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Construct an Enterprise Business Intelligence Maturity Model (EBI2M) Using an Integration Approach: A Conceptual Framework

Min-Hooi Chuah and Kee-Luen Wong
University Tunku Abdul Rahman,
Malaysia

1. Introduction

Today, Business Intelligence (BI) play an essential role particular in business areas. The important role can be seen as the BI applications have appeared the top spending priority for many Chief Information Officers (CIO) and it remain the most important technologies to be purchased for past five years(Gartner Research 2007; 2008; 2009). In fact, various market researchers including Gartner Research and International Data Corporation (IDC), forecast that the BI market will be in strong growth till 2014 (Richardson et.al , 2008).

Although there has been a growing interest in BI area, success for implementing BI is still a questionable (Ang & Teo 2000; Lupu et.al (1997); Computerworld (2003)). Lupu et.al (1997) reported that about 60%-70% of business intelligence applications fail due to the technology, organizational, cultural and infrastructure issues. Furthermore, EMC Corporation argued that many BI initiatives have failed because tools weren't accessible through to end users and the result of not meeting the end users' need effectively. Computerworld (2003) stated that BI projects fail because of failure to recognize BI projects as cross organizational business initiatives, unengaged business sponsors, unavailable or unwilling business representatives, lack of skilled and available staff, no business analysis activities, no appreciation of the impact of dirty data on business profitability and no understanding of the necessity for and the use of meta-data. A maturity model is needed to provide systematic maturity guidelines and readiness assessment for such resourceful initiative. While there are many BI maturity models in the literature but most of them do not consider all factors affecting on BI. Some of BI maturity models focus on the technical aspect and some of the models focus on business point of view.

Therefore, this research seeks to bridge this missing gap between academia and industry, through a thorough formal study of the key dimensions and associated factors pertaining to Enterprise Business Intelligence (EBI). It aims to investigate the dimensions and associated factor for each maturity level. The remainder of this paper has been structured as follows. The next section discusses the components of Business Intelligence (BI), Capability Maturity Model (CMMI) as well as review of BI maturity models. The third section then outlines and discusses the proposed EBIM model, then follows by empirical research.

2. Literature review

2.1 Definition of business intelligence

The concept of BI is very new and there is no commonly agreed definition of BI. In view of this, this section presents the various definitions and categories of BI.

Table 1 summarised various other definitions of BI have come from leading vendors and prominent authors.

| BI vendor/Author	Definition of BI
Reinschmidt and Francoise (2000)	An integrated set of tools, technologies and programmed products that are used to collect, integrate, analyze and make data available
Golfarelli et.al (2004)	Process of turning data into information and knowledge.
Raisinghani (2004)	An umbrella term that includes architecture, tools, database, application and methodologies.
Chang (2006)	The accurate, timely, critical data, information and knowledge that supports strategic and operational decision making and risk assessment in uncertain and dynamic business environments. The source of the data, information and knowledge are both internal organisationally collected as well as externally supplied by partners, customers or third parties as a result of their own choice.
Zeng et.at (2006)	A set of powerful tool and approaches to improve business executive decision making, business operations and increasing the value of the enterprise.
Xu et.al (2007)	Process of gathering enough of the right information in the right manner at the right time, and delivering the right results to the right people for decision making
Jourdan (2008)	Process that analyses the information which resides in the company in order to improve its decision making process and consequently create a competitive advantage for the company.

Table 1. Summary of varied BI definitions

The term Business Intelligence (BI) can be divided into two terms: "business" and "intelligence". According to Turban et.al (2011), BI can defined as "*discipline that combines services, applications, and technologies to gather, manage, and analyze data, transforming it into usable information to develop the insight and understanding needed to make informed decisions*" while Vercellis (2009) stated that BI is a "*set of mathematical models and analysis methodologies that exploits the available data to generate information and knowledge useful for complex decision making processes*". BI can

BI can be viewed as three perspectives: technological standpoint, managerial standpoint and product standpoint. From the managerial standpoint, Whitehorn & Whitehorn (1999) illustrated BI as "*a process that focuses on gathering data from internal and external sources and analysing them in order to generate relevant information*". From product standpoint, Chang (2006) described BI can viewed as "*result or product of detailed business data as well as analysis practices that support decision-making and performance assessment*". From the technological

standpoint, BI can be named as BI systems and is considered as a "*tool that enables decision makers to find or access information from data sources*" (Hostmann 2007; Moss & Atre 2003; Moss & Hoberman 2004).

