

**Extending a Business Performance Improvement Framework with a Semantic
Enhanced Hybrid Recommender System Design**

By

Stephen Wallace

Dissertation

Submitted in partial fulfillment
of the requirements for the degree of Doctor of Professional Studies
in Computing at
Seidenberg School of Computer Science and Information Systems
Pace University
July 2016

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Abstract

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Performance Management Systems (PMS) have been recognized as a crucial element to helping organizations improve their performance. They provide methodologies to help organizations identify Key Performance Metrics that help measure and improve performance. One of the most important Performance Management Systems is the Balanced Scorecard (BSC)

There seems to be a common set of universal business goals that people from multiple organizations, naturally seem to select as goals to improve business performance. So it would be logical to assume that there would be a commensurate set of universal Business Metrics that people would also use. The research shows there is not.

The Balanced Scorecard systems do not provide any guidance or recommendations on which metrics are most effective or valuable. In addition, the Balanced Scorecard System does not provide any guidance or recommendations on what data is needed to calculate the metrics; where the data is located, or what challenges organization will face as they attempt to implement the system.

What is needed is a Recommender System that will extend the Balanced Scorecard system by providing stakeholder with specific recommendations on which metrics others with similar goals have found valuable; the location of the data needed to calculate the metrics; and the barriers practitioners will face as they attempt to implement a BSC. A Recommender System is defined as “any system that produces individualized

recommendations that has the effect of guiding the user in a personalized way to a useful objects in a large space of possible options.

Modern Recommender Systems designs are very good at making certain types of recommendations like which movies to watch or which books to read. However, they are inadequate when attempting to make other types of recommendations like which metrics to apply to improve desired business outcomes, which systems or what data is needed to calculate a metric, or which barriers one should be expected when attempting to change a business process.

This research will introducing a Semantic Enhanced Hybrid Recommender System Design that will address these shortcomings, and extend the Balanced Scorecard System.

PREVIEW

Acknowledgements

I would like to thank my family for their interest and support through this entire project.

Without them, I would never have finished. I would also like to thank my wife Lauren for her tireless efforts as my reader, editor and writing coach. She challenges me to be clear and concise in everything I say.

PREVIEW

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Chapter 1

Introduction

In a highly competitive world it is essential that successful organizations continually improve their business performance. Performance Management Systems (PMSs) have been recognized as a crucial element to improving business performance in organizations [22]. Performance management systems are considered as a means to gain competitive advantages and continuously react and adapt to external marketplace changes. Implementing a PMS can ensure that organizational actions are aligned to organizational strategies and objectives [29].

Modern Performance Management Systems make use of a combination of financial and non-financial performance indicators that managers use to measure and evaluate the performance of business units or organizations as a whole [47]. An effective PMS provides managers with accurate feedback on the efficiency and effectiveness of organizational performance [28]. Performance management systems aim to integrate organizational activities across various managerial levels and functions [34]. Performance measurement systems are tools for balancing multiple measures (cost, quality and time) across multiple levels (organization, processes and people) in an organization [35].

One of the most important tools used to control and measure the performance of an organization is the Balanced Scorecard (BSC), first introduced by Kaplan and Norton (1992) [37]. The BSC is used by more than 50 percent of Fortune 500 companies as a tool to measure their performances [24].

The Balanced Scorecard provides a set of business process methodologies that can help organizations identify a relevant set of *Key Performance Metrics*. These Performance Metrics are a set of measurements that will allow an organization to measure their progress as they attempt to meet business performance goals. Performance measures are considered metrics employed to quantify the efficiency and/or effectiveness of organizational actions. [45].

