MARMARA UNIVERSITY

INSTITUTE FOR GRADUATE STUDIES IN PURE AND APPLIED SCIENCES

AN ADAPTIVE PERFORMANCE ASSESSMENT SYSTEM FOR BUSINESS PROCESSES

NİLGÜN GÖKMEN

Ph.D. THESIS

Department of Industrial Engineering

ADVISOR

Prof. Dr. Ercan ÖZTEMEL

ISTANBUL, 2016

MARMARA UNIVERSITY

INSTITUTE FOR GRADUATE STUDIES IN PURE AND APPLIED SCIENCES

AN ADAPTIVE PERFORMANCE ASSESSMENT SYSTEM FOR BUSINESS PROCESSES

NİLGÜN GÖKMEN

(724409002)

Ph.D. THESIS

Department of Industrial Engineering

ADVISOR

Prof. Dr. Ercan ÖZTEMEL

ISTANBUL, 2016

ACKNOWLEDGEMENT

A lot of people have supported the creation of this thesis study. It is a pleasure to convey my gratitude to all of them. First of all, I would like to thank to my supervisor Prof. Dr. Ercan ÖZTEMEL for his guidance, suggestions, support in the light of his experiences, his tolerance, invaluable encouragement throughout my research and study at Marmara University.

I would also like to thank to my jury members, Assoc. Prof. Dr. Çiğdem ALABAŞ USLU and Assoc. Prof. Dr. Alev TAŞKIN GÜMÜŞ for their valuable guidance and insightful comments to this study. With the same feelings, I would like to thank to Mr. İsa TAŞDELEN who is Company Advisor in TUBITAK BILGEM Information Technologies Institute (ITI) for his valuable comments.

Last but not least, I would like to present my sincere thanks to my husband and daughters whose uncomplaining love enabled me to complete this study. I would like to express my deepest appreciation to my family for their unflagging love and support throughout my life. This thesis is impossible without their support and patience.

June, 2016 **Nilgün GÖKMEN**

TABLE OF CONTENTS

ACKNOWLEDGEMENT…….. i

TABLE OF CONTENTS…….. ii

ÖZET…….. vi

ABSTRACT……..viii

CLAIM FOR ORIGINALITY……. x

SYMBOLS……. xi

ABBREVIATIONS……..xiii

LIST OF FIGURES……. xiv

LIST OF TABLES…….. xvi

1. INTRODUCTION…… 1

1.1. Aim of the Study 1

1.2. Scope of the Study..... 2

2. PROCESS MANAGEMENT…….. 3

2.1. Definition of the Term “Process”..... 3

2.2. The Components of a Process 4

2.3. Process Characteristics..... 6

2.4. Process Hierarcy..... 7

2.5. Classification of Business Processes..... 7

2.6. Business Process Management Overview..... 8

2.7. Business Process Management Methodology 9

2.7.1. Preparation……. 10
2.7.2. Process selection……..11
2.7.3. Process description…….. 11
2.7.4. Process quantification and simplification……11
2.7.5. Process improvement…….. 12
2.7.6. Implementation……13
2.7.7. Continuous improvement…… 13
2.7.8. Benchmarking…… 13

3. PERFORMANCE MANAGEMENT…… 14

3.1. Definition of Business Performance 14
3.2. Performance Measurement..... 16
3.3. Performance Measures 17
3.4. Need for Measures 19
3.5. Performance Measurement Steps 19
3.6. Measuring the Weights..... 25
3.6.1. Analytic Hierarchy Process……26
3.7. Performance Assessment Techniques 30
3.7.1. Balanced Scorecard……31
3.7.1.1. The Dimensions of BSC 32

4. ADAPTIVITY…… 34

4.1. Agents..... 34
4.1.1. Structure of intelligent agents…… 35
4.1.2. Agent types…… 35
4.1.2.1. Simple reflex agents 36
4.1.2.2. Model- based agents 36

4.1.2.3. Goal-based agents 37
4.1.2.4. Utility-based agents 38
4.1.2.5. Learning agents 39
4.2. Adaptability 40
4.3. Adaptive agent 42
4.3.1. Adapting by reaction 42
4.3.2. Adapting by reasoning 42
4.3.3. Adapting by learning 43
4.3.4. Adapting by evolution 43
4.4. Rationale for Adopting Agent Technology 43
4.5. Agent Technology in Business Process Management 44
5. ADAPTIVE BUSINESS PROCESS PERFORMANCE ASSESSMENT MODEL 47
5.1. General Architecture 47
5.1.1. Knowledge Bases 50
5.1.1.1. The Goal Base 50
5.1.1.2. The Process Base 54
5.1.1.3. The Assessment Criteria Base 56
5.1.1.4. Database for Measured Data 57
5.1.1.5. Process Database 58
5.1.1.6. Rule Base 58
5.1.2. Model Agents 65
5.1.2.1. Goal Agent 65
5.1.2.2. Quality Agent 68
5.1.2.3. Performance Agent 71

5.1.2.4. Reporting &Improvement Agent 74

5.2. Adaptivity of the ABPAS Agents 76

6. IMPLEMENTING ABPAS: A CASE STUDY……77

6.1. Case Study 77

6.2. Discussion 93

7. CONCLUSIONS…… 95

7.1. Conclusions 95

7.2. Future Work 95

REFERENCES…… 97

APPENDICES…… 103

ÖZET

İŞ SÜREÇLERİNDE UYARLANABİLİR BİR PERFORMANS DEĞERLENDİRME SİSTEMİ

Performans yönetimi ve değerlendirme tüm alanlarda organizasyonlar için çok önemli ve vazgeçilemez bir olgudur. Kurumlarda kalite yönetiminin temel araçlarından birisidir. Kaliteyi güvence altına almanın yollarından birisi süreçleri belirlemek, onları analiz ederek katma değeri olmayan eylemlerden arındırmak ve daha iyiye götürülecek olan yerleri iyileştirmektir. İyileştirmeye açık alanların belirlenmesinin en önemli yollarından birisi de performans göstergelerinin sağlıklı belirlenmesi ve izlenebilmesidir.

Süreçlerin performanslarının izlenebilmesi ve doğru yönetilebilmesini sağlamak için her iş sürecine yönelik öncelikli olarak hedefler ve amaçlar belirlenir ve süreç yürütülürken toplanan veriler ile oluşan sonuçlar değerlendirilerek hedefler ile karşılaştırmalar gerçekleştirilir. Süreçlerin sağlıklı tanımlanabilmesi kurumlarca ulaşılacak olan kalite düzeyinin belirlenmesinde de yardımcı olur. Belirlenen kalite seviyesinin üzerine çıkabilmek için ilgili hedefler sürekli iyileştirilerek faaliyetler düzenlenir. Bu kalite düzeyinin sağlıklı bir şekilde oluşturulabilmesi de doğru performans göstergeleri ve izleme yöntemlerinin uygulanması ile de yakından ilgilidir. Çalışanların bu kapsamda yeterli uzmanlık ile donatılması, iş yükünü azaltmak, daha güvenilir ölçümler alabilmek ve daha doğru değerlendirmeler yapabilmek için o günün koşulları ile uyumlu ve uyarlanabilir bir performans sisteminin tasarlanmasının önemli olduğu düşünülmektedir.

Yukarıdaki açıklamalarda da görüldüğü gibi kurumlarda önceden belirlenmiş hedef listesine göre belirli kriterleri göz önüne alarak süreç ölçümleri ile bir değerlendirme yapan ve sonucunda da bir iyileştirme planı sunan, her alana uyarlanabilir bir performans değerlendirme sistemine ihtiyaç vardır.

Bu gerçekten hareket ile bu tez kapsamında önceden belirlenmiş hedef ve kriterlere dayalı iş süreçlerinin kalitesini arttırmaya yardımcı olacak uyarlanabilir bir performans değerlendirme ve izleme sistemi tasarlanmıştır. Bu sistem ile yöneticiler ulaşmak istedikleri hedefleri ve ilgili iş süreçlerini tanımladıklarında, sistem belirlenen hedeflere

ulaşma yüzdelerini, hedeflere ulaşmak için tanımlanan süreçlerin yeterliliğini ve hangi alanlarda öncelikli olarak iyileştirmenin yapılması gerektiğini belirlemektedir.

Haziran, 2016 **Nilgün GÖKMEN**

ABSTRACT

AN ADAPTIVE PERFORMANCE ASSESSMENT SYSTEM FOR BUSINESS PROCESSES

Performance management and assessment is very important and essential activity at all areas of the organizations. It is one of the main tools for, especially, quality management. In order to assure the “quality”, it is necessary to define respective business processes and eliminate non-value added activities through improvement programs. Properly defined performance indicators are the main source of process monitoring which clearly indicates the areas open to improvements.

In order to monitor the performance of the business processes, the goals and targets for each business processes need to be clearly defined. During the execution of the processes business results are to be compared against the target values and evaluated. Defining the processes properly may also help the organizations determine expected quality level. That is to say that, the activities are organized by regularly improving the relevant goals to yield pre-determined quality level. Defining accurate and correct performance indicators and monitoring methods are therefore essential for building the right objectives for intended quality level. Based on this fact, it is considered to be important to design a compatible and an adaptive performance assessment system complying with daily quality requirements and to equip the employees with sufficient expertise in this context in order to reduce the workload, to get more reliable measurements and more accurate assessments.

As explanations above indicate, an adaptive performance assessment system provides a baseline for process measurements with respect to pre-defined goals and respected performance criteria. It may sufficiently help creating improvement plans improving the quality level of the products and services generated.

In this thesis, an adaptive performance assessment and monitoring system is designed that helps improvement of the quality level of the business processes based on the pre-defined criteria with respect to pre-defined goals. This system defines the completion percentage of defined goals, the efficiency of related processes and primary

improvement areas when the managers determine the objectives to be reached in accordance with the related business processes.

June, 2016 **Nilgün GÖKMEN**

CLAIM FOR ORIGINALITY

AN ADAPTIVE PERFORMANCE ASSESSMENT SYSTEM FOR BUSINESS PROCESSES

In the concept of this study, contemporary literature was reviewed in order to find out the existing information regarding performance assessment systems. The lack of existent systems was identified and a new framework for business process performance assessment was proposed.

This system has some important features as indicated below:

- The performance indicators are associated with respective quality level.
- The system has the ability to adapt itself in accordance with the current progress. Due to the importance of strategic areas and goals determined, the system is designed to be adaptable and take the attention to the respective recommendations.
- The system is generated in such a way that it can be employed by any organization operating in any sector including manufacturing, education, and informatics, etc.
- The proposed system is enriched by methodologies of Artificial Intelligence and rule-based decision support technologies.

June, 2016 **Prof. Dr. Ercan ÖZTEMEL** **Nilgün GÖKMEN**

SYMBOLS

A : Pairwise Comparison Matrix

$\mathbf{a_{ij}}$:The element of row i column j of the Pairwise Comparison Matrix.

$\mathbf{a_{ji}}$: Reverse comparisons and must be the reciprocals of $a_{ij.}$

C.I. : Consistency Index

C.R. : Consistency Ratio

G : Goal

H_Target : The highest target value

KPI : Key performance indicator

L_Target : The lowest target value

M : Metric

m : The number of Goal in the matrix

Max : The maximum point that the performance should be 0%

Min : The minimum point that the performance should be 0%

mp : The number of Task in the matrix

$\boldsymbol{\lambda_{max}}$: The biggest eigenvalue of matrix A.

n : The number of KPI in the matrix

np : The number of TPI in the matrix

p : Performance value

P : Process

PM : Process metric

RI : Random index

s : The number of Strategic Area in the matrix

SA : Strategic Area

sp : The number of Process in the matrix

T **:** Task

TPI **:** Task performance indicator

W **:**Weight of indicator

ABBREVIATIONS

ABPAS : Adaptive Business Process Performance Assessment System

ADEPT : Advanced Decision Environment for Process Tasks

AHP : Analytic Hierarcy Process

BPI : Business Process Intelligence

BPM : Business Process Management

BPR : Business Process Reengineering

BSC : Balanced Scorecard

CMMI : Capability Maturity Model Integration

COBIT : Control Objectives for Information and Related Technology

CSF : Critical Success Factors

EFQM : European Foundation for Quality Management

EPSRC : Engineering and Physical Sciences Research Council

ID : Identification

ISIP : Intelligent Systems Integration Programme

IT : Information Technology

ITIL : Information Technology Infrastructure Library

KPI : Key Performance Indicator

NR : No Relation

SIPOC : Suppliers-Input-Process-Output-Customers

TPI : Task Performance Indicator

TQM : Total Quality Management

VBA : Visual Basic Application

WFM : Workflow Management

LIST OF FIGURES

Figure 2.1 A general process model (Tekez et al., 2009). 3

Figure 2.2 General hierarchy of processes (Harmon, 2003)..... 7

Figure 2.3 The business process management methodology (Elzinga et al.,1995)..... 10

Figure 3.1 Interactions of performance management, performance assessment and performance measurement (Folan et al., 2007) 15

Figure 3.2 Performance indicators categories 18

Figure 3.3 Hierarchy of performance metrics..... 25

Figure 3.4 Hierarchy of quality metrics..... 26

Figure 3.5 Hierarchy structure of decision problem 27

Figure 3.6 Framework of BSC(Kaplan and Norton, 1996) 32

Figure 4.1 Agent structure (Russell and Norvig, 1995)..... 34

Figure 4.2 Simple reflex agents (Russell and Norvig, 2003) 36

Figure 4.3 Model-based agents (Russell and Norvig, 2003) 37

Figure 4.4 Goal-based agents (Russell and Norvig, 2003)..... 38

Figure 4.5 Utility-based agents (Russell and Norvig, 2003) 39

Figure 4.6 Learning agents (Russell and Norvig, 2003)..... 40

Figure 4.7 Decision making process (Michalewicz Z. et al., 2007) 41

Figure 4.8 Adaptibility module (Michalewicz Z. et al., 2007). 41

Figure 5.1 General architecture of ABPAS 48

Figure 5.2 A screen shot in ABPAS for defining at strategic area 50

Figure 5.3 A screen shot in ABPAS for definition of a KPI 51

Figure 5.4 a) Case 1**:** *Tendency=within range (Project unique requirements etc.),* **b)** *Case 2: Tendency= on target (Customer satisfaction ratio etc.),* **c)** Case 3: *Tendency=decreasing (expense etc.),* **d)** *Case 4: Tendency=increasing (revenue etc.)* 53