2.2 The business intelligence's architecture

Turban et. al (2011) classified BI system as four main components: a data warehousing environment, business analytics, business performance management (BPM) and a user interface such as the dashboard.
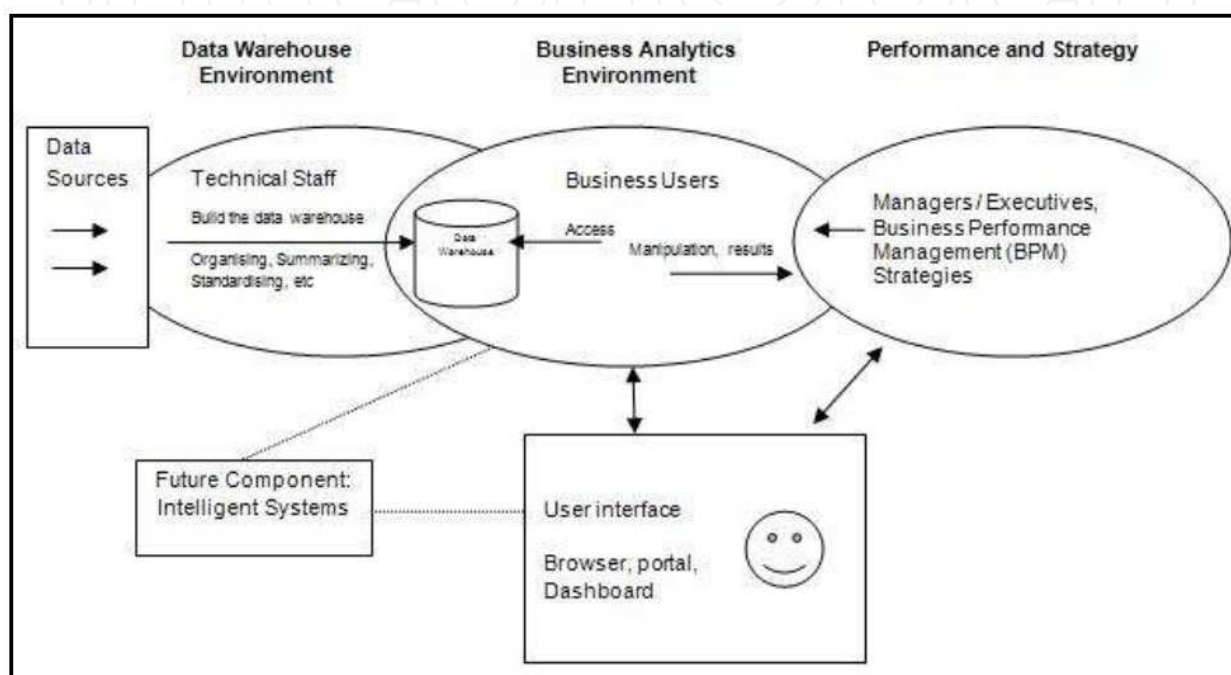
Source: Turban et.al (2011)

Fig. 1. Business Intelligence system architecture

2.2.1 Data warehousing

Data Warehousing is main component of business intelligence. Data warehousing has four fundamental characteristics namely subject oriented, integrated, time variant, non-volatile (Inmon, 2005).

i. Subject oriented
   Data are structured by specified subject such as sales, products or customers, including only information pertinent for decision support.
ii. Integrated
   All data from different department, such as sales department's data, financial data or customer's data must combine and integrated.
iii. Time Variant
   Data Warehouse stores historical data.
iv. Non Volatile
   After data loaded to data warehouse, users cannot change or update the data.

