BI application is generally high when compared to other kinds of business applications due to its development in both vertical as well as horizontal. Moreover, BI applications require high-level

infrastructure which increases the maintenance costs for BI environment (Fereydoon and Mohammad, 2012; Melody *et al.*, 2010; Ming-Kuen and Shih-Ching, 2010). More research is required to improve BI environments which provide higher benefits and lesser cost to develop BI applications.

3.7 Requirement of security and privacy policies for BI applications
Security and privacy policies should be established for BI applications which are not addressed in the literature considered for the study. Privacy should be maintained when BI access data from web repository using information extraction techniques. The information extraction techniques searches information from web repository and made analysis on it and finds the hidden patterns for the business development. Despite this analysis most of the information belongs to a third person or an organization. It may be the data of an organization or an individual data. A stronger business policies to be made to address the above said issues. Privacy could be a big concern while using the data in BI.

The literature study has addressed the various research opportunities in BI in different perspectives. The survey has shown the openings in BI, but BI has wide opening to benefit its entire society.

4. Conclusion
BI research in recent years has been studied and the various developments happened in BI have been described in detail with its research opportunities. We have found totally seven kinds of ongoing research in BI and contribution in each category have been described. From the survey it has been found that in recent research most of the BI contributions are belong to development of BI applications. Despite these huge BI applications developments the other research contributions are very limited. The BIMs, reference models technological advancements to improve BI analytical capabilities, application of text mining in BI and evaluation methodologies for BI should be given more emphasis and these areas have more research openings.

This survey has observed BI developments in the perspective of its convergence. BI domains, problems solved using BI and solutions that have been applied to solve these issues are converged. This convergence gives congregated BI domains, core problems that have been solved using BI and key BI solutions. The proportion of occurrence of congregated BI domains and core problems developed in congregated BI domains has been discussed. The key solutions proposed from this convergence can be applied to issues which are arising from any of the congregated domains. The widely applied BI solutions such as algorithm-based, architecture-based and model-based solutions have been described with its outcome.

In this study, the components that have been applied to develop BI applications have been studied. We have also listed out important BI components along with examples for each kind of component. The implementation issues, security and privacy issues have been described with research openings. This literature study outlines the research opportunities available in BI in various perspectives. This paper will be more useful to researchers who desire to get knowledge about the recent works accomplished in the BI.

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