Figure 5.5 A screen shot in ABPAS for process definition 54

Figure 5.6 A screen shot for TPI definition 55

Figure 5.7 A screen shot for pairwise comparisons of TPIs 57

Figure 5.8 A screen shot for strategic area weight coefficients 57

Figure 5.9 Format of the Database for Measured Data 58

Figure 5.10 Format of the Process Database 58

Figure 5.11 The structure of the Goal Agent of ABPAS 67

Figure 5.12 The structure of the Quality Agent of ABPAS 70

Figure 5.13 The structure of Performance Agent of ABPAS 73

Figure 5.14 The structure of Reporting & Improvement Agent of ABPAS 75

Figure 6.1 Main screen of ABPAS 78

APPENDIX 1-Figure 1 Corporate performance report 104

APPENDIX 1-Figure 2 Strategic Area performance report 105

APPENDIX 1-Figure 3 Goal performance report 105

APPENDIX 1-Figure 4 KPI performance report 106

APPENDIX 1-Figure 5 Process performance report 107

APPENDIX 1-Figure 6 Task performance report 108

APPENDIX 1-Figure 7 TPI performance report 109

APPENDIX 1-Figure 8 Improvement & recommendation report-KPI 110

APPENDIX 1-Figure 9 Improvement & recommendation report-TPI 111

LIST OF TABLES

Table 2.1 The components of a process 5

Table 3.1 Relative scores 28

Table 3.2 Random Consistency Index (RI) 30

Table 3.3 Review of methods, models and systems for performance measurement (Milanović Glavan, Lj. ,2011) 31

Table 5.1 KPI definition 52

Table 5.2 TPI definition 56

Table 5.3 Relationship between business rules and agents 63

Table 6.1 Strategic area definition 79

Table 6.2 Goal definition 79

Table 6.3 KPI definition 79

Table 6.4 Metric definition 80

Table 6.5 Pairwise comparisons and the weights of strategic areas 80

Table 6.6 Pairwise comparisons and the weights of goals with respect to the strategic area criterion 80

Table 6.7 Pairwise comparisons and the weights of KPIs with respect to the goal criterion 81

Table 6.8 Required data mesaured and collected 82

Table 6.9 Process definition 83

Table 6.10 Task definition 83

Table 6.11 TPI definition 84

Table 6.12 Process metric definition 85

Table 6.13 Pairwise comparisons and the weights of processes 85

Table 6.14 Pairwise comparisons of tasks and the weights with respect to the process criterion 86

Table 6.15 Pairwise comparisons and the weights of TPIs with respect to the task criterion..... 87

Table 6.16 Process data 90

1. INTRODUCTION

Organizational performance presents how a manager achieves organizational objectives with available resources. For this reason, process business activities should be measured and analyzed. Process performance assessment systems are used to represent past and current process performance and provides prediction for future performance results related to the processes. That is to say that, the organizational performance can be predicted and it can be increased with the process improvements.

Taking the fact that 85% of the problems occur due to ill-defined processes against 15% of the employee based problems in an organization, well-defined and effective execution of works and related activities will generate a significant contribution to organizational productivity (Rossiter, 1998; Erkılıç, 2007). Originality of this dissertation is to design an adaptive business performance assessment system based on pre-defined strategic goals and criteria that helps to improve the quality level of business processes.

The First Chapter of the thesis outlines the aim and scope of the study. The rest of this thesis is formed in the following way: The Second Chapter provides process management methodology. The Third Chapter introduces the performance management methodology and outlines the related methods. The Forth Chapter describes the adaptivity and the agent technologies. In the Fifth Chapter, the framework of the proposed assessment model is illustrated and explained. The Sixth Chapter consists of a case study and the last chapter is reserved for the conclusions and recommendation for future work.

1.1.Aim of the Study

The main purpose of this study is to design an adaptive performance assessment and monitoring system that helps to improve the quality level of the business processes based on the pre-defined criteria with respect to pre-defined goals so that effective and efficient process improvement plans can be generated. The key feature of the systems to be well-operated is their ability to be able to adapt themselves in accordance with the conditions of the day. If the strategical goals are changed, they have to be aligned into

the organizational processes, this in turn, necessitates the related tasks and performance indicators to be adjusted accordingly.

1.2.Scope of the Study

The proposed system can be used succesfully especially in the enterprises where process management philosophy is implemented. This philosophy is popular in requiring that the system is designed and managed by well-defined both operational and administrative as well as support processes. This understanding defines the scope of the study.

For the proof of concept of the proposed model, the implementation is carried out on a case study in an enterprise operating in IT sector. However the approach is applicable to all business processes in various sectors including manufacturing, health, education, etc.

2. PROCESS MANAGEMENT

In this Chapter, definiton of the term “process”, is introduced in terms of a general model, components, hierarchy, classifications, and management methods.

2.1.Definition of the Term “Process”

There are many definitions of the term “process” some of which are listed below:

A process is a definable, repeatable, measurable and value added combined set of activities that converts a defined set of inputs to a defined set of useful outputs for its customers (Cantürk, 2005).

A business process involves a set of activities that are performed in coordination in an organizational and operational environment. These activities achieve a business goal together (Weske, 2007).

A business process is a specific ordering of work activities across time and place with a beginning and an end containing inputs and outputs (Davenport,1993).

A process is defined as all conversion activities of inputs provided from suppliers to products or services (outcomes) meeting customer needs by processing them in specific operations, adding values to these as shown in the **Figure 2.1**.

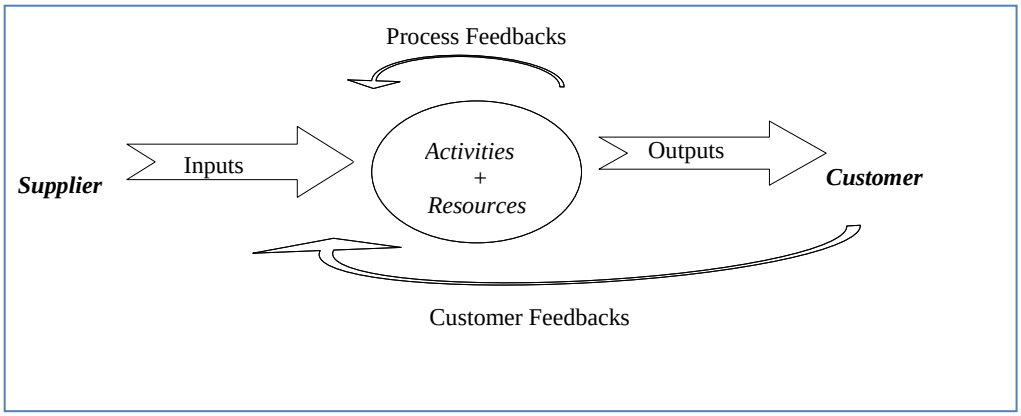


Figure 2.1 A general process model (Tekez et al., 2009).

A business process begins with a mission objective and ends with achievement of the related business objectives. Business processes are designed to add value for the customer and should not include non-value added activities. The output of a well

designed business process is expected to increase the effectiveness (value for the customer) and efficiency (less costs for the company) (Harmon, 2003).

In the light of all above definitions, a process can be defined as ***"the sum of the activities that are performed to provide added value to one or more inputs for the customers in line with a purpose".***

For example, "*completing an order*" is a process; the order is an input in this process and the process is completed by the delivery of ordered materials to the customers at the end. The delivery is the value created by the process (Işılay, 1998).

2.2.The Components of a Process

The components of a process are listed as shown in the **Table 2.1** :

Table 2.1 The components of a process

Component name	**Description**
Customers	They are users of the outputs. As the customers of some processes are direct external customers, some of them are internal customers.
Goals	They identify what a corporate wants to satisfy over a specific period of time.
Inputs	They are items needed to perform the process. They are resources such as people, machine, material, money, information which are provided by suppliers.
Other relevant processes	They are processes that are in touch with inputs and outputs of the processes.
Outputs	They are items that are created as part of the process. They are goods and services that the process produces for the customers.
Performance indicators	They are the indicators that are defined to be able to follow process performance. Performance indicators must contain how much customers were satisfied from outputs and how much resources (labor, time, cost etc.) were used to achieve these results.
Process name	It is the configured name of the business process.
Process owner	The person who is responsible for the correct and efficient implementation of all business processes using this model.
Suppliers	They are part that provide inputs to the process, might be a person or an institution.
Tasks	They are actions that convert inputs to outputs in a process.

These components are extended definitions of the well known process definition method called SIPOC (Suppliers-Input-Process-Output-Customer). The SIPOC model is a system model that is used for process management and improvement. It is proposed by Deming. The SIPOC model indicates that all organisations are a system built by the suppliers, inputs, processes, outputs and customers. These five parts of the system are interrelated and interactive.

Even if, in the small organizations, this diagram can be used as a structure to draw out their business processes. Through this five part analysis;

- the constraints between downstream and upstream regions can be defined,
- the material and information flows can be balanced
- the performance indicator system which can support the effective output of organisation can be created and
- the lateral balance of the targets can be achieved (Cao et al.,2015).

2.3.Process Characteristics

A process must have the following characteristics as listed by Doğan et al. (2004) :

Definable: It is the property of being able to determine the basic elements of a process.

Repeatable: It is the property that outputs can continuously meet the expectations and needs of the customers.

Measurable: It is the traceability specification of the process with performance indicators. Any of nonmeasurable things can not be controlled and managed.

Controllable: It is the property that process owner can continuously control the process operations and collect information about the process performance and carry out the corrective actions when necessary.

Value added: It is the property of process that is able to create positive impact on output quality and satisfaction of customer who uses the outputs.

2.4.Process Hierarcy

A general process hierarchy is shown in the **Figure 2.2** below.

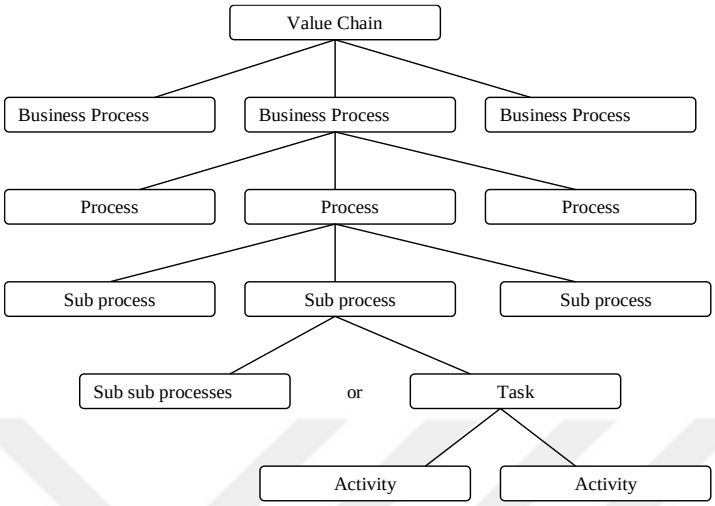


Figure 2.2 General hierarchy of processes (Harmon, 2003)

As soon as a company decides to make a new product or service or a customer orders a product, the overall process that is called "value chain" begins. Until the customer has the product or service and is satisfied with it, this process continues (Harmon, 2003).

Business process is an important process to provide main strategical goals. Process is the set of main activities that begins and finishes with external customers. Sub process is a set of activities that are related with two or more units in a company. Tasks are special works which are completed by only one unit or a person. "What to do" at the level of process, "how to organize" at the level of sub process and "how to do" at the level of task should be taken into account in the analyses of a process performance (Cantürk, 2005).

2.5.Classification of Business Processes

The processes are classified to generate a general structure and to better present their effects and relationships with their managers (Aran, 2002).

Business processes have three main types as listed below (Cantürk, 2005):

- Management processes are the processes which manage the operation of a system, for instance, Project Management and Strategic Management.

- Operational processes are the processes which generate the core business. Examples include Purchasing, Manufacturing, Verification and Validation.
- Supporting processes are the processes which promote the core processes, such as Configuration and Quality Management, Accounting.

Products or services produced as a result of operational processes are used by external customers as information and plans produced as a result of management processes are used by internal customers (Garvin, 1998).

2.6.Business Process Management Overview

Elzinga and their friends (1995) define that Business Process Management (BPM) is a systematic, structured approach in order to analyze, improve, control, and perform processes with the aim of improving the quality of products and services created. BPM is developed from synthesis of Business Process Reengineering (BPR) and Total Quality Management (TQM) (Sharp and Dermott, 2001).

Process management is the set of activities that are executed to assure that the processes are well-defined, performed as expected, monitored and improved continuously (Bozkurt, 2002). It consists of

- Defining processes,
- Determining process owners, suppliers and customers,
- Specifying the needs,
- Monitoring the performance by making measurements,
- Making necessary improvements.

BPM contains methods, techniques, and tools in order to design, enactment, execute, and analyze the operational business processes. It can be considered that BPM is derived from workflow management (WFM) systems and approaches (Aalst, 2003).

BPM aims to put processes, people and information together. BPM makes real-time integration of processes with its suppliers, business partners, and customers as well as managing business processes within the organization (Guclu, 2006).

BPM systems provide the designing and automation of business processes by the aim of enabling fast and cost-effective process management (Tan et al. , 2008).

It provides an organization from four viewpoints (Tian and Quan, 2008):

- the people view (culture, organization structures, roles, responsibilities, accountabilities, competencies, jobs and communication),
- the process view (the method of planning, controlling and changing business processes),
- the resource view (resources used in the organization, their integration way into business processes and their relevant performance and utilization levels) (Antonie, 1998), and
- the customer view (the requirements of customer, service features and design, customer feedback).

Tian and Quan (2008) indicate that BPM has the aim of aligning the organization employees with the customer, producing customer value through its business processes and related resources. So then, performance and knowledge management is used as key factors to improve value delivery to the customers of the organization.

2.7.Business Process Management Methodology

The BPM methodology involves a set of activities from preperation to process implementation as shown in **Figure 2.3**. Each activitiy in this respect is briefly explained below.

