



Towards Knowledge Management for Predictive Healthcare Business Analytics

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Abstract: *In knowledge management based systems data and knowledge are acquired for the purpose of analysis as well as for the predictive analysis. Healthcare systems provide different perspective of KPI's to presents their past, present and future oriented analysis. Different business intelligence tools provide some support of brief analysis of business. However, there are issues related to deciding the KPI's, trends, predictions, actions and initiatives. It is important for the decision makers to understand the business workflow to manage proper performance management system. In this paper, we are using a case study of a healthcare system to provide mechanism and flow to tackle such issues of business analytics in all three directions: Past, Present and Future aspects with the help of knowledge management activities. Our proposed framework also provides an effective decision making process to health care business decision makers and practitioners.*

Keyword: *Analysis; Business Analytics; Healthcare systems; Knowledge management; Software Engineering*

1. INTRODUCTION

Knowledge management refers to managing knowledge of organizations in terms of knowledge storage, capture, acquisition, sharing, discovery and deployment. In business intelligence and analytics systems, there are multiple sources of data and knowledge. Business intelligence experts use different tools, algorithms and techniques to discover the knowledge and perform analytics on that particular data and knowledge [1] [2].

Knowledge management techniques are applied to learn about the organization. Learning organization includes the processes, procedures, techniques, resources, methodologies, workflow, in short, each and every process. Whereas, business intelligence is used to visualize and present complete business flow in front of organization's decision makers. Decision makers have an access on present as well as historical data and knowledge and they can apply initiatives according to their requirements. The relationship between knowledge management activities and business intelligence activities is graphically represented below in a Figure 1.

In this paper, we are focusing on different types of analytics and intelligence (past, present and future aspect) drawn on a healthcare system with integration of knowledge management. We have identified different KPIs (Key Performance Indicators) for a healthcare system to analyze the operational behavior of KPIs, Tactical or trend analysis on KPI's as well as

scorecard or actionable analytics on KPI's.

Knowledge management and discovery provide an assistant to the practitioners to discover the existing knowledge and data of KPI's to perform future predictions, Initiatives or actions on the basis of results. Knowledge management is also useful in such environments, where teams are properly formulated to perform the tasks. In healthcare systems, software engineers usually not fully know the definition of each KPI so the share of knowledge and properly document the existing knowledge is required.

Rest of paper is organized as follows: Section 2 contains evidence from existing literature and describes the current state of the art of related work. Section 3 actually describes the proposed work and its implementation and evaluation through healthcare system as a case study. Section 4 conclude the research work and defines some of the future directions for ongoing research.

2. RELATED WORK

Knowledge management based analytics on healthcare business data is taking an interest of researcher due to the huge demand of such products. There are many case studies, tools, research works related to healthcare business solutions. The main contributions of such systems are related to more accurate data, more resources involvement and more accurate and meaning full analytics on data. In a recent research work given below in [3], researcher's