Extract, Transform and Load (ETL) is main process in data warehouse. Basically, ETL consists of three three steps: extract, transform and load. Extracting is the process of gathering the data from different data source, changed into useful information so that they can use for decision making (Reinschmidt and Francoise, 2000). The data that extracted from different sources are placed to temporary areas called staging area. This can prevent data from being extracted once again if the problem occurs in the loading process (Ranjan, 2009). Next, transformation process take place where data is cleaned, remove errors exist on data such as inconsistencies between data, redundant data, inaccurate data, and missing value and convert to into a consistent format for reporting and analysis (Ranjan, 2009). Loading is the final step of ETL where data is loaded into target repository (Ranjan, 2009).

2.2.2 Business analytics

Business analytics environment is the second core component in BI where online analytical processing (OLAP) tools are located to enable users to generate on-demand reports and queries in addition to conduct analysis of data (Turban et.al, 2011).

Codd et.al (1993) proposed that there are 12 rules for OLAP:

i.   Multidimensional conceptual view for formulating queries
OLAP must view in multidimensional. For example, profits could be viewed by region, product, time or budget

ii.   Transparency to the user
OLAP should be part of an open system architecture that allows user embedded to any part of the system without affect the functionality of the host tool.

iii.   Easy accessibility
OLAP capable of applying its own logical structure that allows users easy to access various sources of data

iv.   Consistent reporting performance
OLAP able to provide consistent reports to users

v.   Client/server architecture: the use of distributed resources
OLAP consists of client and server architectures. The servers are able to map and consolidate data from different departments.

vi.   Generic dimensionality
OLAP consists of multidimensional and every data dimension should be equivalent in its structure and operational capabilities.

vii.   Dynamic sparse matrix handling
The OLAP server's physical structure should have optimal sparse matrix handling.

viii.   Multi-user support rather than support for only a single user
OLAP tools must provide concurrent retrieval and update access, integrity and security.

ix.   Unrestricted cross-dimensional operations
OLAP consists of computational facilities that allow calculation and data manipulation across any number of data dimensional.

x.   Intuitive data manipulation
OLAP allows data manipulation in the consolidation path, such as drilling down or zooming out

xi.   Flexible reporting
OLAP consists of reporting facilities that can present information in any way the user wants to view it.

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Turban et.al (2011) stated there are five basic OLAP operations that can be used to analyse multidimensional data, such as:

- Roll-up or drill-up
  - It allows user to view more summarised information for a given data cube. This can be carried out by moving down to lower levels of details and grouping one of the dimensions together to summarize data.
- Drill-down
  - It is the opposite of roll-up, which is used to view more detailed information by moving upwards to higher levels of details for a given data cube.
- Slice
  - It allows the users to select and analyse specific value of a cube's dimension.
- Dice
  - To analyse data, users can select many dimensions at the same time to view single value in data cube.
- Pivot
  - It enables user to rotate the axes of the data cube, meaning that change the dimensions to get different views of data.

Besides using OLAP, data mining or predictive analysis can be used to analyze data and information in more practical way. Data mining, also called knowledge discovery, is technique to discovery the unknown or unusual patterns from huge database. Predictive analysis is method that used to forecast the future outcome for an occasion or possibility of circumstances will happen

2.2.3 Business Performance Management

Business performance management (BPM) is component or methodology that used by an organisation to measure the performance of an organization in general. BPM usually can be visualised by portal, dashboard or scorecard.

2.2.4 User interface

Portal, web browser, dashboard and scorecard are used to view organization's performance measurement from numerous business areas. Dashboard and scorecard uses visual components such as charts, performance bars, and gauges to highlight data to the user. They provide drill down or drill up capability to enable the user to view the data more clearly and conveniently.

2.3 Capability Maturity Model (CMM)

The concept of Capability Maturity Model (CMM) was initially raised by Watts Humphrey at Software Engineering Institute (SEI), Carnegie Mellon University in 1986. CMM is used in software development and it can provide the guideline, step by step for process improvement across a project, a division, or an entire enterprise (Paulk et al., 2006). CMM offers a set of guidelines to improve an organisation's processes within an important area (Wang & Lee 2008).

Basically, CMM consists of five maturity level, which are level 1 : initial; level2: repeatable; level 3: defined, level 4 : ,managed and level 5 : optimizing.

In the initial level, processes are uncontrolled, disorganised, ad-hoc. Project outcomes are depend on individual efforts. In Repeatable level, project management processes are defined. Planning and managing new projects based on the experience with similar project. In Defined level, the organisation has developed own processes, which are documented and used while in Managed level, quality management procedures are defined. The organisation monitors and controls its own process through data collection and analysis. In optimizing level, processes are constantly being improved (Paulk et.al, 2006).

