Business Intelligence Maturity Models: Toward New Integrated Model
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Abstract: Business Intelligence (BI) has become one of the most important research areas that help organizations and managers to better decision making process. This paper aims to show the barriers to BI adoption and discusses the most commonly used Business Intelligence Maturity Models (BIMMs). The aim also is to highlight the pitfalls of these BIMMs in order reach a solution. Using new techniques such as Service Oriented Architecture (SOA), Service Oriented Business Intelligence (SOBI) or Event Driven Architecture (EDA) leads to a new model. The proposed model named Service-Oriented Business Intelligence Maturity Model (SOBIMM) is briefly described in this paper.

Keywords: Business Intelligence, Business Intelligence Maturity Model, Business Intelligence Barriers, Business Intelligence Integration, SOBIMM

1. INTRODUCTION

Business Intelligence (BI) can be defined as getting the right information to the right people at the right time [1]. David [2] defines BI as, “The processes, technologies, and tools needed to turn data into information, information into knowledge, and knowledge into plans that drive profitable business action”. There are many barriers to BI adoption; using BI maturity models (MM) can help in the decision making process and in assessing the overall performance of an organization. There is a little number of BIMMs but all of them suffer from some pitfalls such as integration, and lack of reliability. These pitfalls make it difficult to assess and guide the organization by using a single BIMM model. So the need to integrate the organizational departments into one pool of services needs to introduce a new BIMM that can use a service dimension as a main component. Although the importance of BI application is more widely accepted, there is a limited study to provide systematic guidelines for such resourceful initiative [3]. Therefore, this research aims to state the common barriers to BI adoption and finds a way for integrating the BI levels inside an organization throughout BIMMs. The remainder of this paper has been structured as follows. The next section introduces the barriers to BI adoption from many perspectives. The third section then outlines and discusses the available and the most important and most commonly used BIMMs and states the pitfalls of these models. The fourth section gives a brief about the available approaches that can help in BI integration, finally the conclusion and further research.

2. BARRIERS TO BI ADOPTION

A barrier is defined in dictionary.com [4] as anything that prevents or obstructs passage, access, or progress. Regarding BI adoption there are many barriers that are discussed in many researches [5], [6] and [7]. Some of the researchers classify these barriers according to questionnaires, and interviews with BI specialists, the others classify them into two categories which are primary and secondary. Let us discuss these barriers in the following section.

Chaffey states that barriers ‘restrict’ while drivers ‘encourage’ organizational adoption of IT systems [8]. Business Intelligence [5] also announces that the main barriers to BI adoption are ‘cost’ and ‘complexity’. It also states that BI is the most highly desired technology but it still suffers from a ‘relative inability to prove its value’. A survey performed by Information Week in 2007 cited in the BI guide reports that some BI vendors were unable to provide the internal stockholders with the benefits of BI. The Guide announces that 40% of the cost involved in ‘moving data between systems’, which means that data migration and integration becomes critical barriers to BI adoption.
The study of the Economist Intelligence Unit [9] reports that the BI barriers or problems are: the departmental data stores remain the biggest barrier to data sharing, data access and clean data, employee resistance to adoption of new technology, and the lack of Chief Information Officer (CIO) participation in decision making process.

Another set of barriers to adoption are the organizational efficiency issue. Fielding [10] stats a set of BI implementation barriers which are: Usability verses feature mismatch, enough already about metadata. Jason and Ari [11] classify the barriers and challenges into two categories which are primary and secondary. The primary contains two reasons which are: working with multiple data sources and dealing with report elements that are currently not collected. But the secondary one contains three reasons which are: improving existing data systems and / or developing and implementing new systems, exporting and sorting data from multiple systems.

mobcon reports [6] in a paper named ‘The Five Barriers to Business Intelligence’ that the 5 key barriers for any organization seeking to capitalize on its stored data are: the amount of data stored in the corporate information systems, data quality, the proliferation of IT systems and technologies the organization employs to manage its corporate knowledge, the organizational structure, and corporate culture.

Khan et al. in a study named ‘drivers and barriers to Business Intelligence adoption’ [7] clarify that the drivers and barriers to BI adoption change with each user type. They also point out that the identification of the challenges and problems also change by time besides they affirm that the major barrier to BI adoption is “the lack of user’s awareness” Mitchell Ocampo suggests, overcoming these barriers by involving end users early and often, leveraging executive sponsorship, and adapting to change requirements [12]. The following section will discuss the existing BIMMs that may help in adapting and assessing the BI organizational behavior. By the end of this discussion, the aim is to reach a mature model for eliminating the barriers to BI adoption and enhancing the efficiency of Business Intelligence systems (BIS).