Examples of performance which metrics surfaced in this research are as follows:

A company wanting to expand their Customer Base, should use the following metrics:

- Change in Market Share per Period
- Change in Number of Orders per Period
- Change in Revenue per Period
- Change in Number of New Customers per Period
- # of Proposals that Convert to a Sale per Period

A company wanting to Improve Customer Satisfaction should use the following metrics:

- % of Satisfied Customers
- % of Customers who Leave Every Period (Churn)
- # of Customer Complaints
- Net Promoter Score

A company wanting to Improve Customer Retention should use the following metrics:

- % of Customer Complaints Resolved on 1st Call
- Average Delivery Time per Order
- % of Orders Not Accepted By Customer
- Customer Retention Rate

By using the Scorecard, the management team will know more about the company's needs and ensure the alignment of the management processes and long-term strategies [27].

There seems to be a common set of universal business goals that people from multiple organizations, in multiple industries, naturally seem to select as goals to improve business performance. So it would be logical to assume that there would be a commensurate set of universal Business Metrics that people from multiple organizations, in multiple industries, would naturally select for common goals. The research indicates otherwise.

Many companies face a great number of problems during a BSC implementation project: [39] [41].

1. Too many performance indicators are developed, making it difficult for managers to know which metrics are most important.
2. Irrelevant performance metrics are selected by executives removed from the day to day business operations.

While there did not appear to be any universal set of Business Metrics, the researcher believed there could be and should be. The researcher also came across additional problems cited in peer reviewed literature that he also observed many times in his professional experience:

3. The data needed to calculate the metrics is not available in the organization.
4. It is not understood what software tools are needed to successfully implement a program.

5. Organizations do not adopt to the required organizational change necessary to successfully implement a BSC systems

In summary, while the Balanced Scorecard Framework excels at linking business strategy with the metrics needed to track business performance progress, the cited research above shows the framework is incomplete in several important ways:

1. The Balanced Scorecard Framework does not provide **Business Leaders** with any guidance or *recommendations* on which performance metrics are considered most valuable by other companies who want to achieve similar business outcomes. This forces Business Leaders to invent their own metrics that may not conform to industry best practices.
2. If the organization uses mostly Commercial Off The Shelf software (COTS), the Balanced Scorecard Framework does not provide the **IT Manager** with any guidance, or *recommendations* on which Commercial Business Systems and Modules are likely to house the data that will be needed to calculate each metrics. This can lead to a situation where a critical metric simply cannot be delivered because the underlying business system is not available or accessible. This factor can decrease the likelihood that the business will achieve its desired outcomes.
3. If the organization uses mostly internally developed software (Homegrown), The Balanced Scorecard Framework does not provide the **IT Manager** with any guidance or *recommendations* on which Data Sources will likely be needed to calculate each metrics. In many organizations the data required to calculate those

metrics is spread across multiple disconnected source systems making it very difficult or expensive to identify, locate, and extract the data actually needed to accurately calculate the critical metrics. This factor can decrease the likelihood that the business will achieve its desired outcomes.

4. The Balanced Scorecard Framework does not provide the **Project Manager** with any guidance or *recommendations* on the Barriers to Adoption they could face as they attempt to lead implementation projects. Knowing this ahead of time can help them develop educational programs and risk mitigation strategies.
5. The Balanced Scorecard Framework does not provide the **IT Managers** with any guidance or *recommendations* on which Best in Class Commercial Systems are most Prevalent. Knowing this ahead of time can help them understand which software to use or purchase.

This research introduces a novel systems design that will extend the Balanced Score Card Methodology by providing the following capabilities:

1. *Recommend* a set of empirically derived Best Practice Metrics considered most valuable by other companies who want to achieve similar business outcomes.
2. For companies that use *COTS Software*, the system needs to identify, or *recommend*, the Primary Business Systems Modules needed to source the data used to calculate the Key Performance Metrics. Armed with this information the IT Manger can determine if the data will be available ahead of time.
3. For companies that use *Homegrown Software* the systems needs to identify the Primary Data Sources that will be needed as the source of the data used to

calculate the Key Performance Metrics. Armed with this information, the IT Manger can determine if the data will be available ahead of time.