CMMs have been developed in many disciplines area such as systems engineering, software engineering, software acquisition, workforce management and development, and integrated product and process development (IPPD). The utilization of various models that are not integrated within an organization in terms of their architecture, content, and approach, have created redundancy as an organisation need separate model to measure different disciplines areas.

Thus, Capability Maturity Model Integration (CMMI) was derived in 2000 and it is an improved version of the CMM. CMMI is an integrated model that combines three source models which consist of *Capability Maturity Model for Software* (SW-CMM) v2.0, the *Systems Engineering Capability Model* (SECM), the *Integrated Product Development Capability Maturity Model* (IPD-CMM).

2.4 Business Intelligence Maturity Model

There are numerous Business Intelligence maturity model developed by different authors such as Business intelligence Development Model (BIDM), TDWI's maturity model, Business Intelligence Maturity Hierarchy, Hewlett Package Business Intelligence Maturity Model, Gartner's Maturity Model, Business Information Maturity Model, AMR Research's Business Intelligence/ Performance Management Maturity Model, Infrastructure Optimization Maturity Model and Ladder of business intelligence (LOBI). This section reviewed several of business intelligence maturity models by different authors.

Maturity models	Description
TDWI's maturity model	• The maturity assessment tool is available in the web to evaluate BI's maturity level as well as documentation. • Concentrates on the technical viewpoints especially in data warehouse aspect. • Can be improved on business viewpoint especially from the cultural and organizational view.
Business Intelligence Maturity Hierarchy	• Applied the knowledge management field • Author constructed maturity levels from a technical point of view but can considered as incomplete. • The documentation of this model in the form of one paper and is not enough for maturity level assessment.

Maturity models	Description
Hewlett Package Business Intelligence Maturity Model	• Depicts the maturity levels from business technical aspect. • This model is new and need to improve to add more technical aspects such as data-warehousing and analytical aspects.
Gartner's Maturity Model	• Uses to evaluate the business maturity levels and maturity of individual departments. • Provides more non technical view and concentrates on the business technical aspect. • Well documented and can search easily on the Web. • The assessment offers the series of questionnaire to form of spreadsheet.
Business Information Maturity Model	• Well documented with the series of questionnaire to assist the users to perform self evaluation. • However, criteria to evaluate the maturity level are not well defined.
AMR Research's Business Intelligence/ Performance Management Maturity Model	• Concentrates on the performance management and balanced scorecard rather than business intelligence. • Not well documented and criteria to evaluate the maturity level are not well defined. • No questionnaire to evaluate the maturity levels and is very hard to analysis the model (Rajteric, 2010).
Infrastructure Optimization Maturity Model	• Focuses on the measurement of the efficiency of reporting, analysis and data-warehousing and is not complete in the business intelligence area (Rajteric, 2010). • Discuss about the products and technologies rather than business point of view (Rajteric, 2010). • Not well documented and criteria to evaluate the maturity level are not well defined.
Ladder of business intelligence (LOBI)	• Apply the knowledge management field • Author constructed maturity levels from a technical point of view but can considered as incomplete. • Not well documented and criteria to evaluate the maturity level are not well defined.
Business intelligence Development Model (BIDM)	• Not well documented and criteria to evaluate the maturity level are not well defined. • Concentrates on the technical aspects rather than business point of view

Table 2. Summary of various maturity models

Table 2 above depicts summary of various business intelligence maturity models. As shown in the table 2 above, the majority of the models do not focus the business intelligence as entire which some of models focus on the technical aspect and some of the models focus on

business point of view. For example, TDWI's model only concentrates on the data warehousing while Business Intelligence Maturity Hierarchy only concentrates on knowledge management. It is not complete to represent business intelligence. We know that business intelligence covers not only data warehousing, but also business performance, balanced scorecard, analytical components.