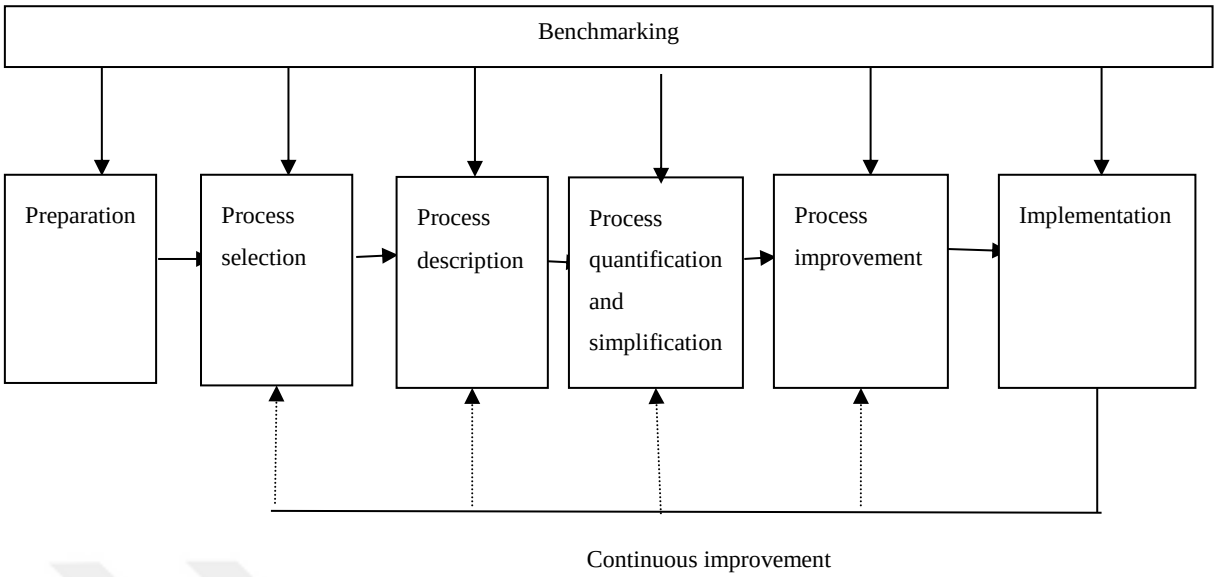


Figure 2.3 The business process management methodology (Elzinga et al.,1995)

2.7.1.Preparation

Firstly, guiding principles (vision, mission and goals) for the organization should be published and made known by all employees. The enterprise should focus on its published guiding principles and so a set of key performance indicators (KPIs) should be generated.

KPI is a methodology which systematically identifies the necessary actions in order to facilitate an enterprise to satisfy its goals. The definition of KPI involves two steps. The first one is to make an interview with executives. With this interview, the identified vision and mission are reviewed, goals are determined and documented, and KPIs related to these goals are become clear and classified. In the second step, the outcomes of the first step are checked up by top management, and measures in order to monitor the KPI performance are defined.

Following this, “Quality Council” or “Performance Monitoring Committee” are established. It consists of high-ranking managers and a “Quality Manager” who is responsible for selecting the specific process(es) to improve, guide and monitor the improvement in activities. The Quality Manager monitors the progress of process owners and reports to the Quality Council. The Quality Manager works with facilitators

employed as process owners and coordinates required training for facilitators and process owners.

2.7.2.Process selection

In this step, a particular process is chosen up from a few choices for analysis and improvement. For the selected process, a cross functional team is formed in order to perform the BPM study by the process owner. This team constitutes of responsible employees for the process operation and facilitators who are expert about BPM.

Mostly, it is important to evaluate the "value" of a process before the process selection for improvement. Forecasting the value that is derived from intangibles for a process is a difficult job. In such cases, the assessment of value is a decision-making study. The Analytic Hierarcy Process (AHP) method can be used to estimate the value.

2.7.3.Process description

In BPM, it is necessary to establish common definitions for each process. There are often some conflicts without a certain process documentation. There has been several methods such as SIPOC (Supplier, Input, Process, Output, Customer) implemented in generating proper definitions. Note that, the process documentation generally involves the definition of the following:

- Process aims and objectives
- Process owner
- Process inputs and outputs
- Process suppliers and customers
- Process activities
- Process performance indicators and respective target values

2.7.4.Process quantification and simplification

A quantification of the process can be achieved by measuring the related performance indicators. This is important in order to define possible targets or external resources for

improvement. One of the main motivation behind improvement is the process simplification. This makes sure that only value added tasks to be performed within the framework of the process design. The activities related to the process can be described as value-adding or nonvalue-adding activities to carry out this step. Then a set of performance indicators with respective target values is defined for especially value added activities as well as expected results to be obtained.

Information on resource needs, cost, time and value can be obtained for more certain quantification. Simple visual data representation tools such as pie charts, histograms, Pareto charts, and bar graphs can be used to enable quantified comprehension of the process.

2.7.5.Process improvement

This step involves identifying areas to be improved in a process. The performance assessment is a key tool for process improvement. The process performance indicators are instantly and periodically measured and compared with target values. Gap analysis provides a good source of information for identifying the areas to be improved.

Initially, in the improvement process, the non-value adding activities should be handled to evaluate the potential for reduction or direct elimination.

- High cost and high value activities are chosen for special concern and maintained for cost reduction opportunities.
- Low cost and low value activities should be maintained or eliminated.
- High value and low cost activities may be invested in.

The process improvement can be incremental or it can be managed toward major changes. So, KAIZEN (incremental improvement) or Business Process Reengineering (BPR) (major, significant changes) can be chosen as the process improvement method (Hammer and Champy, 1993). Although both BPR and KAIZEN aims to bring process improvements into action, BPR is mainly a "project" with a defined beginning and end of the overall process design, whereas the KAIZEN is continuous improvement tool that makes small changes.

2.7.6.Implementation

Specific improvements have to be recommended and implemented after improvement opportunities have been selected. This is achieved by first generating a prototype or pilot study in order to align the improved process to business requirements. This generates a modified but standardized definition which requires further process quantification. Supplemental quantification may need to be performed to create new, projected measures or to get better existing measures determined before.

After implementation, each improvement opportunity should be monitored over time and actual outcomes should be compared to those projected.

2.7.7.Continuous improvement

Once the improved process is implemented, going back to the second step (the process selection step) can be necessary to select a process for further study. A new process can be chosen in order to be improved by a specified process owner and a new BPM team formed.

The BPM method on the improved process should be repeated beginning with the process selection step, searching new opportunities for continuous improvement by the process owners.

Continuous improvement ensures eliminating waste, improving process and product quality in order to sustain more competitive advantages especially by reducing costs.

2.7.8.Benchmarking

A benchmark is a defined productivity measure compared to something else. Camp (1989) describes the benchmarking as a process that searches for new methods, practices, and processes, and either adopting them or their good features, and implementing them to obtain the best of the best. A company can benchmark internally by looking for maintaining or improving performance, or trying to find industry benchmarks, and compare itself to its competitors.

3. PERFORMANCE MANAGEMENT

In this Chapter, definition of the terms “performance”, “measures”, “measurement”, “management”, “evaluation of performance” are provided and process improvement methodology is given.

3.1. Definition of Business Performance

Business performance is the evaluation of all efforts devoted to achieving the business objectives (Akal, 2000; Karaman, 2008). Performance management can therefore be defined as looking over through the business performance and determining how the business can better achieve its goals. It is the combination of process, methodologies, metrics and technologies to measure, monitor and manage the performance of the business. This requires the cooperation of strategic and operational objectives and the business' set of activities in order to manage performance.
One of the main activity in performance management is performance assessment which can be described as reviewing the progress of a company in the direction of its pre-defined goals.

The assessment of the process performance (goodness) is to be achieved through a series of measurements on several indicators defined as to be the indicator of the goodness. The measurement in this respect is all about to identify deviations from the expected results of process performance.

Based on the definitions provided above, a basic comparison of those are illustrated in the **Figure 3.1**.

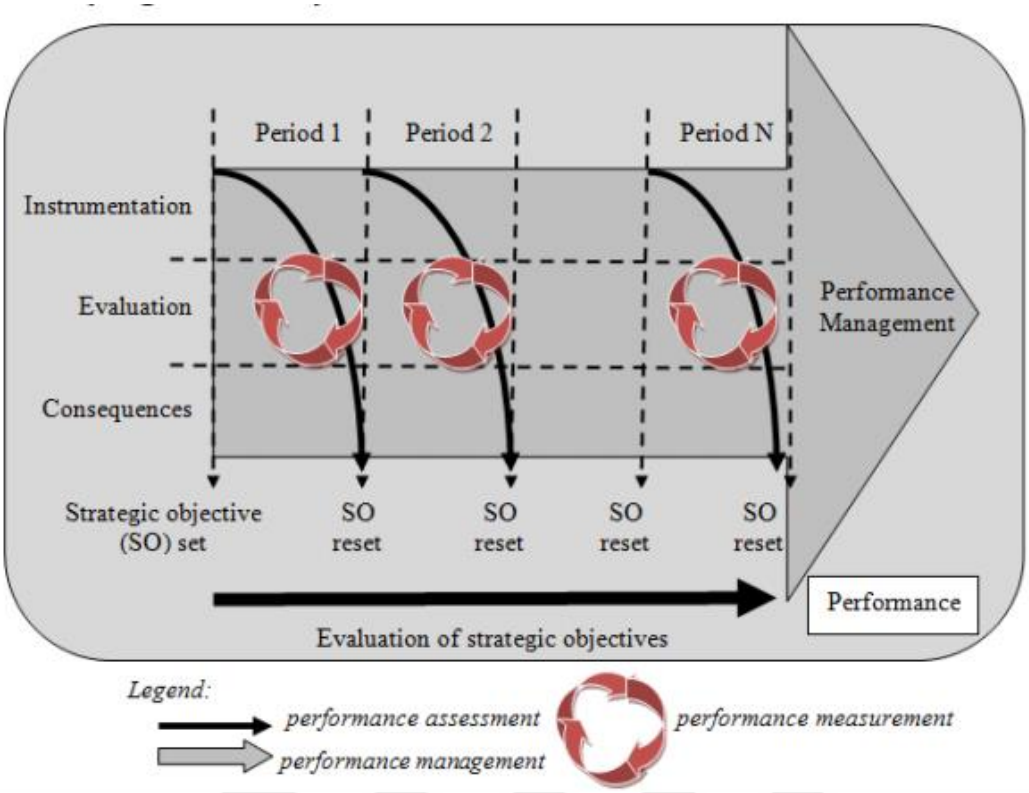


Figure 3.1 Interactions of performance management, performance assessment and performance measurement (Folan et al., 2007)

As shown in **Figure 3.1**; the terms "performance", "performance management", "performance measurement" and "performance assessment", their interactions and meanings are shown together and separately.

The large arrow stands for the structure of performance management. It is often holistically designed and hence exists often in an unconscious state in the organisation (or inter-organisation).

The curved decreasing arrow shows the periodic form of performance assessment. When the strategic objective is set and reset, it comes to an end and delivers its assessment report. It comes to the beginning point once a new objective is set. Thereby, it is periodic.

The performance measurement is located in the evaluative box of performance assessment. It also occurs periodically as part of performance assessment (Folan et al., 2007).

Folan et al. (2007) report the analysis of Bourguignon and Chiapello (2005) worked to develop a three-step model of performance assessment. This approach consists of the following:

- Instrumentation (the step used to define the preconditions of assessment),
- Evaluation (the step for the actual production of a value assessment),
- Consequences (where the value assessments reached result in various consequences).

3.2.Performance Measurement

One of the required conditions for success in process management is that the processes have to be evaluated with correct measures. But, when the process execution is begun as planned, new factors which are not foreseen may come into forward. Performance is the set of values used primarily to see if the processes are executed as planned or not, and then directs the areas to be improved. It is not possible to improve a process without measuring the respective outputs. A good performance measurement system should not only evaluate the process effectiveness, at the same time it should also check if the process is aligned with the company's vision and mission (Bennis and Biche, 1997). Likewise, the performance measurement is used for indicating the effects of improvement studies on the process outputs or comparing the situations before and after the improvements (Özay, 2003; Tütüncü et.al., 2004).

Performance assessment for business processes is an important aspect in the business process lifecycle. Because, it is required for measuring progress towards pre-determined goals of the organizations. Performance needs on business processes can be determined via Task Performance Indicators (TPIs) with target values that must be achieved in a certain period. A TPI is a measure that reflects the KPIs of a business process defined within an organization. Its target value represents the objectives followed by the organization with that business process. Today, many methodologies and frameworks like, for instance, COBIT (Control Objectives for Information and Related Technology), ITIL (Information Technology Infrastructure Library) or EFQM (European Foundation

for Quality Management) excellence model confirm the importance of defining TPIs to assess the performance of the existing business processes (Del-R´ıo-Ortega et al., 2010).

3.3.Performance Measures

As stated earlier, performance measures help comprehend, execute, and improve what the organizations could do. That is to say that the performance measures make it easy to understand (TRADE, 1995):

- how well the workers are doing,
- if the goals are achieved,
- if the customers are pleased,
- if the processes and tasks are in statistically under control,
- if improvements are necessary and
- where improvements are required.

Performance measures supply the necessary information in order to make healthier decisions about what the enterprise can and cannot do.

A performance measure is formed of a unit of measure and a number. The unit gives a meaning (what) and the number shows a size (how much). Performance measures should always be connected to a goal. Most performance measures can be classified into one of the following categories as shown in the **Figure 3.2** .

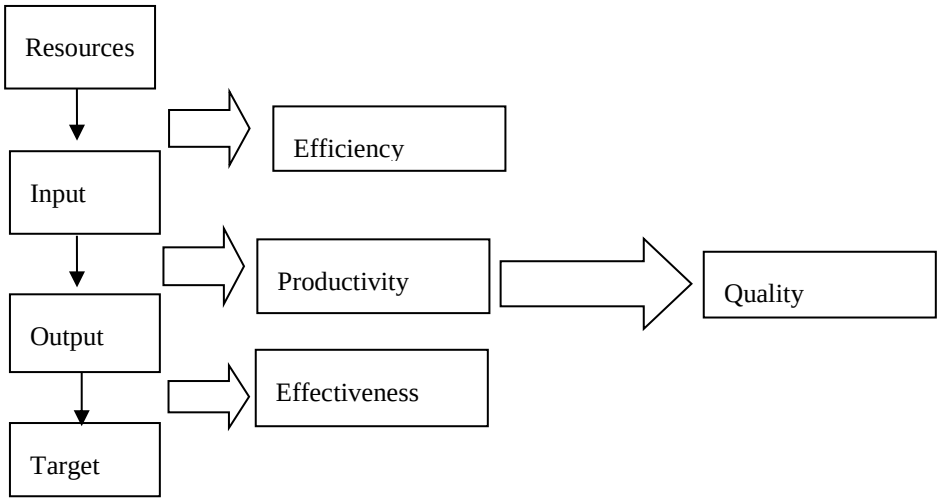


Figure 3.2 Performance indicators categories

1. Efficiency: A process characteristic that indicates the degree of which the process produces the output at minimum resource cost. In order to say that efficiency is the measure of how well the resources expended are utilized.