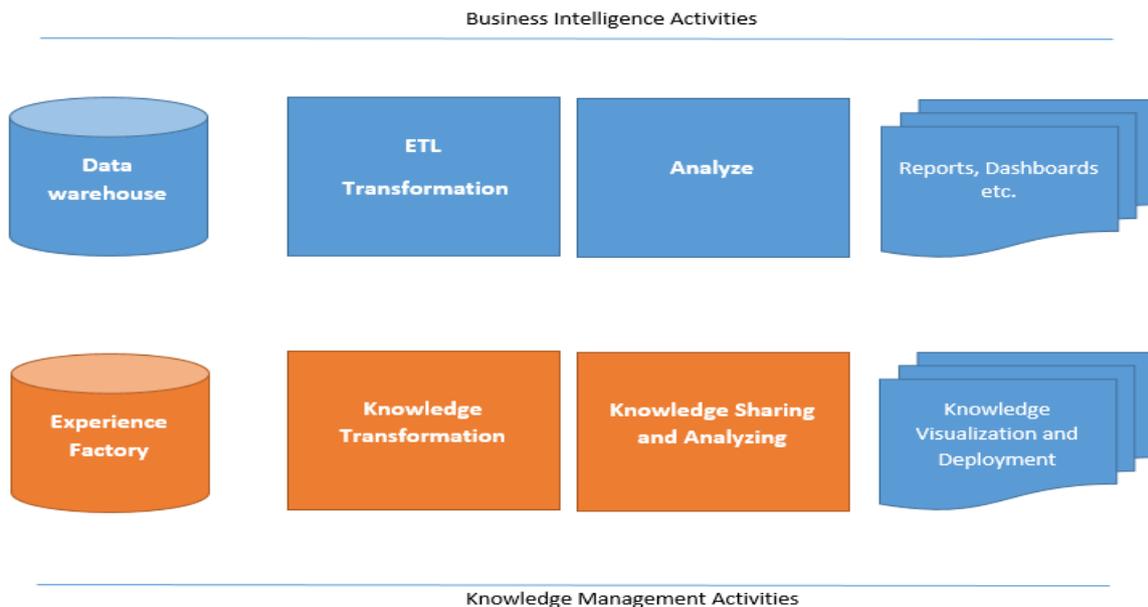


Figure 1 Aligning Knowledge Management with Business Intelligence Activities

uses survey methodology to extract different techniques from case studies as well as direct observations of discovering data and transform them into different reports, dashboards and grids for the purpose of analysis. The techniques, discussed in this research work is based upon existing knowledge and provides less contribution to provides assistance in decision making to the healthcare decision makers.

In another research work given in [4], a new concept of healthcare analytics highlighted, that is social business intelligence. Different knowledge discovery algorithms are highlighted in this study to extract the data from social platforms to review and analyze the potential of social media in the healthcare industry and conclusion of the study is drawn to provide the concept of social business analytics and intelligence for the healthcare industry.

In another research work, authors focus on different sources like past publications, case studies, social sensors and many others to discover the knowledge to improve employee's retention reasons and effects. The analysis drawn in this study is based on past data, but the data and knowledge is visualized in such a way that it improves the decision support system of an organization. [5]

Creation of Knowledge and wisdom is a proper formal process. It starts with the symbols, raw data. Data gives some information and by applying some process and its processed information is called Tacit Knowledge. Now if tacit knowledge relates with the explicit knowledge, it becomes wisdom. In proposed framework knowledge management is integrated with the business intelligence and has six stages. The first stage is sharing existing knowledge with the team, secondly create and define the process of knowledge creation, acquisition, discovery, then process of knowledge extraction, process of knowledge visualization, process of data and knowledge mining and

finally help the practitioners in decision making. [6].

In [7], the need of performance management is healthcare business by using past and present data is defined. Moreover, future analytics concept is also presented to perform predictions on given data. Performance management life cycle consists four levels. Strategize the business, Plan the strategy, Monitor & Analyze the performance and Take corrective actions against analysis.

In above mentioned few studies we have lighted the contribution of researcher and presents the current state of the art of integration of knowledge management in business intelligence and analytics especially related with healthcare business. There is a lack of presenting proper and formal analytic implementation in a creation of future oriented or actionable analytics in business intelligence and analytics. In our work, we are presenting formal framework from knowledge discovery to visualization as well as analysis, all possible calculation and results to assist the practitioners and decision makers.

3. PROPOSED SOLUTION

A proper systematic approach is defined and evaluated through implementation on a healthcare business to tackle the issues of data and knowledge analytics by integrating the knowledge management guidelines in existing data analytics workflow.

In our proposed approach knowledge is discovered from different available resources. For example, we are working on healthcare business, so the measure, attributes and all other data is related to the healthcare business. And once, data and knowledge are acquired and extracted, it is important to validate and clean it and make it easy to understandable and transformable for analytics.