4. Identify, or *recommend*, an empirically derived set of Barriers to Adoption so that so that the Project Manager can develop a plan to mitigate risk.
5. *Recommend* a set of empirically derived set of Systems Vendors who supply best in class applications software whose systems would store all requisite data.
6. Present a Metrics recommender query tool that will allow a practitioner to input a desired performance improvement outcome and see all of the relevant information outlined above to help improve the chances of a success implementation.

1.1 Current Recommender Systems Design Approaches

The Internet has brought about exponential growth of information about products and services such as hotels, movies, books, products, etc. This information is available from review and ranking sites to e-commerce sites aiming to sell products and services to online users. Rather than supporting users in their choices, this abundance of information has caused an information overload problem. Customers can't find what they want in a sufficiently short time and often get lost during the searching process. Recommender systems (RS) have been developed as an effective solution to this problem [27].

A Recommender System is defined as “any system that produces individualized recommendations as output or has the effect of guiding the user in a personalized way to interesting or useful objects in a large space of possible options” [27]. Historically, there are two basic underlying approaches to Recommender Systems design: *Content-based filtering systems and Collaborative filtering systems* [11] [25] [26]. *Hybrid recommender*

systems are a newer breed of systems that incorporate more than one recommender systems design approach [11].

As the technology matures, researchers are developing new recommender systems designs to address known short comings with the traditional approaches. While there are far too many new approaches to mention for the scope of this paper, there are two new approaches that are directly relevant to this research. The two new approaches are *Multi-criteria Recommender Systems*, and *Semantic – Hierarchical Based Recommender Systems*

This paper introduces the (P)erformance (I)mprovement (R)ecommender (S)ystems design. This novel recommender systems design combines features from both the Multi-criteria Recommender Systems and Semantic – Hierarchical Based Recommender Systems. In addition, this Performance Improvement Recommender Systems design will address several problems discovered in this research. The problems will be outlined in the section: “Challenges with Current Recommender Systems Designs” later in this chapter.

1.2 Problem Statement:

While modern recommender systems are very good at making certain types of recommendations like: which movies to watch, books to read, or hotels to choose [27]; they are inadequate when attempting to make other types of recommendations like: which metrics to apply to improve a desired business outcome, which systems are most likely

needed to calculate a metric, or what barriers should be expected when attempting to change a business process.

The researcher believes that there two primary reasons for this:

1. Modern Recommender systems models rely on observer behavioral data collected by counting web site visits, purchases, ratings etc. What is needed is empirically derived data collected using scientifically validated survey instruments and Delphi techniques.
2. Modern Recommender systems designs rely on simple, single-tiered relationships derived from analyzing web site visits, purchasing history and web site “like/dislike” flags. What is needed are complex, multi-tiered relationship derived from robust data collections instruments and input from experts.

The net result is that the researcher does not believe modern Recommender Systems Designs are adequate when attempting to extend a Business Performance Framework for the following reasons:

1. They are not designed to catalog and store empirically derived Business Performance Metrics, and the business value that decision makers have assigned to the individual Performance Metrics.
2. They are not designed to catalog and store a list of the primary business systems that would be needed as the source of the data used to calculate the Key Performance Metrics.
3. They are not designed to catalog and store a list of the primary data sources needed to house the data used to calculate the Key Performance Metrics

4. They are not designed to catalog and store the most prevalent barriers to adoption most organizations face as they attempt to implement the Key Performance Metrics in their organizations.
5. They are not designed to catalog and store the most prevalent Best in Class Commercial Systems that can be used or purchased.

Each of these capabilities outlined in points one thru five above are needed in a recommender system that extends a Business Performance Framework. This research will introduce a new Recommender Systems design pattern that will address these shortcomings.

1.3 Dissertation Research Approach

This Research introduces the (P)erformance (I)mprovement (R)ecommender (S)ystems (PIRS) Framework. The PIRS framework will provide an important bridge between an organization's desired business performance outcomes, and the empirically derived most valuable metrics; the commercial or homegrown systems, and the data needed to calculate the key metrics; and the barriers to adoption organizations will face as they attempt to improve their business performance outcomes.