Efficiency= Standard use of inputs /Actual use of inputs (1.1)

Example: The required time for evaluating a report is 48 hours but the report was evaluated in 60 hours. Here, efficiency=48/60=80%.

2. Productivity: It is the ratio of output to input (the value of the labor and capital consumed).

Productivity=Output/Input (1.2)

Example: The document writing capacity of an employee in a month is 50 pages and that employee writes 40 pages. Productivity is 40/50=80%.

3. Effectiveness: A process characteristic that indicates the degree of which the process output (work product) conforms to requirements. In order to say that effectiveness is defined as the extent to which goals are accomplished.

Effectiveness=Output/Target (1.3)

Example: Average monthly goal of duration for completing the similar business processes in a company is planned 20 minutes. This duration was confirmed 25 minutes

and so effectiveness is 25/20=125%. It means that the actual result is 25% less effective result than planned.

4. Quality: It is the degree of which customer requirements and expectations are met by a product or service. Quality measures can be defined according to the context of the process definition.

3.4.Need for Measures

If an activity cannot be measured, it cannot be controlled. If it cannot be controlled, it cannot be managed. Healthy and intelligent decisions cannot be made without reliable measurements. Therefore, measurements can be used for (TRADE, 1995):

- **Controlling:** Measurements help to reduce deviations.
- **Self-Assessment:** Measurements can assess how well a process is executing, including improvements.
- **Continuous Improvement:** Measurements can be used to specify process improvement levels, defect causes and resolutions. They can also be used to determine process efficiency and effectiveness, as well as improvement opportunities.
- **Management Assessment:** Measurement can be used for;
    - determining and satisfying goals or standards;
    - determining variances from planned degrees of performance; and
    - improving performance to the planned degrees or achieving new degrees of performance.

3.5.Performance Measurement Steps

Performance measurement steps are listed and explained below (TRADE, 1995):

Step 1: Identify the Process

Deciding of what to measure has critical importance in identifying the process. A process should be controllable in size. If a process is not well-defined, a lot of effort can be wasted.

Before controlling a process, it must be well understood. A flow diagram is often used as a tool in order to understand a process.

Output: A list of processes, key processes, and their flow diagrams.

Step 2: Identify Critical Activity(ies) to be Measured

Analyzing each activity or task in the process and identifying those are important. Critical activities are those which significantly effect total process efficiency, effectiveness or productivity. At the managerial level, those activities impact management priorities, internal and external customer goals.

Output: A list of the critical activities for the key process.

Step 3: Determine Performance Goal(s) or Standard(s)

A performance goal or standard should be determined for each critical activity selected for measurement. The overall process output or the critical activities can have performance goals. If the goals or standards are established for the first time and no baseline for setting goals or standards exists, a baseline period is required for observation.

Well-defined performance goals or standards are:

- **Economic:** Should have low cost of establishing and managing relative to the activity covered.
- **Attainable:** Should be satisfied with feasible effort under the conditions that are expected to override.
- **Applicable:** Should fit the conditions applying and have flexibility versus varying conditions.

- **Consistent**: Should help to associate communication and operations throughout all functions of the company.
- **All-inclusive:** Should cover all interrelated activities.
- **Understandable:** Should be stated in simple, clear terms and be avoided misinterpretation or uncertainness.
- **Measurable:** Should have a concrete criteria for measuring progress.
- **Adaptable:** Should have a style that components can be added, changed, and updated without rebuilding the whole framework.
- **Legitimate:** Should be formal approved.
- **Equitable:** Should be characterized by equity or fairness by the people who work for satisfying the goal or standard.
- **Customer Focus:** Should involve the issues essential for the customer such as cycle time, quality, and customer satisfaction and so on.

Output: A list of performance goals for each critical activity

Step 4: Establish Performance Measures (indicators)

To develop a measure (indicator), the following activities are performed:

- deciding what to know and translating it into a performance measure
- identifying the raw data that will form the performance measure
- determining the related parameters where to locate the raw data
- identifying measurement tool that will collect the data for the performance measures
- defining the method to calculate the value of the defined measure.
- determining how often to make the measurements.

Output: The performance measures (indicators) and its components

Step 5: Identify Responsible Party(ies)

To continue the performance measurement process, the related responsibility should be assigned to employee(s) and decision maker(s). This is to decide appropriately who should do:

- Gather the data
- Analyze and compare actual performance with defined goal or standard target value
- Decide if corrective action is necessary or not
- Make changes

Output: A list of responsible people and their responsibilities.

Step 6: Gather the Data

Data is a set of facts or numbers presented in quantitative form.

There are two main types of data:

- **Continuous data (measured):** This type of data may take on any value within some range. These data necessitate collecting numeric values that quantify a measurement and for this reason require small samples. A representative sample is recorded if the data set is potentially large.

For example:

  - A person's height
  - Cost of stock
  - Temperature
  - Time to complete a project

- **Discrete data (counted):** Discrete data may take on only certain values. These kinds of data are not measured and not needed to be numeric. These data generally require large sample sizes to be useful. Counting methods include defective/nondefective; yes/no; accept/reject.

For example:

- The number of people in an organization
- Did the meeting finish on time?
- Was the phone answered by the third ring?
- Was the report delivered on schedule?

The conformance is determined according to meaningful and valid data.

Output: A list of data.

Step 7: Analyze/Report Actual Performance

Performance measurements are usually formulated depending upon one or more raw data inputs. Therefore, there is a need to convert the raw data into a performance measurement.

The following step in analyzing data is to decide how to present or display the data. The data is usually grouped in a form that make it easier to make inferences.

After summarizing the data, the report which consists of sets of tables or charts that follow the performance measures, supplemented with basic conclusions then can be prepared.

Output: A performance report.

Step 8: Compare Actual Performance with Goal/Standard

The responsible employees compare actual performance with the goal or standard. A report is presented to the responsible decision maker if the variance assures an action.

After the comparison against the goal or standard initially established, there are several alternatives for possible actions. They may include:

- If variance is not important then it can be forgotten.
- It can be fixed (go to Step 9 and 10).

- The goal or standard can be challenged (go to Step 11).

Output: Performance variance decision.

Step 9: Decide if Corrective Action(s) is Necessary

The process or the goal can be changed. Making some corrections will need to satisfy the desired performance level of determined goals or standards if the variance is large.

If the variance is small, then the process is most likely in good shape. But, still it should be considered to be reevaluated against the goals. Additionally, if any changes are made to the process, the goals will need to be reevaluated in order to make sure they are still applicable.

The correction is made in order:

1. To remove defects (worker-controllable).

2. To eliminate the cause of defects. (worker or management controllable).

3. To avoid defects from happening.

4. To maintain or improve the efficiency and effectiveness of the process.

Output: Action plan to implement changes or reevaluate goals (go to step 11).

Step 10: Make Changes to Satisfy Goal or Standard

Changes constitute a number of correction actions listed in Step 9 to achieve determined goal or standard. The significant result of these corrective actions should be removal of all identified causes of defects resulting in an improved or a new process definition (set up).

Output: A successfully implemented improvement plan.

Step 11: Determine New Goals or Measures Needs

The decision of establishing new performance measures or goals depends on three major factors as listed below:

1. The satisfying level of former objectives.

2. Any change to the scope of the business processes.

3.The ability of current measures to communicate improvement status relative to critical business processes.

Goals should be realistically achievable. If previously set objectives were reached to the target value with great difficulty, or not reached at all, then it may be reasonable to re-arrange expectations. This can also be applied to the objectives that were too easily met. Extensive target value changes to the business processes will also require establishing new performance measures and goals.

Output: New goals, measures, or no change.

3.6.Measuring the Weights

During the calculation of business and process performance, the hierarchy between the metrics should be taken into account. The hierarchy of metrics which will be used by calculation of the business performance is shown in the **Figure 3.3** below.

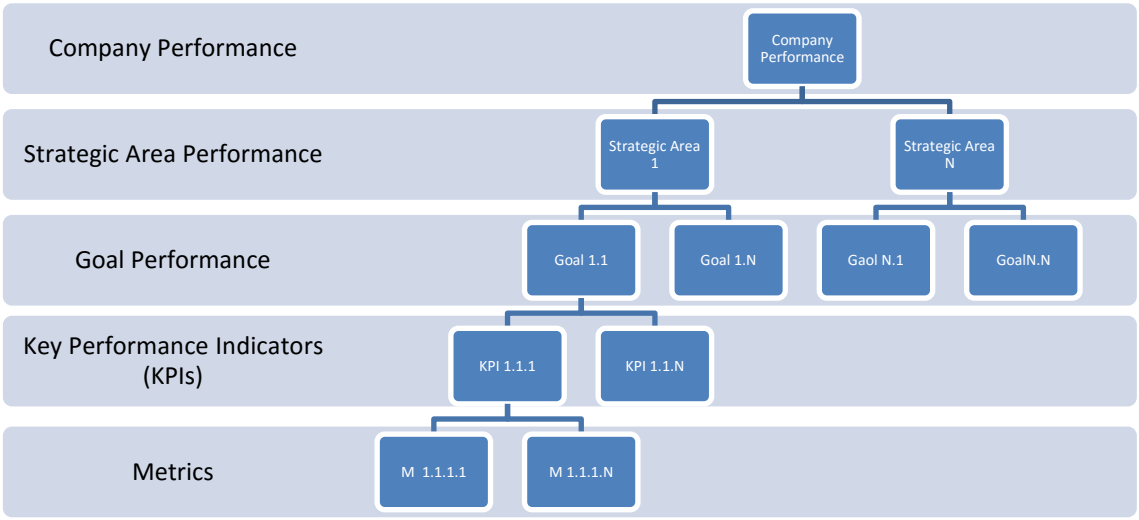


Figure 3.3 Hierarchy of performance metrics

Similarly, the hierarchy of quality metrics that will be used by calculation of process performance is shown in the **Figure 3.4** below.

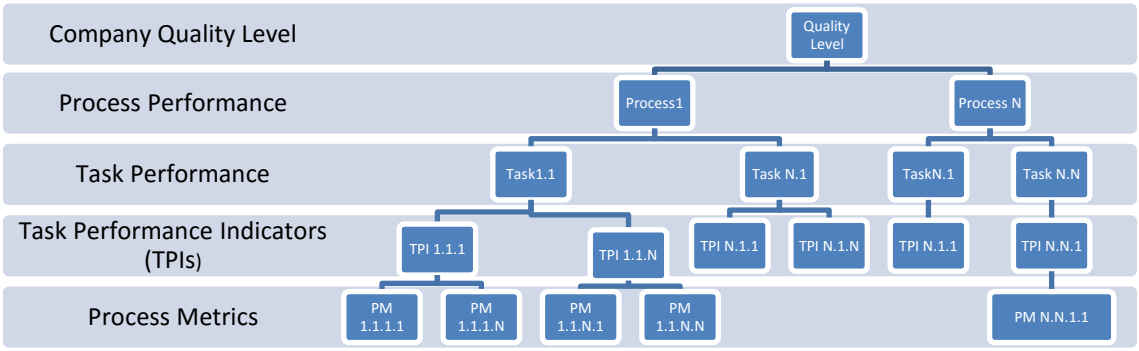


Figure 3.4 Hierarchy of quality metrics

Different measures have different effects in the process performance. Their contribution to quality and performance need to be weighted. In this study, The Analytic Hierarchy Process (AHP) was employed in determining the weights of strategic areas, goals, KPIs, processes, tasks, TPIs and prioritizing them because of the linear hierarchy.

3.6.1.Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) is a multi criteria decision making method widely used in decision making that was designed by Thomas L. Saaty in 1971.

The AHP method helps to represent both subjective and objective aspects of a decision by reducing complex decisions to a series of pairwise comparisons, and then synthesizing the results. Additionally, the AHP is a useful technique for checking the consistency of the decision maker's assessments, so reducing the prejudgement in the decision making process (Saaty, 1980).

The AHP method is based on decision-makers' knowledge and expressed ideas in order to build a structure of hierarchically-organized objectives, criteria and decision alternatives. AHP builds a ranking of the alternatives according to the objective and indicates the extent to which each alternative is better (or worse) than each of the others based on decision-makers' explicitly stated priorities across criteria (Bentes et al., 2011). The structure of the method is shown in the **Figure 3.5**.

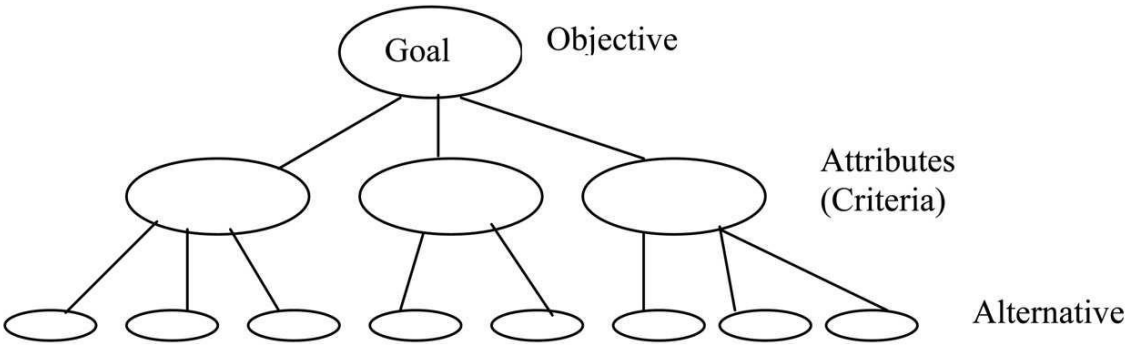


Figure 3.5 Hierarchy structure of decision problem

The AHP method composed of six main steps (Lee et al., 2008).

1. Defining the unstructured problem

2. Developing the AHP hierarchy

3. Making pair-wise comparison

4. Estimating the relative weights

5. Checking the consistency

6. Obtaining the overall rating

Step 1: Defining the unstructured problem

In this step the unstructured problem and their characters should be recognized and the objectives and outcomes should be indicated clearly.

Step 2: Developing the AHP hierarchy

The second step of the AHP procedure is to decompose the decision problem into a hierarchy that consists of the most important components of the decision problem (Boroushaki and Malczewski, 2008). In this step, the complex problem is separated into a hierarchical framework with decision components.

Step 3: Making pair-wise comparison

Using pairwise comparisons, the relative importance of one criterion over another can be expressed. For each element of the hierarchy structure, all the associated elements in low hierarchy are compared in pair-wise comparison matrices as follows:

	to	A1	A2	A3
Alternative 1 (A1)		a_{11}	a_{12}	a_{13}
Alternative 2 (A2)		a_{21}	a_{22}	a_{32}
Alternative 3 (A3)		a_{31}	a_{32}	a_{33}

Pairwise Comparison Matrix A = (a_{ij})

Where a_{ij} indicates the element of row i column j of the Pairwise Comparison Matrix.