Knowledge management involvement is important in each and every phase. The sharing of knowledge

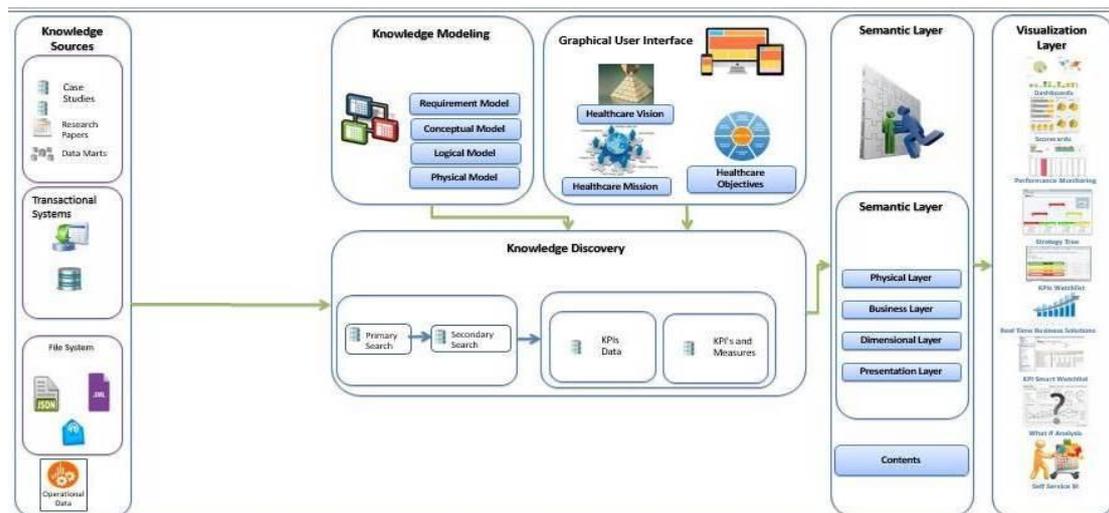


Figure 2 Proposed framework to integrate knowledge management in Business Analytics

allows the development teams and software engineers to relate the tacit knowledge with explicit knowledge and vice versa. Proposed framework is graphically represented below in a Figure 2. Our proposed solution discovers the knowledge from different sources like: data warehouse, operational databases, transactional systems, file system etc. For this purpose, our research analyzes that there is two type of knowledge available in any organization. The first one is the proper and documented data stored in database and documents, stored in a central repository of an organization. Secondly, the most important, data or knowledge that is not stored in a formal way and available in different research reports, preserves in records of seniors, organizers, analysts etc. In other words, a lot of data in the organizations are hidden and needed to be discovered.

Business Intelligence tools and applications provide help to understand, collect and visualize the data that is available and based on daily transactions but by integrating knowledge management concepts, we can discover that particular hidden data and knowledge as well.

For this purpose different knowledge sharing sessions are suggested in research, [8] [9] [10] which are:

- Meetings
- Collaboration
- Discussions
- KJ Sessions
- SECI (Socialization, Externalization, Combination and Internalization)

Next step is identification of such metrics which are to be used as key performance indicators. In any business there are many metrics but there are only few metrics which can work as key performance indicators. The detail of all phases of proposed model is described below:

3.1 Knowledge Acquisition Layer

Knowledge can be acquired from different and multiple sources. To mine the knowledge from different available sources ETL process is used. It has capability to acquire and discover the data as well as it can clean the data and knowledge by using middle-ware architecture. Some of the possible sources are Transactional systems, case studies of organizations, past research papers, academic reports, industrial case studies and data warehouses etc.

3.2 Semantic Layer

Knowledge of healthcare business is acquired and discovered from different available sources and then it is organized in such a way that is easy to understand by analytics experts. Data and knowledge analysts are responsible to develop reports, dashboards, scorecards and other visualization attributes more and more accurate.

In a context of data warehousing and business intelligence, a semantic layer may include Physical layer, dimension layer, business layer and presentation layer. Physical layer is responsible to fetch the data from backend database. Business layer and dimension layer are responsible for applying business rules like formulas etc. on data according to the business requirements. And finally, a presentation layer is responsible for making attributes and facts in a meaningful form for the purpose of transform and visualize the data in form of reports, dashboards and scorecards etc.