In addition, the documentation of some maturity models above is not well defined and they do not provide any guidelines or questionnaire to evaluate maturity levels. From example, only TDWI's maturity model provides questionnaire and assessment tool on the web while other BI maturity model such as Business Intelligence Maturity Hierarchy, Hewlett Package Business Intelligence Maturity Model, Gartner's Maturity Model, Business Information Maturity Model, AMR Research's Business Intelligence/ Performance Management Maturity Model, Infrastructure Optimization Maturity Model, Ladder of business intelligence (LOBI) and Business Intelligence Development Model (BIDM) do not provide any guidelines or questionnaire to evaluate maturity levels.

Since the majority of the models do not focus the business intelligence as entire which some of models focus on the technical aspect and some of the models focus on business point of view, if the organizations want to know exact their business intelligence maturity levels as whole, they have to use multiple models and that it is time consuming. Therefore, there is need to have an integrated maturity model to consolidate existing different maturity models. In view of this, an Enterprise Business Intelligence Maturity model (EBI2M) is proposed.

3. Proposed Enterprise Business Intelligence Maturity model (EBIM)

Based on the literature review in the section 2.3, a preliminary version of an enterprise business intelligence maturity model (EBI2M) is developed. The proposed EBI2M's structure is borrowed from the CMMI concept. There are two main reasons to justify the use of CMMI model in the EBI implementation. First, the CMMI maturity structure is generic enough to provide a more holistic integration approach (Paulk et.al, 2006) as compared to CMM. Secondly, CMMI consists of two representations: staged representation and continuous representation while other maturity model such as CMM consists of only staged representation. Continuous representation is necessary for providing organizations with the freedom to select the order of improvement that best meets the organization's requirement (Paulk et.al, 2006).

The proposed EBI2M consists of two representations: staged representation and continuous representation. The staged representation consists of five levels namely; initial, managed, defined, quantitatively managed and optimizing; all of which are adapted from CMMI maturity levels.

Figure 2 depicts the stage representation of the proposed EBI2M.

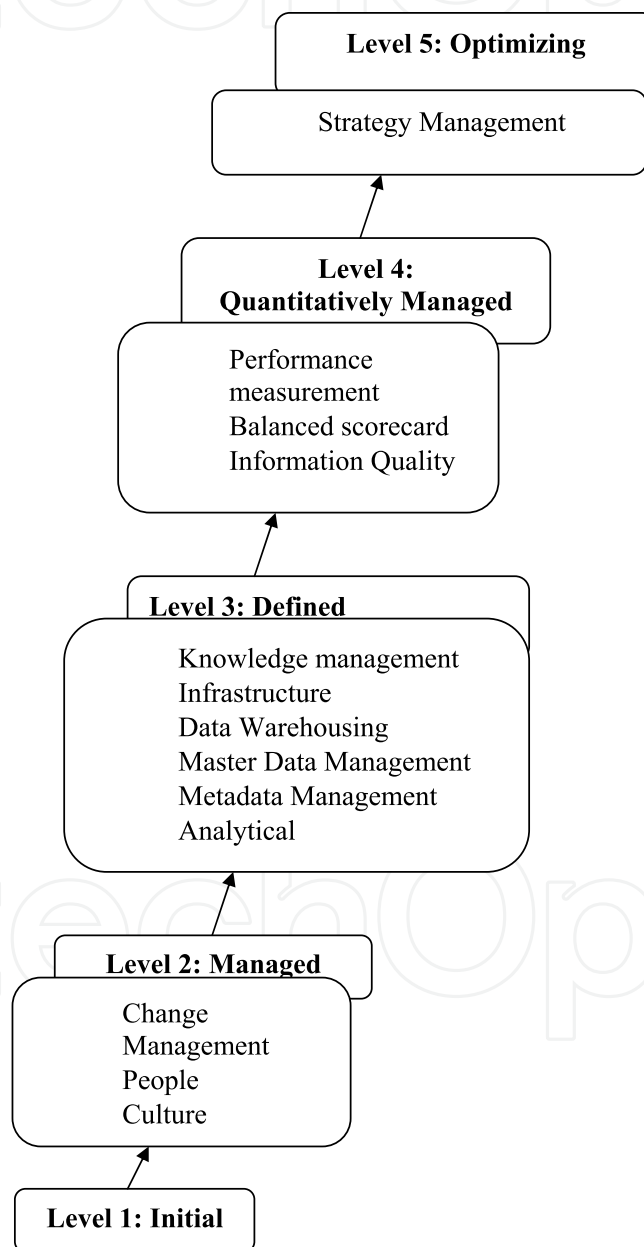In the level 1 (initial), there is no process area and process is chaotic.