In order to determine the relative preferences for two elements of the hierarchy in matrix. The scale used for comparison with values from 1 to 9 to rate as shown in the **Table 3.1**.

Table 3.1 Relative scores

Scale	Numerical rating	Reciprocal
Extremely importance	9	1/9
Very to extremely strongly importance	8	1/8
Very strongly importance	7	1/7
Strongly to very strongly importance	6	1/6
Strongly importance	5	1/5
Moderately to strongly importance	4	1/4
Moderately importance	3	1/3
Equally to moderately importance	2	1/2
Equally importance	1	1

AHP: Analytic hierarchy process

For all i and j it is necessary that:

- $a_{ii}=1$ A comparison of criterion I with itself: equally important.
- $a_{ij}=1/a_{ji}$ a_{ji} are reverse comparisons and must be the reciprocals of a_{ij}.

Step 4: Estimating the relative weights (priority vectors)

This step consists of the computation of a vector of priorities from the constructed pairwise comparison matrix. According to the AHP methodology, the eigenvector of the

pairwise comparison matrix with the largest eigenvalue provides the priority ordering, and the eigenvalue is a measure of consistency of the judgement (Saaty, 1980).

Each column of the pairwise comparison matrix is summed. Then each component of the matrix is divided by the sum of its column, relative weight has been normalized. The sum of each column is 1. The normalized principal Eigen vector (is also called priority vector) can be obtained by averaging across the rows. The priority vector shows relative weights among the things that are compared.

Step 5: Checking the consistency

In this step the consistency property of matrices is checked to ensure that the judgments of decision makers are consistent. Hence, some pre-parameter is needed.

Pairwise comparisons *nxn* matrix (for *n>2)* is consistent if

$$a_{ik} = a_{ij}a_{jk} \qquad i, j, k = 1,..., n$$

The matrix of comparisons on the right is multiplied by the estimated eigenvector obtaining a new vector. If the first component of this vector is divided by the first component of the estimated eigenvector, the second component of the estimated eigenvector, and so on, another vector is obtained. If the sum of the components of this vector is taken, and divided by the number of components, an approximation to the value of λ_{max} is to be used in estimating the consistency. The closer λ_{max} is to n (the number of criteria in the matrix) the more consistent is the result.

Consistency Index (*CI*) is calculated as:

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

where λ_{max} = the biggest eigenvalue of matrix A.

The consistency index of a randomly generated reciprocal matrix - the random index (*RI*), with reciprocals forced. An average *RI* for the matrices of order from 1 to 15 was generated by using a sample size of 100 (Nobre et al., 1999). The table of RI of the matrices of order from 1 to 10 is shown in the **Table 3.2**.

Table 3.2 Random Consistency Index (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The last ratio that has to be calculated is *CR* (Consistency Ratio). Generally, if *CR* is less than 10%, the judgments are consistent, so the derived weights can be used. The formulation of *CR* is:

$$CR = \frac{CI}{RI}$$

Step 6: Obtain the overall rating

In last step, the relative weights of decision elements are aggregated to obtain an overall rating for the alternatives. Once the criteria weight vector and the alternative relative weight matrix have been computed, the AHP obtains a vector of global scores by multiplying these two vectors. As the final step, the option ranking is accomplished by ordering the global scores in decreasing order.

3.7.Performance Assessment Techniques

Performance assessment techniques are techniques that indicate to what extent enterprises have satisfied their goals. Some of the those are listed in **Table 3.3** :

Table 3.3 Review of methods, models and systems for performance measurement (Milanović Glavan, Lj. ,2011)

Period of introduction	*Name of the model/framework*	*References*
Before 1980s	The ROI, ROE and derivatives	Simons (2003)
1980	The Economic Value Added Model, EVA	Stewart (2007)
1988	The Activity Based Costing, ABC	Cooper and Kaplan (1998)
1989	The Supportive Performance Measures, SPA	Keegan (1989)
1990	The Customer Value Analysis, CVA	Customer Value Inc. (2007)
1990	The Performance Measurement Questionnaire, PMQ	Dixon (1990)
1991	The Results and Determinate Frameworks, RDF	Fitzgerald (1991)
1992	The Balance Scorecard, BSC	Kaplan and Norton (1992)
1994	The Service Profit Chain, SPC	Heskett (1994)
1995	The Return on Quality Approach, ROQ	Rush (1995)
1996	The Cambridge Performance Measurement Framework, CPMF	Neely (1996)
1996	The Consistent Performance Measurement System, CPMS	Flapper (1996)
1997	The Integrated Performance Measurement System, IPMS	Bittici (1997)
1998	The Comparative Business Scorecard, CBS	Kanji (1998)
1998	The Integrated Performance Measurement Framework, IPMF	Medori (2000)
1999	The Business Excellence Model, BEM	EFQM (2007)
2000	The Dynamic Performance Measurement System, DPMS	Bittici (2000)
2001	The Action Profit Linkage Model, APL	Eppstein (2001)
2001	The Manufacturing System Design Decomposition, MSDD	Cochran (2001)
2001	The Performance Prism, PP	Neely (2001)
2004	The Performance Planning Value Chain, PPVC	Neely (2004)
2004	The Capability Economic Value of Intangible and Tangible Assets, CEVITA	Ratnatunga (2004)
2006	The performance, Development, Growth Benchmarking System, PDGBS	St-Pierre (2006)
2007	The Unused Capacity Decomposition Framework, UCDF	Balachandran (2007)

Balanced Scorecard method has also become a preferred performance management model since it does not involve only the financial dimension but four dimensions of the company performance as explained below.

3.7.1.Balanced Scorecard

Today, one of the techniques used in performance evaluation is “Balanced Scorecard (BSC)”. Since the advocacy of Kaplan and Norton (1996), the Balance Scorecard has become not only the main stream of performance evaluation but also an effective tool in assisting the implementation of organization strategies. In the past, the emphasis of

short-term financial performance in most companies has caused the ignorance of the long-term strategy implementation, and the missed linkage between such short-term actions and the long-term strategy often leads to the failure of the firm's strategic objectives. To remedy this deficiency, the BSC complements the financial measures with non-financial measures, expecting that these non-financial measures will drive future financial success. Thus, to direct the management and employees' efforts to the organization's strategic objectives, the BSC translates an organization's strategic objectives into a comprehensive set of performance measures. The BSC presents managers four different perspectives from which to choose performance measures: The financial perspective, the customer perspective, the internal business process perspective, and the learning and growth perspective (Cheng, 2008).

The companies that use the financial and non-financial indicators together, can provide the opportunity to perform performance evaluation and process management activities more effectively (Axelsson and Sonesson, 2004).

3.7.1.1.The Dimensions of BSC

The dimensions of BSC are presented in the **Figure 3.6**.

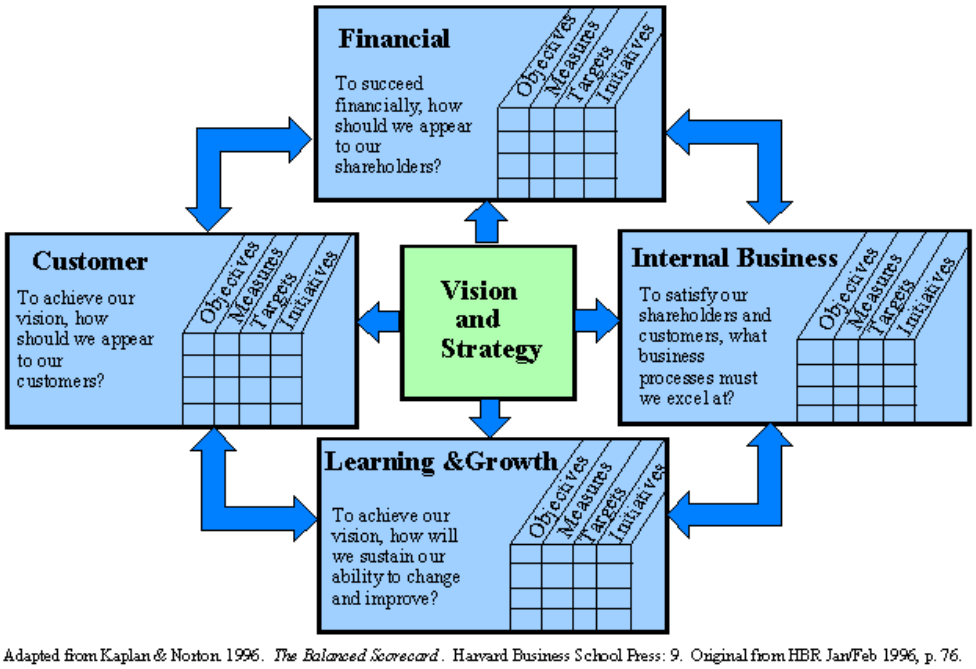


Figure 3.6 Framework of BSC(Kaplan and Norton, 1996)

- **Financial Dimension**

Timely and accurate funding data will always be a priority, and managers will do whatever necessary to provide it. Maybe, in this category, additional financial-related data, such as cost benefit and risk assessment data is needed to include (Gu et al., 2009).

- **Customer Dimension**

Customers should be analyzed from the point of kinds of customers and the processes that are providing a product or service to those customer groups in developing metrics for satisfaction (Gu et al., 2009).

- **Internal Business Process Dimension**

Metrics based on this dimension allow the managers to know how well their business is running, and whether its products and services conform to customer requirements (the mission) (Gu et al., 2009).

- **Learning and Growth Dimension**

This perspective includes employee training and enterprise cultural behaviours related to both individual and enterprise self-improvement. Metrics can be put into place to guide managers in focusing training funds where they can help the most (Gu et al., 2009).

There are cause and effect relationships between the dimensions of BSC. For example: Training the employee in order to improve her/his skills provides that the employee satisfaction goal of learning and growth dimension is reached. The satisfied employee provides that the internal business process goals are reached by producing qualified products and making speedy delivery. Speedy delivery and production of qualified product make the customer dimension goals reached by providing customer satisfaction. The customer satisfaction provides that the financial dimension goals are reached by increasing the sales and profitability (Tekeli, 2003).

4. ADAPTIVITY

Adaptivity is the ability of an organization to align itself and its processes to the changes as well as to strategic goals. When the strategical goals of an enterprise changes, the processes are redesigned (if needed), and the organizational performance values can be recalculated accordingly. A performance assessment system designed with agents can provide the necessary adaptivity against the organizational changes. Therefore firstly the agents and then the adaptability concept are introduced in this Chapter.

4.1.Agents

‘‘An agent is a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives” (Wooldridge & Jennings, 1995). An agent structure is shown in the **Figure 4.1**.

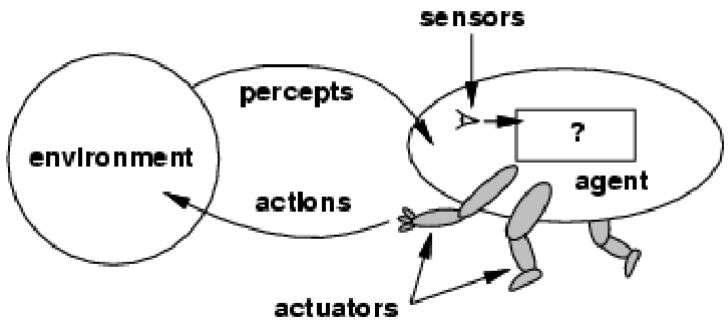


Figure 4.1 Agent structure (Russell and Norvig, 1995)

An agent exhibits the following properties:

- Agents involve some level of intelligence, from fixed rules to learning engines that allow them to adapt to changes in the environment.
- Agents are autonomous, that is, they act on behalf of the user.
- Agents sometimes act proactively not only reactively. They should not simply act in response to their environment, they should be able to display opportunistic, goal-directed behaviour and take the initiative where it is appropriate.

- Agents may also cooperate with other agents to achieve more complex tasks than they themselves can handle.
- Agents have social ability, that is, they communicate with the user, the system, and other agents as necessary.
- Agents may migrate from one system to another to access remote resources or even to meet other agents.

In addition to these necessary conditions, a number of other potentially desirable features have been suggested like "*adaptability"(*the ability of an agent is to modify its behaviour over time in response to changing environmental conditions or an increase in knowledge about its problem solving role).

4.1.1.Structure of intelligent agents

The agents consist of an architecture and a program.

Agent program is the implementation of f: P* $\rightarrow$ A, the agent's perception-action mapping.

Architecture is a device that can execute the agent program (e.g., general-purpose computer, specialized device, beobot, etc.).

4.1.2.Agent types

Agents are classified accroding to their degree of perceived intelligence and capability (Russell and Norvig, 2003):

- Simple reflex agents
- Model-based agents
- Goal-based agents
- Utility-based agents
- Learning agents

Note that only goal-based agents are used in this study. But berief definitions of these are provided below for the sake of completeness and for the information of the readers.

4.1.2.1.Simple reflex agents

A simple reflex agent works by finding a rule whose condition matches the current situation (as defined by the percept) and then doing the action associated with that rule. The architecture of a simple reflex agent is shown in the **Figure 4.2** below.

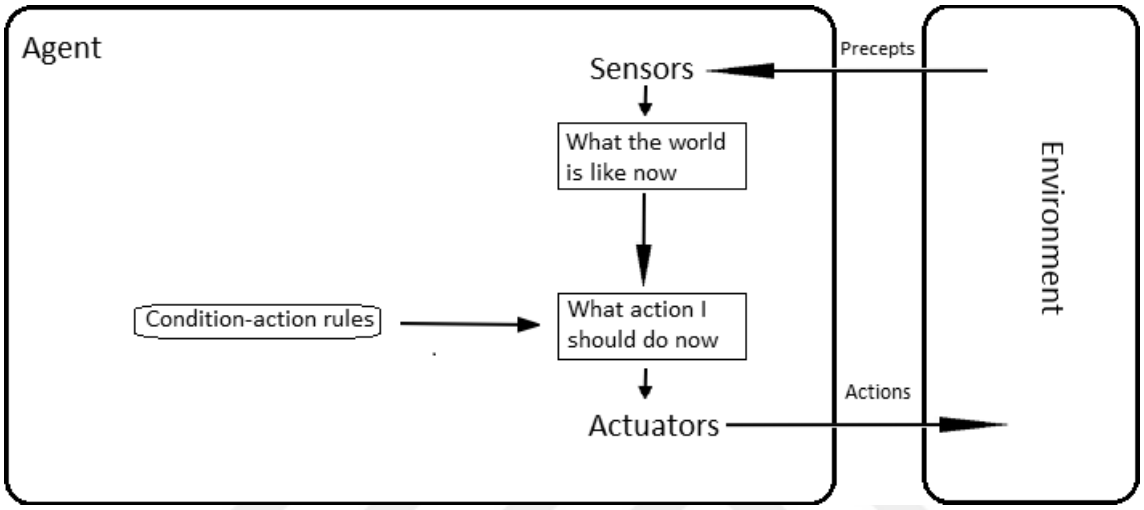


Figure 4.2 Simple reflex agents (Russell and Norvig, 2003)

4.1.2.2.Model- based agents

A model-based agent can manage a partially observable environment. Its current state is stored inside the agent maintaining some kind of structure which describes the part of the world which cannot be seen. This knowledge about how the world works is called a model of the world, so its name is “model-based agent.”