3.3 Visualization Layer

In visualization layer, KPI's are visualized in different forms according to the business requirement. In our healthcare scenario, we have selected some of the KPI's from a different perspective and perform some of the calculation to find an overall score, performance, predictions and other measurements and visualize them in different perspectives. The detail of calculations and visualization is given below in next sections.

There are different data visualization standards used in healthcare business analytics, some of them are:

- Balance scorecard [11]
- Scorecard
- Dashboards
- Reports
- Strategy Map and Tree
- Fish Eye Diagram
- Cause and Effect Flow [12]
- What If Analysis [13]
- Strategy contribution wheel

3.4 Selection of Key Performance Indicators

As discussed above, we use healthcare business as a case study of our proposed framework and implementation, so we have selected some of the KPI's of healthcare business analytics [14] of different perspectives by getting domain knowledge and domain understanding.

Some of the KPI's have positive behavior and some of the KPI's have negative behavior. Which means, business owner wants to increase the score of some KPI's (like Admission Rate and Total Funds etc.) and decrease the score of some KPI's (like medicine costs, indirect expense etc.).

Our selected KPI's along with their perspectives are given below in Table 1:

TABLE 1 HEALTHCARE KPI ALONG PERSPECTIVES

Healthcare Operations:	
Patient wait time	Decrease
No. of patients served per month	Increase
No. of beds	Increase
No. of new patients	Increase / Decrease
Financial:	
In direct Expenses	Decrease
Labor cost	Decrease
Third party revenue	Increase
Equipment maintenance cost	Decrease
Public Health:	
No. of educational programs	Increase
Tobacco usage rates	Decrease
No. of vehicle accidents	Decrease
Emergency:	
Arrival to bed	Decrease
Arrival to Nurse	Decrease
Patient Care:	
Patient follow-up	Increase
Medication error	Decrease
Quality of nursing care	Increase
Communication:	
No. of website hits	Increase
Public support	Increase
Fund Raise	Increase

After selection of performance indicators, it is important to decide the weightage or contribution percentage of each measure. And each measure has its own present or actual score and its target score that is decided by the business owner.

By using sample data across above mentioned measures and KPI's, we have added some calculations against given data to enrich our visualizations. The details of all calculations are given below in next section.

3.5 Calculations for Performance Indicators

First step is calculating overall score of all KPI's enlisted in a particular project. Each metrics has its own actual value, planned or target value and its contribution percentage.

To calculate overall score of KPI's and their performance, we use following formula as given respectively in Equation 1 and Equation 2:

$$\text{Equation 1: Overall Score} = (\text{Actual Value} * \text{Weightage}) / \text{Target Value}$$

$$\text{Equation 2: Performance of Measures} = (\text{Max} - \text{Actual Value}) / (\text{Max} - \text{Min})$$

After applying above mentioned formulas, in some of our KPI's actual value, target value as well as their weightages, the results are presented below in tabular form in Table 2:

TABLE 2 CALCULATIONS ON MEASURES

Actual Value	Target Value	Weight	Result	Performance
100	120	20	16.67	14.28
110	120	20	18.33	0
105	120	20	17.5	7.14
90	120	15	11.25	28.57
40	120	5	1.67	100
101	120	20	16.83	12.85

The above mentioned calculations show the scoring and performance (%) achieved by each performance indicator. As we can see that the results are affected by the weightage of each measure. And these results will guide the decision makers to increase or decrease the weightage of each measure. Now business analysts can derive many other calculations on the basis of these formulas. For example, predictive analysis, sales and profit analysis, organization's internal or external performance and processes analysis etc.

Weightage of measures depends upon the importance and these may vary with respect to business. For example, a sales oriented business will give more weightage to the customer's related indicators.