Level 2 (managed) concentrates on the change management, organization culture, and people.

Level 3(defined level) is the level where EBI implementation processes are documented, standardized, and integrated into a standard implementation process for the organization.

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This level contains data warehousing, master data management, analytical, infrastructure and knowledge management

In level 4 (quantitatively managed level) EBI process and activities are controlled and managed based on quantitative models and tools. Hence performance management, balanced scorecard, information quality factors are placed at this level.

Level 5 (optimizing level) is the level where organizations establish structures for continuous improvement and contains strategic management factor.

Level 5: Optimizing

Strategy Management

**Level 4:
Quantitatively Managed**

Performance
measurement
Balanced scorecard
Information Quality

Level 3: Defined

Knowledge management
Infrastructure
Data Warehousing
Master Data Management
Metadata Management
Analytical

Level 2: Managed

Change
Management
People
Culture

Level 1: Initial

Developed by author

Fig. 2. Proposed staged representation of Enterprise Business Intelligence Maturity model (EBI2M)

A staged representation of EBI2M can be reasonably mapped in five evolutionary levels as shown in figure 2. Each maturity level is a prerequisite to the next higher one. Therefore each higher maturity level encompasses all previous lower levels. For instance, a company at level 3 maturity level embraces the important factors of level 1 and 2.

The continuous representation consists of thirteen dimensions: change management, organization culture, strategic management, people, performance management, balanced scorecard, information quality, data warehousing, master data management, metadata management, analytical, infrastructure and knowledge management.

As discussed in the literature review, data warehousing, master data management, metadata management, analytical, infrastructures, performance management, balanced scorecard are the main components in business intelligence architecture. Therefore, these seven factors (data warehousing, master data management, metadata management, analytical, infrastructures, performance management, and balanced scorecard) should be considered for key maturity indicators for EBI2M.

In order to be success in the implementing of BI, organization need to ensure they can adapt to the any changes in the organization, people or knowledge workers have good skills and they willing to face any challenges. Besides that, organization must analyze their strengths and weakness and competitors' strengths and weakness.

Change management, organization culture, strategic management and people are chosen for key maturity indicators for EBI2M with rationale organization need to ensure they can adapt to the any changes in the organization, people or knowledge workers have good skills and willing to face any challenges. Besides that, in order to be success in the implementing of BI, organization must analyze their strengths and weakness and competitors' strengths and weakness.

Information quality or data quality is another factor to be considered for key maturity indicators for EBI2M. Organization must make sure that the data that entered to data warehouse is clean and no redundancy occurs.

The advantage of having continuous representation in EBI2M is that it allows organization to measure the dimensions independently. For example, if organization wants to measure capabilities of change management of independently, they can use continuous representation in EBI2M.

4. Methodology

The Stage 1 Delphi study is used to narrow down the scope of this research because of limited academic literature. The rationale of choosing Delphi study in this research is due to lack of complete information and limitation of literature review especially on business intelligence maturity model. Therefore, there is need for experts to explore and identify the key process areas so that these opinions can be useful to construct maturity models. Furthermore, by using Delphi method, experts do not involve in a face by face discussion; so, there is little chance of one of more individuals' opinions being influenced by more experience individual. Moreover, compare to other method such as focus group, Delphi was used due to geographical location. It is not convenient for all expert panels to gather together due to the time constraint and location constraint.

Around 15 BI experts were chosen through various BI forums in Linkedin Connections. These BI experts were chosen based on their experience on BI. Table II shows the experiences of 15 participants.