3. BUSINESS INTELLIGENCE MATURITY MODELS

Maturity describes a “state of being complete, perfect or ready” [13]. To reach a desired state of maturity, an evolutionary transformation path from an initial to a target stage needs to be progressed [14]. Maturity models define levels of definition, efficiency, manageability and measurement of the monitored environment [15]. A BI maturity model can be invaluable in this process as it outlines a path forward and helps companies work toward closer alignment of their business and IT organizations [16]. The following section describes the recent and the most usable BIMMs; during this description it will be obvious to review the structure (levels and dimensions) of each BIMM. Finally, the pitfalls of each model will be presented.

3.1 AMR research’s BI/Performance Management (PM) MM, version 2

This MM is introduced in the early 2004 by AMR research and Consultancy Company. This model is oriented to enterprise-wide for BI/PM [17]. As figure 1 depicts, the model is composed of four-stage progression outlining a framework for business and Information Technology (IT) leaders to assess group and/or firm-wide actions.

![Figure 1: AMR BI/PM MM, Version 2 (source [17])](image)

AMR as a maturity model, its steps have specific attributes and characteristics which are:

Step 1: Reacting—where have we been? The main objective of this step is to display what has happened in the last business cycle, providing details and status to support a specific department.

Step 2: Anticipating—where are we now? The main objective of this step is to introduce the data issues and increase the domination of projects. Emphasis expands to include current performance data, and dashboards appear as the primary vehicle to inform workers what performance is now. Using real-time or near real-time data provides the organization with a prominent role.
Step 3: Collaborating—where are we going?
The objective of this step is to use dashboards and scorecards to align resources and objectives within and across groups that harness the power of existing data. Scenarios and models let analysts provide alternatives and recognize that decisions made are positive or negative.

Step 4: Orchestrating—are we all on the same page?
The objective of this step is to obtain a single, consistent, and streamlined view of the enterprise.

Regarding the pitfalls of the AMR MM, Hagerty points out that the unanticipated complexity of this model can be attributed primarily to data issues. Additionally, once companies go into Step 2, they immediately find that isolated, disparate, and overlapping data sources are barriers to expanding BI/PM more broadly [17]. AMR model doesn’t cover all data structures that customers use in each step it also focuses less on BI, while emphasizing PM. Key areas, focused by the model, are: technology, processes, and people (responsibility, flexibility) [14].

3.2 Gartner’s MM For BI and PM
Gartner has created a five-level MM to help IT leaders in charge of BI and PM initiatives to assess the maturity of their organizations’ efforts, and how mature these organizations to reach the business goals. [18]

![Figure 2: BI and PM Maturity (source [18])](image)

Business intelligence competency centers” (BICCs).

The characteristics of the Gartner’s model are described in the following section.

Level 1: Unaware
At this level no real BI capability is in place. This level is described as “information anarchy,” because data is inconsistent across departments, metrics are not effectively identified, defined or used, and the value of formalizing and managing metrics is not well understood. The major challenges at this level are identifying business drivers and understanding the current information management structure.

Level 2: Tactical
At this level organizations employ managers who need data to drive tactical decisions. Employees and managers use their own metrics to run specific parts of the business, but most tools, applications and data are in different data stores. At this level, Executives lack confidence in the quality and reliability of the data, leading to arguments over “whose data is right.”

Level 3: Focused
At this level, Gartner finds a stronger commitment to BI and PM among senior executives. Metrics are formally defined to enable management to analyze departmental performance and there is rising demand for management dashboards. During this level, there is no formal linkage to broad enterprise objectives, resulting in inconsistent goals and metrics among departments. The challenge is to extend the successes more widely across systems and architecture, and expand the scope of the application and user base.

Level 4: Strategic
At this level organizations derive their BI strategy according to the overall strategic objectives. They integrate BI and PM into critical business processes, making information available to executives and managers. At the strategic level, strategic data is trusted and acted upon at the executive level. The main challenge for these organizations is developing a balanced organizational structure, consistent with the company’s business objectives and strategy.