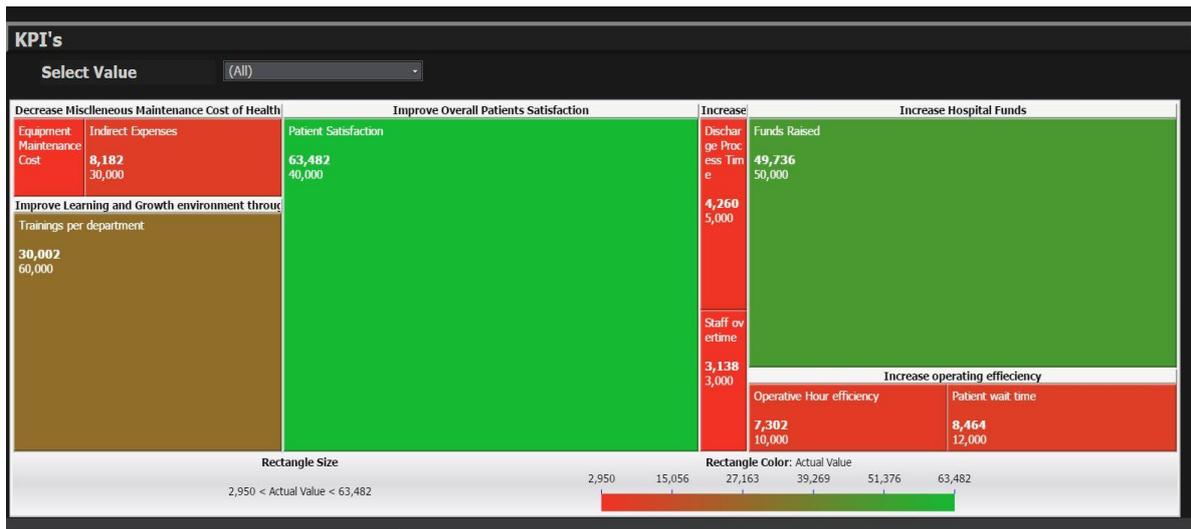


Figure 3 Performance score of different healthcare KPI's

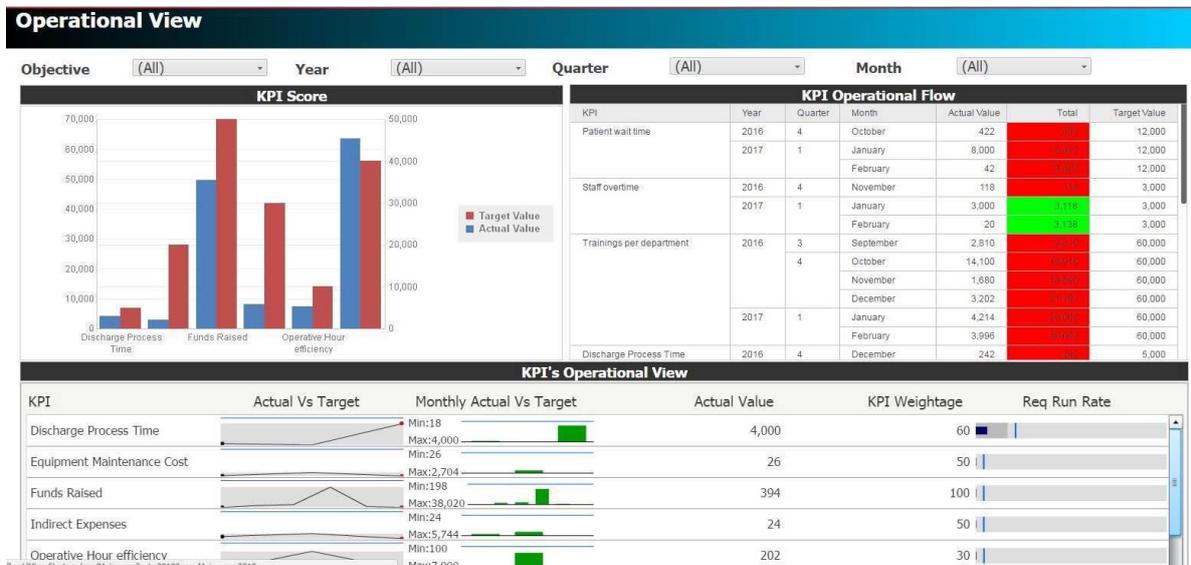


Figure 4 Performance score along with required score of healthcare KPI's

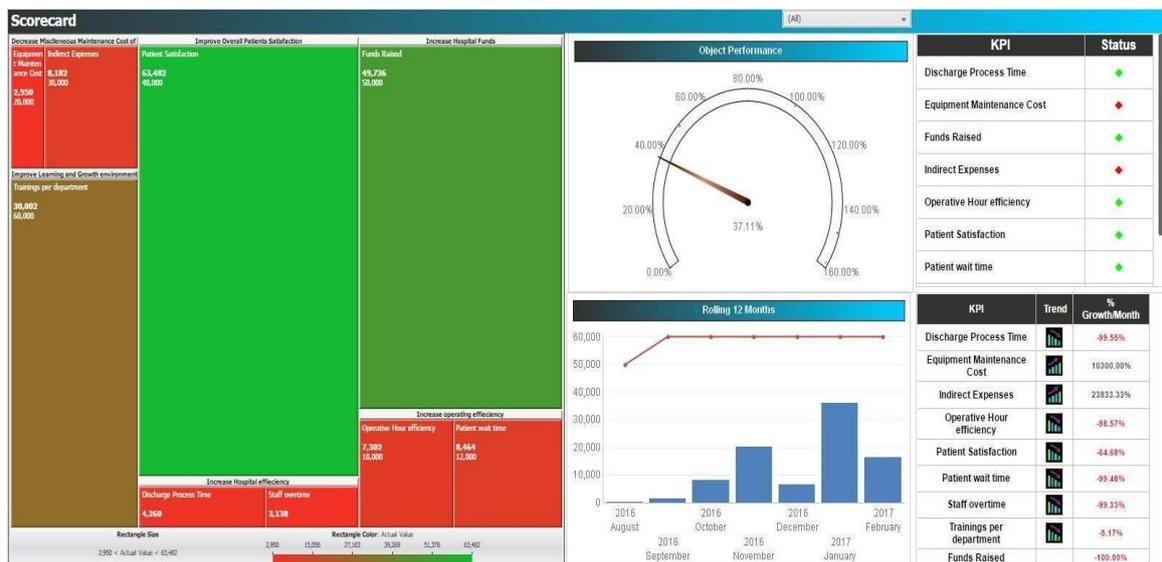


Figure 5 Visualization of different aspect of healthcare KPI's

KPI What if Analysis

KPI	Target Value	Actual Value	Score	Predicted Value
Discharge Process Time	5000	2,130	213	2,343

Figure 6 Predictive Analysis for Initiatives on different healthcare KPI's

Whereas, human resource department or related businesses will give importance to the employees or on internal process.

3.6 Analytics on Results

After calculations of metrics and measures we have drawn analytics in different views to present the past, present and future aspect of healthcare analytics on selected key performance indicators. A visualization of KPI's is show below in a Figure 3.

Different type of visualizations can be performed on discovered data as well as on the basis of calculations. And some of the visualizations are introduced in previous sections. However, we have performed some of the visualization on our selected KPI's and generates sample data and another visualization of Present and Future oriented intelligence analytics is shown below in a Figure 4 and Figure 5. These visualizations and analysis is performed in Micro Strategy Business Intelligence Tool [15].

Similarly, decision makers can predict the score of any selected KPI's to get initiatives and actions. This helps the decision makers to take actions and initiatives on the basis of current results and required run rate of KPI's. A sample predictive analysis score is given below in a Figure 6.

4. CONCLUSION AND FUTURE WORK

In this paper, we have integrated the knowledge management with business intelligence and data analytics to provide a solution to all three aspects of an intelligent or actionable analysis and analytic approach. Past analytics contains historical data and knowledge, present reports or analytics contains the flow of data and knowledge which is most recent and future analytics contains prediction on the basis of past and present knowledge.

In this paper, we have placed knowledge management attributes in existing business intelligence and analytics workflow to provide assistant to the software engineers to tackle all three dimensions of business analytics. We have evaluated our framework and approach in a healthcare system and gets reliable output.

In future, we are focusing on more accurate and simple formulas to calculate and predict data. Moreover, we are focusing on more easy approaches to discover the data from different sources for better visualization and analytics of healthcare business.

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