The architecture of a model-based agent is shown in the **Figure 4.3**.

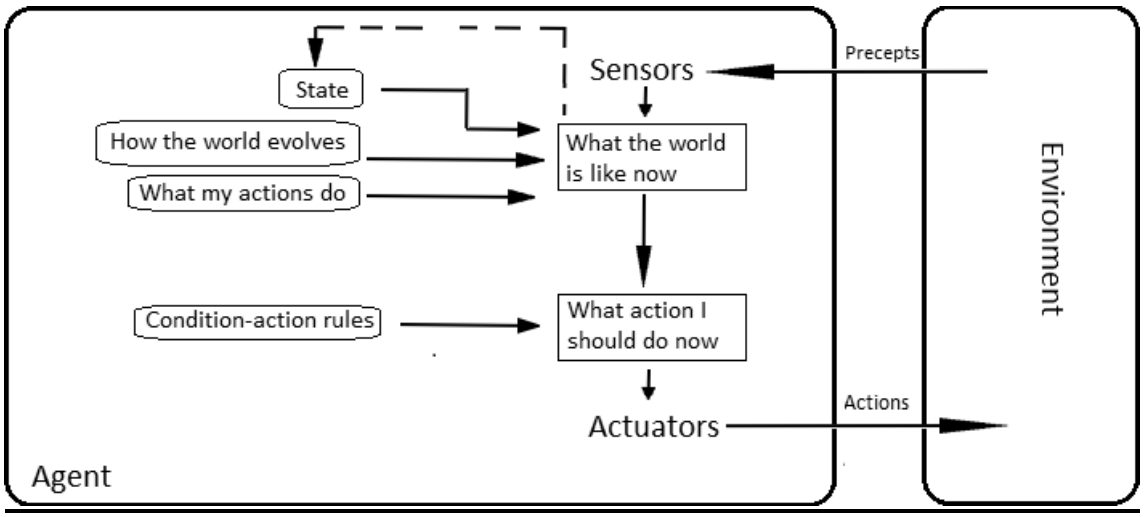


Figure 4.3 Model-based agents (Russell and Norvig, 2003)

4.1.2.3.Goal-based agents

Goal-based agents further enlarge the capabilities of the model-based agents, by using "goal" information. Goal information describes desirable situations. It allows the agent a way to select among multiple possibilities, choosing the one which reaches a goal state. Searching and planning are the subfields or artificial intelligence devoted to find action sequences that satisfy the agent's goals.

The architecture of a goal-based agent is shown in the **Figure 4.4**.

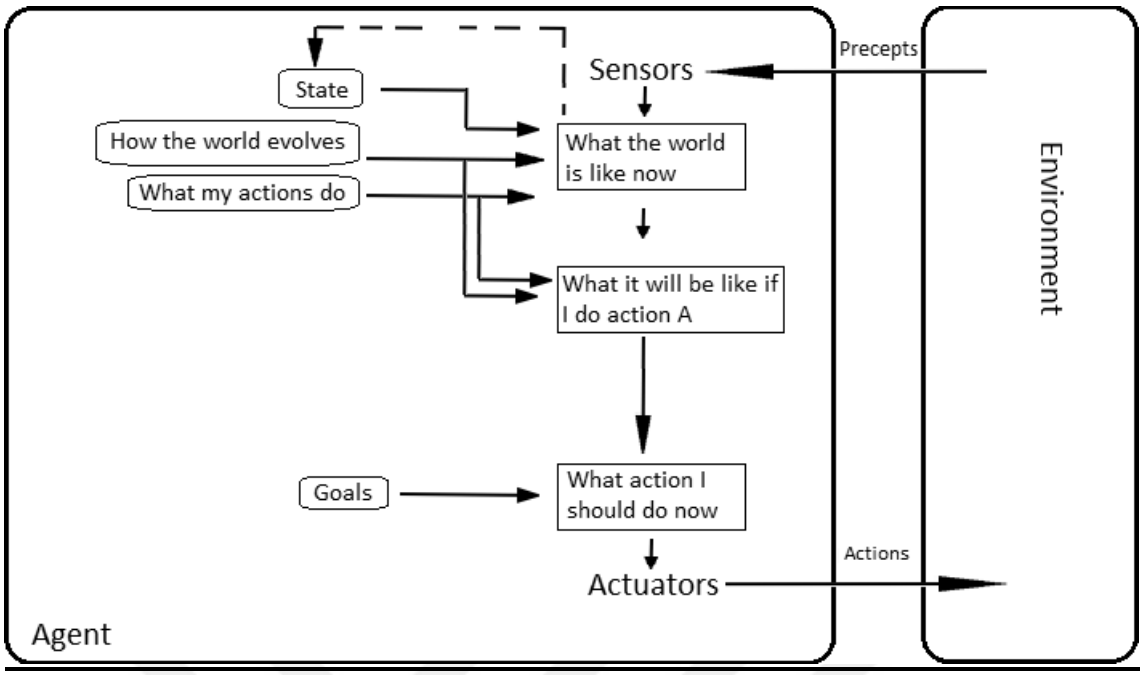


Figure 4.4 Goal-based agents (Russell and Norvig, 2003)

4.1.2.4.Utility-based agents

One more feature is added to goal-based agent, to make it even more adaptive. Goal-based agents only separate goal states and non-goal states. It is possible to determine a measure of how desirable a specific state is. A utility function which maps a state to a measure of the utility of the state is used to obtain this measure.

The action that maximizes the expected utility of the action outcomes (what the agent expects to derive, on average, given the probabilities and utilities of each outcome) is chosen by a rational utility-based agent. A utility-based agent has to model and keep track of its environment, tasks that have involved a great deal of research on perception, representation, reasoning, and learning.

It allows decisions comparing choice between conflicting goals, and choice between likelihood of success and importance of goal (if achievement is uncertain) (Sandholm T. , 2015).

The architecture of a utility-based agent is shown in the **Figure 4.5**.

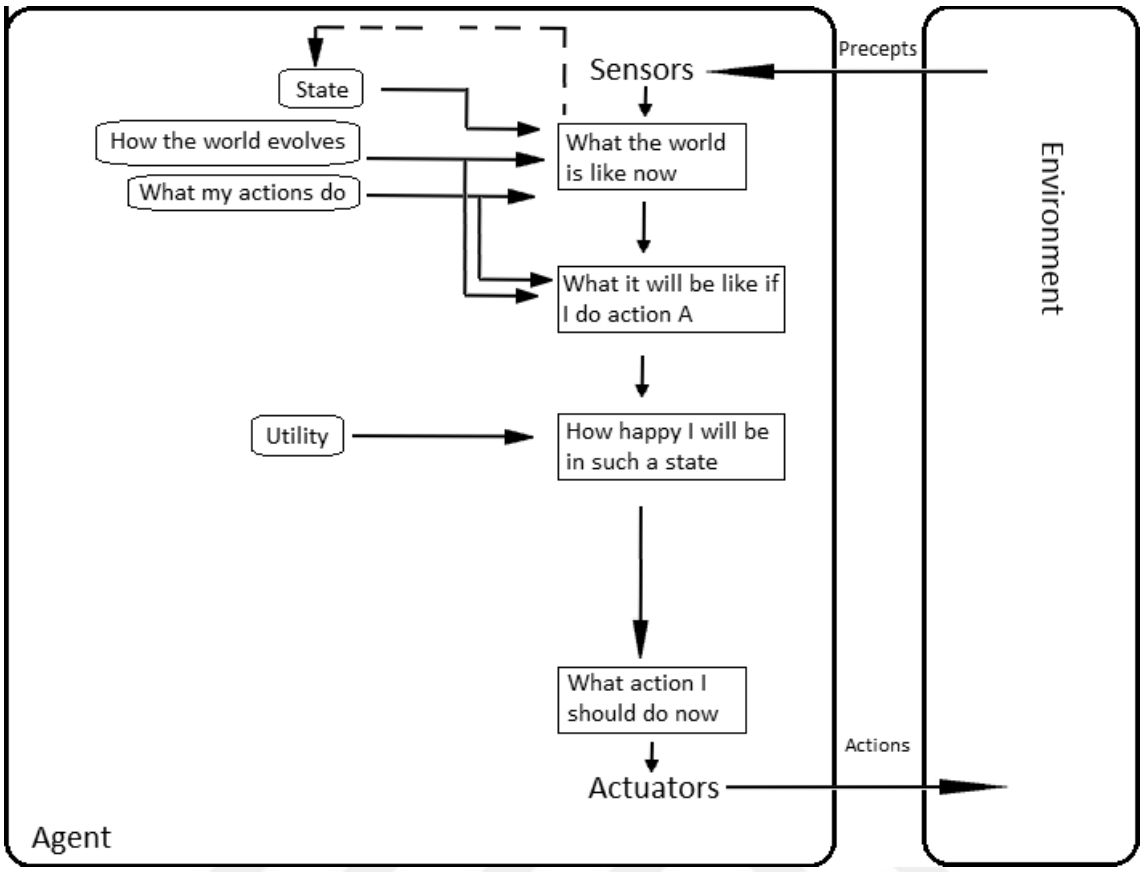


Figure 4.5 Utility-based agents (Russell and Norvig, 2003)

4.1.2.5.Learning agents

Learning feature allows the agents to be initially engaged in unknown environments and to become more competent than its initial knowledge alone might allow.

The learning element is responsible for making improvements, and the performance element is responsible for selecting external actions.

The learning element uses feedback from the "critic" on how the agent is doing and determines how the performance element should be modified to do better in the future. The performance element is what have been considered beforehand to be the entire agent. It takes in percepts and decides on actions.

The problem generator is the last component of the learning agent. It is responsible for suggesting actions that will lead to new and informative experiences.

The architecture of a learning agent is shown in the **Figure 4.6**.

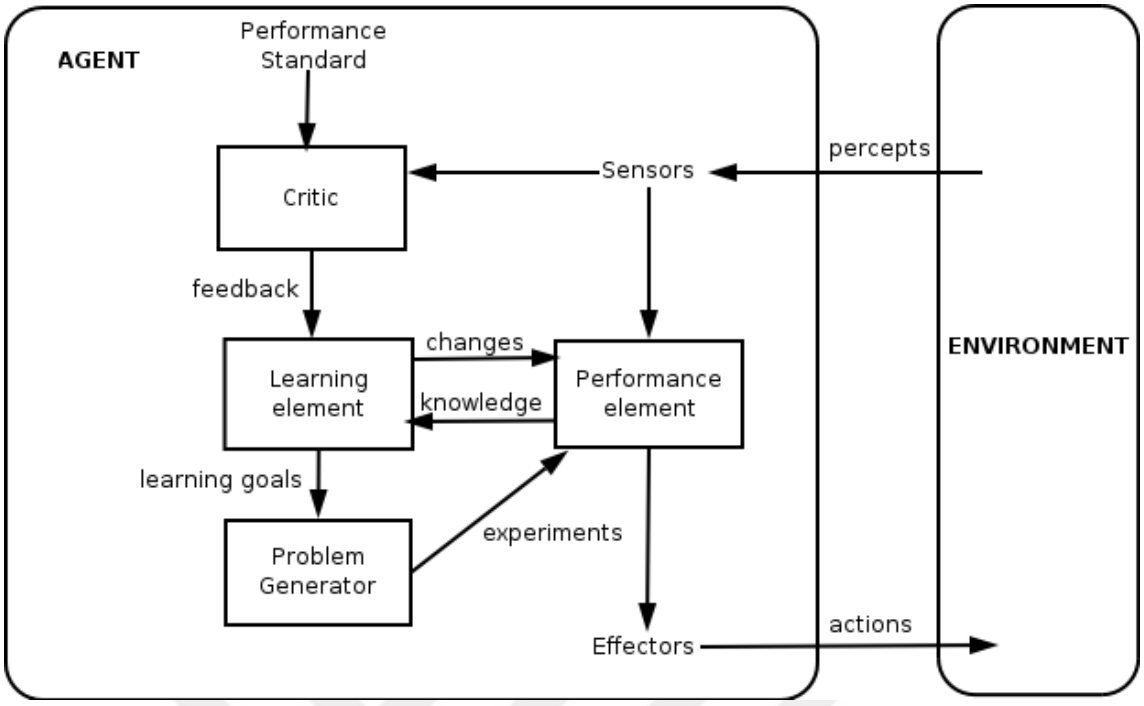


Figure 4.6 Learning agents (Russell and Norvig, 2003)

4.2.Adaptability

Adaptability is the ability of a system to adapt itself efficiently to new needs. The choices of an agent can be guided by feedback received from previous executives of particular paths through the business process. So agent-based approach offers greater adaptability.

Nowadays, most business managers notice that a gap exists between having the right knowledge and making the right decision. Because this gap influences management's ability to answer base business questions (such as "What should be done to increase profits or reduce costs? Or increase market share?"), the future of business intelligence lies in systems that can provide answers and recommendations, rather than mounds of knowledge in the form of reports. The systems that can make decisions generate the future of business intelligence. Consequently, there is a new trend emerging in the marketplace called "Adaptive Business Intelligence".