Level 5: Pervasive
At this level, BI and PM systems are integrated into business processes and agility is built into the systems. Users at multiple levels in the organization have access to information that allows them to do analysis to help manage, innovate and make decisions to drive performance.

Regarding the pitfalls of Gartner’s MM, Lahrmann et al. report that the reliability of this MM is not documented and also its application needs third-party assistance [19].

3.3 TDWI’s BIMM
Wayne Eckerson originally developed The Data Warehouse Institute (TDWI) MM in 2004 [20]. In 2009 the model was redeveloped to be convenient with BI
domain so it is called TDWI’s BIMM [21]. This model is focused mainly on the technical aspect for maturity assessment of organizations [15]. Figure 3 shows the main stages of the TDWI’s BIMM and the following section describes its grading levels [22]:

Stage 1: The Infant Stage
The Infant stage is composed of two stages, Prenatal and Infant. The Prenatal phase lasts until a data warehouse is created. Lack of agility forces business users to take actions themselves resulting in partial data sources [15]. In the Infant phase, a company is faced with numerous partial data sources called Spreadsheets. Each of them contains a specific set of data; besides the fragmented data sources are producing conflicting views on business information.

The Gulf: The Gulf is not so wide or deep that organizations cannot cross it and move from the Infant to the Child stage, but it has significant threats. Combination of poor planning, data quality issues, cultural resistance, and spreadmart proliferation prevents the organization from making a clean crossing [22].

Stage 2: The Child Stage
At this level, knowledge workers join the community of BI users. Information demands are gathered on the department level and cover only the needs of the same department members. Regional data warehouses are built on this level are not linked to each other.

Stage 3: The Teenager Stage
The Teenager stage continues the work begun in the Child phase but in a broader, more integrated fashion. Rather than allowing departments to spawn a multiplicity of nonintegrated data marts [15].

Stage 4: The Adult Stage
The Adult stage occurs when BI/DW teams cross the Chasm and deliver a strategic, enterprise resource that enables organizations to achieve its key objectives [21]. The main characteristics of the Adult level are: centralized management of BI data sources, common architecture of the data warehouse, fully loaded with data, flexible and layered, delivery in time, predictive analysis, performance management, and centralized management [15].

Stage 5: The Sage Stage
The Sage stage completes the cycle by converting core BI/DW capabilities into services and distributing development back out to the business units via centers of excellence [22]. The main characteristics of this level are: distributed development, data services, and extended enterprise [15].

Regarding the pitfalls of TDWI’s BIMM; there are two major obstacles on the path from Infant to Sage. First; on dealing with the Gulf problems such as poor planning and data quality issues, will stretch the BIS program until it snaps and breaks apart. Second; Chasm combines challenges and obstacles preventing a company to move from the Teenager to Adult stage. To overcome this obstacle, Enterprise Data Warehouse is usually built. Lahrmann et al. report that the reliability in the TDWI’s BIMMs is not addressed [19]. Rajterič reports that, Gartner’s maturity model, compared to TDWI’s, also offers a more non-technical view and discusses maturity from the business-technical aspect [15].

3.4 HP Maturity Model
In 2009, HP developed a BIMM [23] as a context for describing the evolution of its clients’ BI capabilities. It represents a formula for success that is a function of three capabilities: business enablement, information technology, and strategy and program management as depicted in figure 5. For long-term BI success, companies must achieve a winning formula comprised of the three core capabilities: first; Business Enablement which is considered as an understanding of the types of business needs and problems that are solved with BI solutions. Second; Strategy and Program Management which are considered as the key enablers and catalysts for BI success. Third; Information Management which is considered as the information strategies and solutions a company adopts to solve business problems. By using the HPBIMM, companies can obtain the results they want by working through the five stages of the model, which are:

- Operations: organizations focus on running the business.
- Improvement: organizations focus on measuring and monitoring the business.
- Alignment: in which organizations are focused on integrating performance management and intelligence
Empowerment: in which organizations are focused on business innovation and people productivity

Excellence: in which organizations are focused on strategic agility and differentiation [24].

The model also highlights a critical emerging need for a new breed of talent and leadership, namely program managers, business architects, and information architects, that can guide the next generation of integrated, high-value BI solutions [17]. Regarding the pitfalls of HPBIMM, Lahrmann et al. point out that the reliability is not documented and the HPBIMM is targeted at HP’s clients. Finally the HPBIMM is not available free of charge [19].