Participants	Positions	Years of experiences in BI
1	Data Warehouse Architect	6 – 7 years
2	Manager DW/BI	10 years and above
3	IT Support Executive	6 – 7 years
4	Business Intelligence/Data Architect	10 years and above
5	Senior IS Manager	6 – 7 years
6	Vice President	10 years and above
7	CIO	4 – 5 years
8	Vice President (IT)	10 years and above
9	BI manager	10 years and above
10	BI / DW Architect	10 years and above
11	Functional Analyst	8 – 9 years
12	ETL Developer	6 – 7 years
13	Data Warehouse Lead Architect	10 years and above
14	Manager	10 years and above
15	Director	6 – 7 years

Table 3. Delphi study's participate

In the first round of Delphi study, the series of questionnaire distributed to 15 participants. The participants are asked to map the key process area (change management, culture, strategic management, people, performance measurement, balanced scorecard, information quality, data warehousing, metadata management, master data management, analytical, infrastructure and knowledge management) to suitable the maturity levels.

5. Preliminary results

Delphi study results were analyzed using descriptive statistics, including the median and the interquartile range. Interquartile ranges are usually used in Delphi studies to show the degree of group consensus. When using a 5-point Likert scale, responses with a quartile deviation less than or equal to 0.6 can be deemed high consensus, those greater than 0.6 and less than or equal to 1.0 can be deemed moderate consensus, and those greater than 1.0 should be deemed low consensus (Raskin, 1994; Faherty, 1979).

Table 4 depicts the Delphi study round1's result. As shown in table 4, only 'Infrastructure' achieve strong consensus. Change management, organization culture, performance measurement, people, balanced scorecard, information quality, metadata management, master data management and knowledge management achieve moderate consensus. The other key process area such as analytical do not achieve consensus among the Delphi panels. Therefore, 'Infrastructure' is shortlisted in subsequent round.

The median values were used to indicate the preferred Capability Maturity level for each Maturity Indicator, where 1 indicates the lowest and 5 the highest Maturity level. For example, 'Infrastructure' is short listed and placed in maturity level 3.

Key Process Area	Medium	Interquartile
Change management	3	1
Organization Culture	2	1
Strategic Management	4	2
People	3	1
Performance Measurement	4	1
Balanced Scorecard	3	1
Information Quality	3	1
Data Warehousing	3	2
Master Data Management	3	1
Metadata Management	4	1
Analytical	3	2
Infrastructure	3	0
Knowledge Management	4	1

Table 4. Delphi study round 1's result

6. Conclusion and future works

This paper proposed an enterprise business intelligence maturity model (EBI2M). The purpose of EBI2M is assisting the enterprise on BI implementation. This research is the preliminary endeavour at identifying the dimensions and associated factors influencing EBI maturity. Based on the maturity constructs of CMMI and relevant literature of BI, the concept of EBI maturity was explored and defined.

This research is benefit to the enterprises or organizations because it enables the organizations to know their current BI implementation status and how to achieve the higher level of BI implementation. Amongst the findings, this paper indicates that only key process area 'Infrastructure' achieve strong consensus by all Delphi panels. In the future, the subsequent round will be conducted to ensure that all key process areas achieve consensus among the Delphi panels.

7. Acknowledgment

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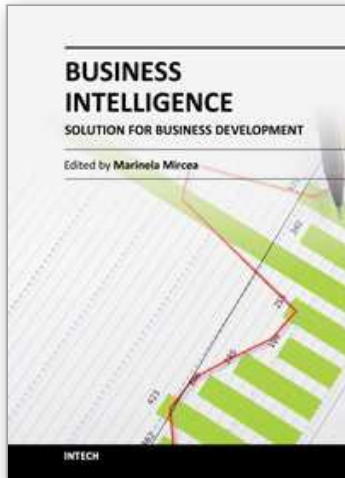
Business Intelligence - Solution for Business Development

Edited by Dr. Marinela Mircea

The work addresses to specialists in informatics, with preoccupations in development of Business Intelligence systems, and also to beneficiaries of such systems, constituting an important scientific contribution. Experts in the field contribute with new ideas and concepts regarding the development of Business Intelligence applications and their adoption in organizations. This book presents both an overview of Business Intelligence and an in-depth analysis of current applications and future directions for this technology. The book covers a large area, including methods, concepts, and case studies related to: constructing an enterprise business intelligence maturity model, developing an agile architecture framework that leverages the strengths of business intelligence, decision management and service orientation, adding semantics to Business Intelligence, towards business intelligence over unified structured and unstructured data using XML, density-based clustering and anomaly detection, data mining based on neural networks.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

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