Adaptive Business Intelligence also includes the decision making process, which is based on prediction and optimization in addition to performing the role of traditional business intelligence (transforming data into knowledge), (see **Figure 4.7**) :

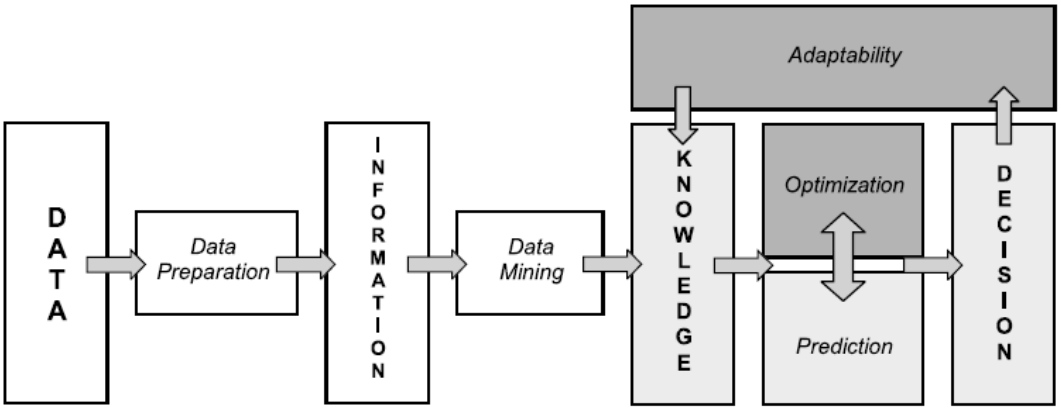


Figure 4.7 Decision making process (Michalewicz Z. et al., 2007)

Business Intelligence is often described as "an extensive category of application programs and technologies for collecting, storing, analyzing, and providing access to data". The term of Adaptive Business Intelligence can be defined as "the discipline of using prediction and optimization techniques to build self-learning "decisioning systems" (as shown in **Figure 4.7**). An Adaptive Business Intelligence System contains prediction and optimization modules to recommend near-optimal decisions, and an "adaptability module" for improving future recommendations (Michalewicz Z. et al., 2007).

The adaptability process can be displayed as shown in **Figure 4.8**:

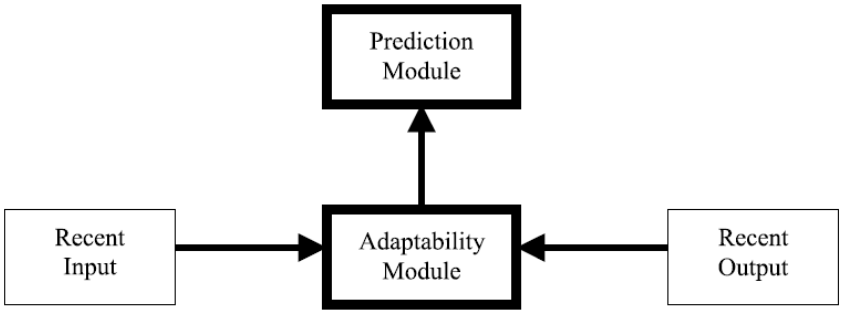


Figure 4.8 Adaptibility module (Michalewicz Z. et al., 2007).

To detect errors between the predicted result and the actual result, an adaptability module compares the results. If an error exists, the adaptability module will "tune" the prediction module to decrease the prediction error. The adaptability module can "adapt" to environmental changes by updating the prediction module rules, with the update frequency depending on how fast the environment changes.

4.3.Adaptive agent

Adaptive agent is an agent that can react to its environment. That is to say that an agent must be able to respond to a simple actuator to make a direct, predetermined response to unexpected variations of its environment.

Four primary ways of adapting (see Odell, 2011 for more information):

- reaction
- reasoning
- learning
- evolution

4.3.1.Adapting by reaction

It is a direct, predetermined response to a particular event or environmental signal. Typically, the behaviour of a reactive agent is expressed in the form "WHEN event, IF condition(s), THEN action"

An example:

- Robotic sensors that can detect the existence of a nearby wall and activate a device for keeping away from it.

4.3.2.Adapting by reasoning

It is a reactive response that uses inference rules. It is more advanced form of reactive adaptation using a set of rules to infer. The expert system rules can be encapsulated within agents. Furthermore, the agent can be designed to be proactive in its use of

reasoning. It is typically chains of rules in the form—"WHEN event, IF condition(s), THEN action"

A typical kind of technique:

- Patient diagnosis (It uses cases to suggest explanations for symptoms and warn of explanations that have been found to be in appropriate in the past.)

4.3.3.Adapting by learning

Learning agents can change their behaviour based on their experiences. They need the capacity to modify their actions as a way to improve their performance.

A typical kind of technique:

- Credit assignment (The learner links to the feedback with earlier actions, and the interdependencies of actions require the learner to either remember past choices of actions or rely on external cues in the environment to choose the right actions.)

4.3.4.Adapting by evolution

Evolution is a kind of change that occurs over successive generations of the agents. A primary technique usually involves genetic algorithm. Agents can be bred to fit specific purposes.

A typical kind of strategy:

- Natural selection (From one generation to the next, the fight for resources will favor individuals with some variations over others and hence, change the frequency of traits within the population. The characteristics that provide an advantage to those individuals who leave more offspring are called adaptations.)

4.4.Rationale for Adopting Agent Technology

The agents can often provide an effective solution when the domain involves a number of distinct problem solving entities (or data sources) which are physically or logically distributed (in terms of their data, control, expertise or resources) and which need to

interact with one another (or be combined) in order to solve their problems (or one common problem) (Bond and Gasser, 1988). To provide the appropriate software support for this system it was decided to adopt an agent-based approach. In companies, the strategical management and quality assurance departments are usually separate units. But their decisions and actions need to be coordinated to meet the organizational goals.

4.5.Agent Technology in Business Process Management

Jennings and his friends (1996) decided to conceptualize, design, and implement the business process management system using an agent based approach. In ADEPT (Advanced Decision Environment for Process Tasks) Project, the business process is examined as a collection of autonomous problem solving entities that negotiate with one another and come to mutually acceptable agreements that coordinate their interdependent sub-activities. Each agent represents a significant role or department in the enterprise and is capable of providing one or more services. The main advantages of this approach over more traditional counterparts such as workflow management, management information systems and enterprise integration are that it offers greater flexibility, agility, and adaptability. ADEPT was a collaborative project under the The Engineering and Physical Sciences Research Council (EPSRC) Intelligent Systems Integration Programme (ISIP) (Jennings et al., 1996).

ADEPT2 Project is one of the few available research prototypes for adaptive, high-performance process management. The developed system enables the realization of adaptive, process-aware information systems based on a conceptual framework for dynamic process changes, on novel process support functions, and on advanced implementation concepts. Primarily, process changes can take place at the type as well as the instance level: Changes of single process instances may have to be carried out in an ad-hoc manner (for instance, to deal with an exceptional situation) and must not affect system robustness and consistency. Process type changes, in turn, must be quickly accomplished in order to adapt the process-aware information systems to business process changes. This may require the outgrowth migration of thousands of instances to the new process schema (if desired). Important requirements are to perform respective

migrations on-the-fly, to protect correctness, and to prevent performance penalties. In order to gain usability experience they have deployed this system to different research groups like e-health and e-business (Reichert et al., 2005).

An agent based process management tool that is called “Mercury” is presented in Kim and Choi’s paper. They define the work procedure and process by rules in order to enable accurate execution of the process. Besides that, collection of accurate data concerning the competency of individuals, the subjects of the process execution, allows prevention of weakness of the process execution result and is the basis for identifying the areas of improvement. For this reason, high visibility can be obtained through the work knowledge and processes presented in rules, and it can help certainly establish the process centered work culture (or system) in the organization by process improvement strictly based on data (Kim and Choi, 2007).

Business process management systems have the objective of enabling fast and cost-effective process execution so they focused on supporting the modeling and automation of business processes. As more and more processes become automated, customers become increasingly interested in managing process execution. Tan and his collages present a set of concepts and a methodology toward business process intelligence (BPI) using dynamic process performance assessment, including measurement models based on activity-based management and a dynamic enterprise process performance assessment methodology. The proposed measurement models provide the analysis of six process flows within a manufacturing enterprise including activity flow, information flow, resource flow, cost flow, cash flow, and profit flow, which are vital for corporate managers to control the process execution quality and detect problems and areas for improvements. Seven evaluation criteria as time, quality, service, cost, speed, efficiency, and importance are used by the proposed process performance assessment methodology. A prototype system supporting dynamic enterprise process modeling, analysis of six process flows, and process performance prediction has been implemented to validate the proposed methodology (Tan et al., 2008).

Bosilj-Vuksic and his friends focus on organizational performance measurement. They offer an overview of the literature on organizational performance measures, approaches and frameworks. Their analysis indicates that organizational performance measurement

is well recognized as an important part of the business process management literature. The purpose of this paper is to propose a performance measurement guideline. Defining an appropriate guideline helps to explain and systemize this field, but also represents a critical step for business practitioners since it could influence the success of organizational performance measurement system development (Bosilj-Vuksic et al., 2008).

Healthcare organizations are meeting the challenge of delivering high-quality services through effective process management. There have been frequent changes of clinical processes and increased interactions between different functional units. Wu and his collages' study present an agent-based cognitive approach to facilitate the dynamic and interactive processes in healthcare organizations. The emphasis is placed on dynamic clinical and administrative process management, and knowledge building as the foundation for process management. The treatment of primary open angle glaucoma is used as an example to demonstrate the effectiveness of approach for healthcare process management (Wu et al., 2009).

As reviewed above, there are a lot of process management or enterprise performance assessment systems provided by the literature but a process-based business performance assessment system that is adaptable to any sector is deficient. Similarly, there is a lack of system for evaluating the business process performance against pre-determined objectives for different strategical areas.

5. ADAPTIVE BUSINESS PROCESS PERFORMANCE ASSESSMENT MODEL

The proposed “Adaptive Business Process Performance Assessment System (ABPAS)” will provide a baseline for process measurements with respect to pre-defined goals and performance criteria. It may sufficiently help creating improvement plans, improving the quality level of the products and services. In this Chapter, ABPAS is introduced in terms of its architecture, model components and operations.

5.1.General Architecture

In order to efficiently and effectively utilise the proposed methodology; ABPAS is designed in such a way that it has two users, six knowledge bases and four agents in the system. The components of the system proposed are shown in the **Figure 5.1**.

.

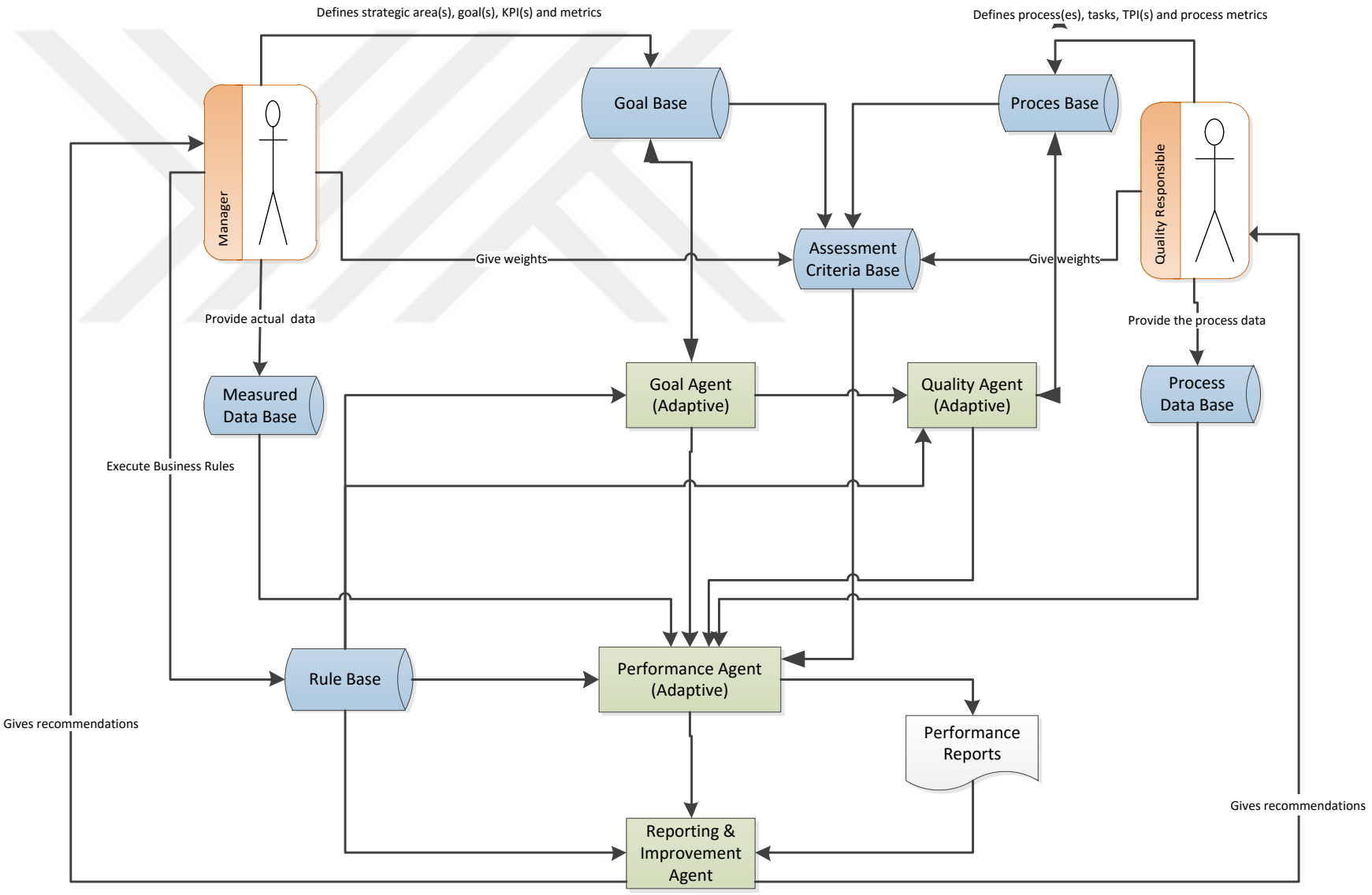


Figure 5.1 General architecture of ABPAS

According to the model, enterprise management with employee participation defines the strategic areas, goals, KPIs and related metrics in consideration of the organization's strategies into the "*goal base*". The "*goal agent*" helps the manager during this process. It is particularly designed to follow the relationship between the KPIs. Then, the quality responsible employees or managers define or update the related processes, tasks as well as, TPIs and related process metrics into the "*process base*" in order to assure satisfaction of the organizational goals. The "*quality agent*", in turn, helps the quality responsible during the definition of the content of process base. Similar to goal agent, this agent is designed to follow the relationship between the TPIs.

The pairwise comparison tables are set up in the "*assessment criteria base*" by using the related knowledge in the goal and process bases. The top management makes the pairwise comparisons of pre-defined strategic areas, goals and KPIs. At the same time, the quality responsibles make the pairwise comparisons of pre-defined processes, tasks and TPIs. The system generates the weights as a result of the these comparisons by using the AHP method as explained above.