3.5 Enterprise BIMM (EBIMM)
Chuah developed this model in 2010; it is based on Capability Maturity Model (CMM) and it does not address the maturity of organizations in which enterprise-scale BI is managed [3]. EBIMM provides useful basis to firms aspiring to elevate BI endeavor to higher levels of maturity. Figure 5 depicts the structure of each maturity level along the three key dimensions of an enterprise BI initiative.

Level 1: Initial
At this level, the EBIMM concentrates on the lowest level in the organization.

Knowledge process: this dimension focuses on day-to-day operations and the long-term plans of the enterprise.

Information quality: this dimension depends on the skills of the technical programmer analysts, database analysts and designers, and coders.

Data warehouse: this dimension focuses on data resides in multiple files and databases using multiple formats. Redundant data marts are often created.

Level 2: Repeatable
This level concentrates on system development and basic information management

Knowledge process: in this dimension data management processes are well defined within each department but not across department.

Information quality: in this dimension the organization follows a documented procedure for implementing quality control activities.

Data warehouse: this dimension contains data management policy that dictates how and when data structures are created, changed, and managed. It contains also fewer independent data marts.

Level 3: Defined
At this level, the EBIMM model treats the enterprise data as an asset and concentrates on the information quality.

Knowledge process: in this dimension information management concepts are applied and accepted.

Information quality: in which the organization develops its own Information Quality (IQ) processes, which are documented and used.

Data warehouse: in which treating data as a corporate asset.

Level 4: Qualitative managed
At this level, the EBIMM model concentrates on extended enterprise, IQ condition governance, and managed meta-data environment.
Knowledge process: in which Knowledge management concepts are applied and accepted.
Informaion quality: in which the organization provides adequate resources and funding for the quantitative process management activities.
Data warehouse: in which data Warehouse projects are consistently successful and the organization can predict their future performance with reasonable accuracy.

Level 5: Optimizing
At this level, the EBIMM model concentrates on situation matrix, continuous Information Quality Management (IQM) improvement, and low level data redundancy.
Knowledge process: in which Knowledge Process continuously improved.
Information quality: in which IQM processes are continually being assessed and improved.
Data warehouse: in which continually improvement of data access and data warehouse performance.

From a practical standpoint the EBIMM model provides useful basis to firms aspiring to elevate their BI endeavor to higher levels of maturity. Regarding the pitfalls of the EBIMM; it doesn’t provide guidelines for the technical issues; although it is the first time a research related to EBI attempts to identify the dimensions and associated factors influencing EBI maturity. There is no a questionnaire or a qualitative study that can provide metrics for evaluating the EBIMM model to ensure its efficiency.

Why a new model?
According to the previous survey we can summarize the pitfalls of the existing and the most frequently used BIMMs as follows:
• No information integration; the data sources are isolated, disparate, and overlapped.
• Do not cover all data structures that customers use in each stage.
• They focus less on BI.
• Reliability is not documented or addressed and also their applications need third-party assistance.
• Poor planning and data quality issues leads to stretching the BIS program.
• Do not provide guidelines for the technical issues
• Targeted to specific clients.
• Not available free of charge.
• Need qualitative and quantitative metrics to be truly evaluated.

4. TOWARDS A NEW SOLUTION

Although BI and data services offer commercial services, some organizations use Service-Oriented Architecture (SOA) to accelerate the development of BI-enabled solutions. By wrapping BI functionality and query object models with Web services interfaces, developers can make BI/DW capabilities available to any application regardless of the platform it runs on or programming language it uses. Then, approved developers inside or outside the organization, can write applications that use various components encapsulated by the BI or data services. The most common of these applications today is a portal that displays charts or Key Performance Indicators (KPIs) managed by a remote BI server [21].

Nowadays, many organizations are oriented to invest in phases of BI solutions maturity although; the market is going faster to increment the use and development of mature BI solutions [25]. From the above investigation about BIMMs, all of these models aim to reach the highest level of maturity but it is one way to reach maturity which is ‘integration’.

Regarding the last stage of BI maturity, BI providers aim to provide a platform that sustains the requirements imposed by the BI service. Thus, providers must be oriented towards the latest technologies that allow them to solve the integration problems among enterprises’ sectors. Ghilic et al. clarify the problems of integration which are infrastructure, meta data, development [25], and reliability [19] in order to find technical or tactical solution which may help the existing BIMMs to reach the highest level of maturity.