This PIRS Framework will:

1. Catalog and store the desired Performance Outcomes measures that an organization hopes to achieve.
2. Collect, catalog and store empirically derived Performance Metrics and the associated value (High, Med, Low) that decision makers have assigned to the individual Performance Metrics.

3. Collect, catalog and store a list of the primary systems that will be needed as the source of data used to calculate the Key Performance Metrics
4. Collect, catalog and store a list of the primary data types that will be needed as the source of data used to calculate the Key Performance Metrics
5. Collect, catalog and store the most prevalent barriers to adoption the organization should expect to face as they attempt to implement the Key Performance Metrics in their organizations.
6. Collect, catalog and store the most prevalent Best in Class Commercial Systems that can be used or purchased.
7. Provide a Metrics and Systems Recommender Tool that will allow users to input a desired business performance improvement outcome, and receive a set of recommended metric, systems, data they will need, and a set of barriers to implementation they should expect.

The research will then demonstrate how to apply the Business Performance Improvement Recommender Systems Framework to extend a Performance Management Framework in two use cases.

Use Case Number One – Customer Relationship Management

In their paper “A Study on Developing CRM Scorecard” Kim and Kim introduce a performance measurement framework called the CRM scorecard. This framework is an integrative organizational artifact to diagnose and assess a firm’s CRM practice. The CRM scorecard was developed through comprehensive literature review and in-depth

interviews with CRM practitioners, with specific objective and subjective instruments added to measure corporate CRM capability and readiness [30].

This use case will demonstrate how the PIRS Framework can be applied to improve business performance.

Research Use Case Number Two – Population Health Management

To demonstrate the versatility of the framework, and as a prelude to future research, the author will show how the PIRS Framework can be applied to a Population Health Use Case. The US Healthcare System is in the early stages of a transition from its traditional “Fee for Service” deliver model to a “Shared Risk” delivery model that promises to improve outcomes and reduce costs. To accommodate this transition, a new type of healthcare Delivery organization is emerging.

The Centers for Medicare & Medicaid Services (CMS), an agency within the Department of Health & Human Services (HHS), finalized regulations under the Affordable Care Act to allow doctors, hospitals, and other health care providers to better coordinate care for Medicare patients through Accountable Care Organizations (ACOs). Participation in an ACO creates incentives for health care providers to work together to treat an individual patient across care settings—including doctor’s offices, hospitals, and long-term care facilities. The Medicare Shared Savings Program (Shared Savings Program) will reward ACOs that lower their growth in health care costs while meeting performance standards on quality of care and putting patients first [48].

Thirty-three individual measures of quality performance are used to determine if an ACO qualifies for shared savings. These 33 measures span four quality domains: Patient Experience of Care, Care Coordination/Patient Safety, Preventive Health, and At-Risk Population [48].

This use case will demonstrate how to use the PIRS Framework to construct a Healthcare Performance Management Recommender system that will help improve health outcomes.

1.4 Performance Improvement Recommender Systems Framework Overview

The PIRS Framework has four modules:

1. **The PIRS Data Collection Module** uses a survey instrument to define and quantify the business value for a set of Key Performance Metrics that can be used to measure actual business performance against performance goals.
2. **The PIRS Recommendation Module** is a Graph database solution designed to link the critical metrics identified in PIRS COLLECT to the Performance Outcomes, Systems Entities and the Business Applications that house the source data needed to support and enable improved business performance.:
3. **The PIRS Visualization Module** is a Recommendation tool that can be used by both business analysts and developers. The tool allows users to select a specific business performance outcome to discover which critical metrics and business applications are required to achieve the desired business performance outcomes.
4. **The PIRS Integration Module** is a tool that facilitates the movement of data between the other modules. The PIRS system uses the commercial Extract,