Service Oriented Architecture (SOA), Event Driven Architecture (EDA), and Service-Oriented Business Intelligence (SOBI) are ways to solve the IT integration problems in an organization. SOA is a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains and implemented using various technology stacks [26]. EDA is a paradigm for communications in SOA, being a SOA in which the entire communication is achieved through events and all services are processes of reactive events (react to entry events and produce exit events) [27]. On EDA architecture, an application detects an event and issues a notification while other applications have handlers which may receive notifications and may react by invoking the services [25]. SOBI is an attempt to combine two architectural paradigms that have developed independently, namely BI and Service
Orientation. SOBI is an attempt to define a framework, in which both architectures and benefits can exist. Table 1 summarizes the strengths of the two terms that constitute the SOBI.

Table 1: the benefits of SO and BI (26)

<table>
<thead>
<tr>
<th>Service Orientation</th>
<th>Business Intelligence</th>
</tr>
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<tbody>
<tr>
<td>• Provides Application to application integration</td>
<td>• Well suited for Data to data integration</td>
</tr>
<tr>
<td>• Well suited to events and real-time data – high frequency</td>
<td>• Can handle large data volumes</td>
</tr>
<tr>
<td>• Provides operational platform</td>
<td>• Provides foundation for business decisions</td>
</tr>
<tr>
<td>• Allows agile change in business processes</td>
<td>• Provides a combined model of the enterprise data</td>
</tr>
<tr>
<td>• Supports reuse of enterprise components</td>
<td>• Good tools and mechanisms for transforming data</td>
</tr>
<tr>
<td>• Encapsulates and abstracts functionality</td>
<td>• Ability to ask and question of the data and to answer key business questions</td>
</tr>
<tr>
<td>• Tightly defined data formats and structures</td>
<td></td>
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</tbody>
</table>

Horne et al. [28] Point out that SOBI can provide best practice implementation framework and it also be used to integrate at the most appropriate architectural level. This may help in solving the lack of integration and reliability problems during the grading in maturity levels. The proposed model will be named as Service Oriented Business Intelligence Maturity Model (SOBIMM). As the name implies, the model uses service orientation checklist as a pool of services evaluation that can be used to assess the technical rather than the tactical issues in the organization's IT overall progress. But some of the existing maturity models focus on other areas like Software Development, Knowledge Management, Performance Management and Data Management [15]. In the next section a brief introduction about the SOBIMM model will be introduced.

5. THE PROPOSED MODEL

The proposed model is named SOBIMM. Its aim is to solve problems such as No information integration, focus less on BI issues, Reliability, Poor planning, and Need qualitative and quantitative metrics. As figure 6 depicts SOBIMM model is divided into 5 grading levels (initial, immature, controlled, managed, and mature), 3 dimensions (technology, organization, and business expertise), and service orientation checklist. The technology dimension deals with two critical metrics which are quality (data warehouse, data marts, and analytical services) and flexibility of the technology used. The organization dimension deals with some issues metrics such as the system oriented services, profitability. The business expertise dimension deals with 3 metrics which are enterprise value, business validity, business services, and steering processes.

In order to provide integration to this model a service orientation checklist is considered as pool of services' evaluation questions. Answering these questions will provide rating for each maturity level.

Regarding the computational method, reaching the mature level the organization should pass through the lower levels. Each level has a score of 100% which represents 20% of the overall score of the model and the final percent of the model is calculated cumulatively. Using this model will help in solving problems such as the integration, qualitative, and quantitative metrics which will be clear throughout an investigation in the future work.

6. CONCLUSION

There are many barriers to BI adoption. Barriers such as: isolation of departmental data stores, employee resistance, and low data quality vary from general and organizational to implementation. Using BIMMs can help the organizations to assess its BIS to determine in which maturity level it resides. By discussing the most commonly used BIMMs, some pitfalls arise such as: no information integration, data sources are isolated; less focus on BI and reliability is not documented or addressed. The most common pitfall is the lack of integration between data stores which leads to thinking in a way of integration. The available ways of integration are SOA, SOBI, and EDA. By using SOBI as a core for the proposed SOBIMM model may help in
finding a solution for the existing problems such as integration, and quality problems. The future research of this paper will introduce the SOBIMM in details by providing an investigation about this model.

REFERENCES