In the next step, while the manager provides the strategic data to the "*measured database*", the quality responsible provides the process data to the "*process database"* essential for calculating the related metrics. After data entry, the manager or responsible employee then executes the business rules described in the "*rule base"* or updates the rules if necessary.

"*Performance agent*" gets inputs from both the goal and quality agents. It receives weight coefficients from assessment criteria base. It collects data related to the parameter values from the measured databases and process databases in order to perform gap analysis according to the target values assigned. Based on this analysis the performance of the enterprise is calculated. This completes the performance assessment cycle.

As a result of process assessment according to the present performance criteria, a report is generated and improvement recommendations related to the lack of performance (areas open to improvements) are provided by the "*reporting and improvement agent*".

All agents use the related business rules for their operations.

5.1.1.Knowledge Bases

There are Four Knowledge Bases and Two Databases in the proposed system as listed below:

- Goal Base
- Process Base
- Assessment Criteria Base
- The Rule Base
- Database for measured data
- Process Database

5.1.1.1.The Goal Base

All strategic areas, goals, related KPIs and metrics are stored in this knowledge base. **Figure 5.2** shows an example of a screen shot for strategic area definition. The respective screens for goal and metrics definitions are quite similar to this one.

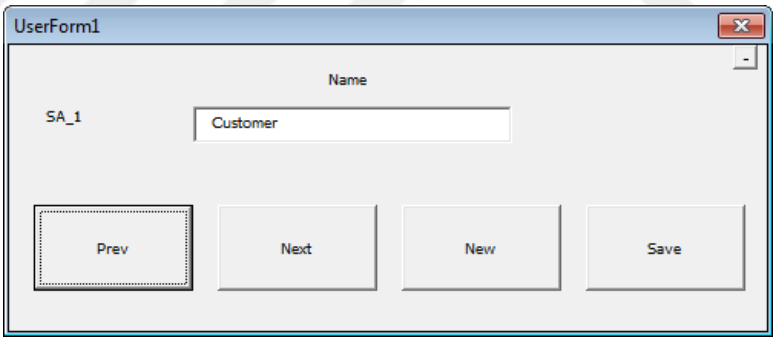


Figure 5.2 A screen shot in ABPAS for defining at strategic area

Strategic area, goal and metrics are saved with an ID and a name. For example:

SA_1 Customer

G_1 To increase customer satisfaction score

M_1 # Customers stating that they are satisfied

Similarly, a screen shot for defining the KPIs in this knowledge base is shown in the **Figure 5.3**.

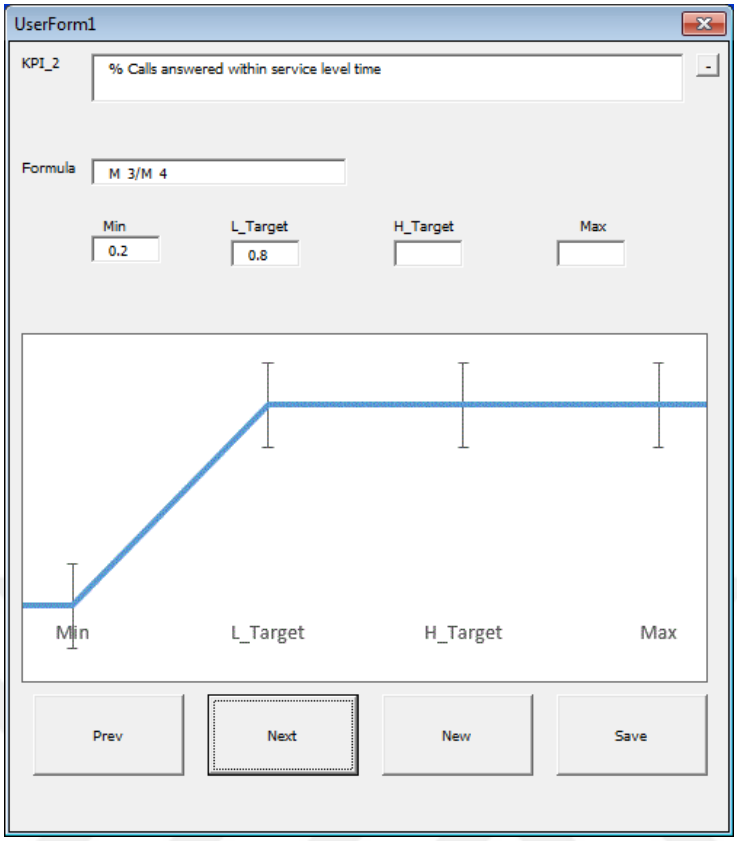


Figure 5.3 A screen shot in ABPAS for definition of a KPI

As with the goals, the KPIs are also defined with the following attributes:

- an ID,
- a name,
- a unit definition (ratio, number, money, duration, average),
- min value (the minimum point that the performance should be 0%),
- low target value,
- high target value,
- max value (the maximum point that the performance should be 0%) as well as
- the method to calculate the metrics (formula).

An example is provided in **Table 5.1** :

Table 5.1 KPI definition

ID	Name	Unit	Min	L_Target	H_Target	Max	Formula
KPI_1	*% Customer satisfaction score*	*Ratio*	*0,5*	*0,9*			*M_1/M_2*

Where M_1 and M_2 are defined as "# Customers stating that they are satisfied" and "# Customers surveyed" respectively. According to this example, if KPI_1 value is smaller than or equal to 50%, the performance is 0%. If KPI_1 value is greater than or equal to 90%, the performance is 100. If KPI_1 value is between 50% and 90%, the performance is calculated by "(X-Min)/ (L_Target-Min)" equation.

There are four cases for calculation of KPI performance value as shown in **Figure 5.4**.

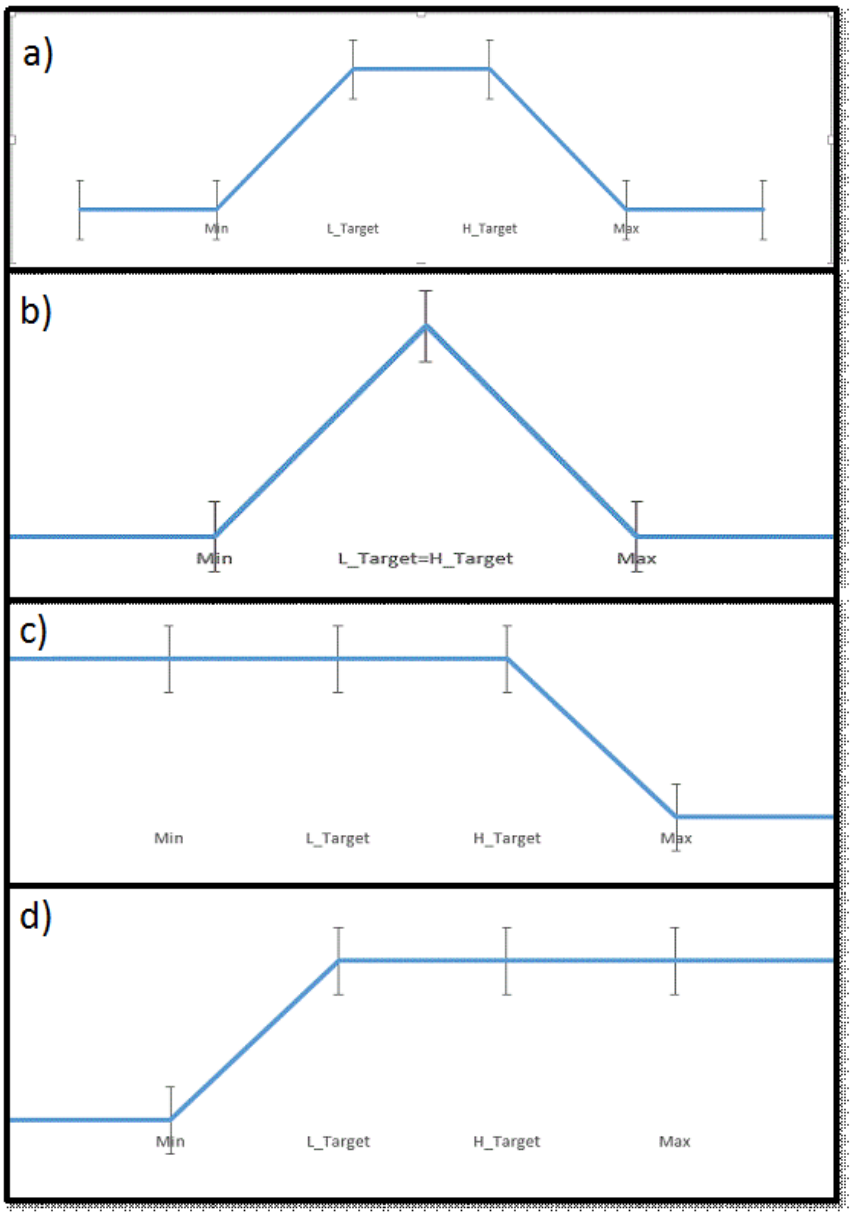


Figure 5.4 a) Case 1**:** *Tendency=within range (Project unique requirements etc.),* **b)** *Case 2: Tendency= on target (Customer satisfaction ratio etc.),* **c)** Case 3: *Tendency=decreasing (expense etc.),* **d)** *Case 4: Tendency=increasing (revenue etc.)*

In **Figure 5.4** there are four points (min, max, low target and high target). The min indicates that the minimum point that the performance should be 0%. The max indicates that the maximum point that the performance should be 0%. Low target shows the

lowest target value that user defines and high target shows the highest target value that user defines.

For all cases where;

- Before min and beyond max points, KPI performance value is equal to 0%.
- Between L_Target and H_Target points, KPI performance value is equal to 100%.
- Between min and L_Target values, KPI performance value is calculated by the equation "(X-Min)/ (L_Target-Min)".
- Between max and H_Target values, KPI performance value is calculated by the equation " 1-((X-H_Target)/(Max-H_Target))".

5.1.1.2.The Process Base

All processes, tasks, related TPIs and process metrics are stored in here.

An example screen shot is provided in **Figure 5.5** design to define the process. Print screens of task and process metrics definition are similar.

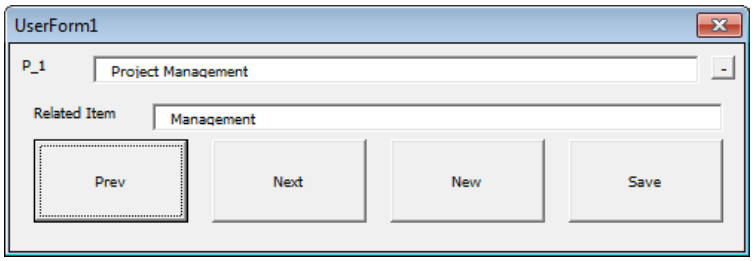


Figure 5.5 A screen shot in ABPAS for process definition

Process, task and process metrics are saved with an ID and name. For example:

P_1 Project Management

T_1 Plan the project

PM_1 # Projects completed on time

Similarly, TPI definitions can be entered into the knowledge base using the screen as shown in **Figure 5.6**.

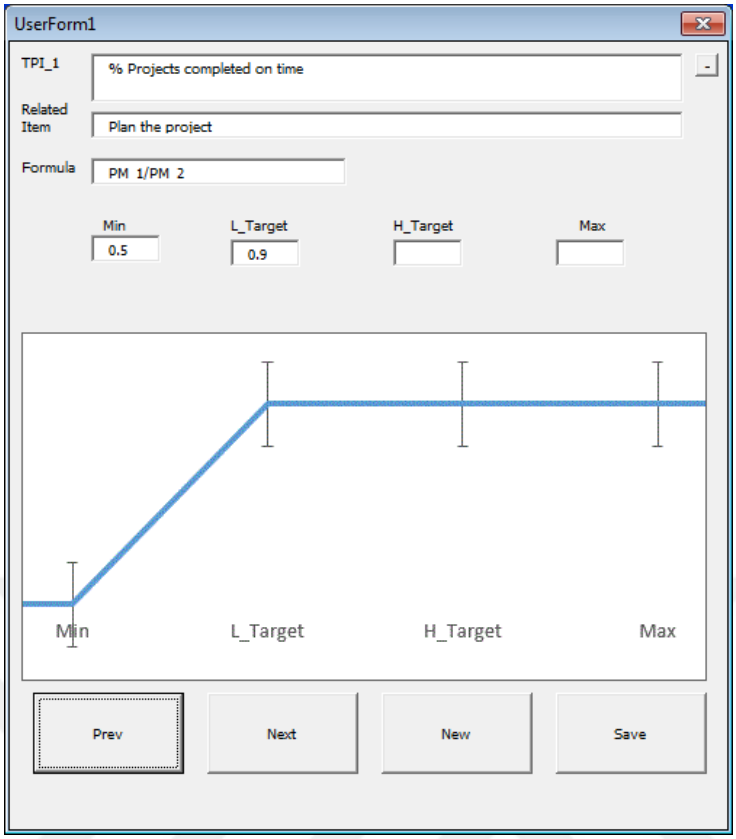


Figure 5.6 A screen shot for TPI definition

TPIs are defined in similar way as the following attributes:

- an ID,
- a name,
- related tasks,
- unit (ratio, number, money, duration, average),
- min value (the minimum point that the performance should be 0%),
- low target value,
- high target value,
- max value (the maximum point that the performance should be 0%) and
- the method to calculate the respective metrics (formula).

For example:

Table 5.2 TPI definition

ID	Name	Related_Task	Unit	Min	L_Target	H_Target	Max	Formula
TPI_1	% Projects completed on time	Plan the Project	Ratio	0,5	0,9			PM_1/PM_2

Where PM_1 and PM_2 are defined as "# Projects completed on time" and "# All projects" respectively.

Note that the four cases designed to be utilised in performance calculation for KPIs as explained above are also valid for calculation of TPI performances.

5.1.1.3.The Assessment Criteria Base

All pairwise comparisons listed below with calculated weight coefficients are stored in this base.

- Strategic Areas
- Goals with Respect to the Strategic Area Criterion
- KPIs with Respect to the Goal Criterion
- Tasks with Respect to the Process Criterion
- TPIs with Respect to the Task Criterion
- Processes

In **Figure 5.7**, a screen shot for pairwise comparisons of TPIs is shown as an example. In the example, for "Task 1: Plan the Project", "TPI-1 % Projects completed on time" is defined strongly important from "TPI-2 % Projects completed on budget" so its value is given as 6. Other pairwise comparisons are similar.

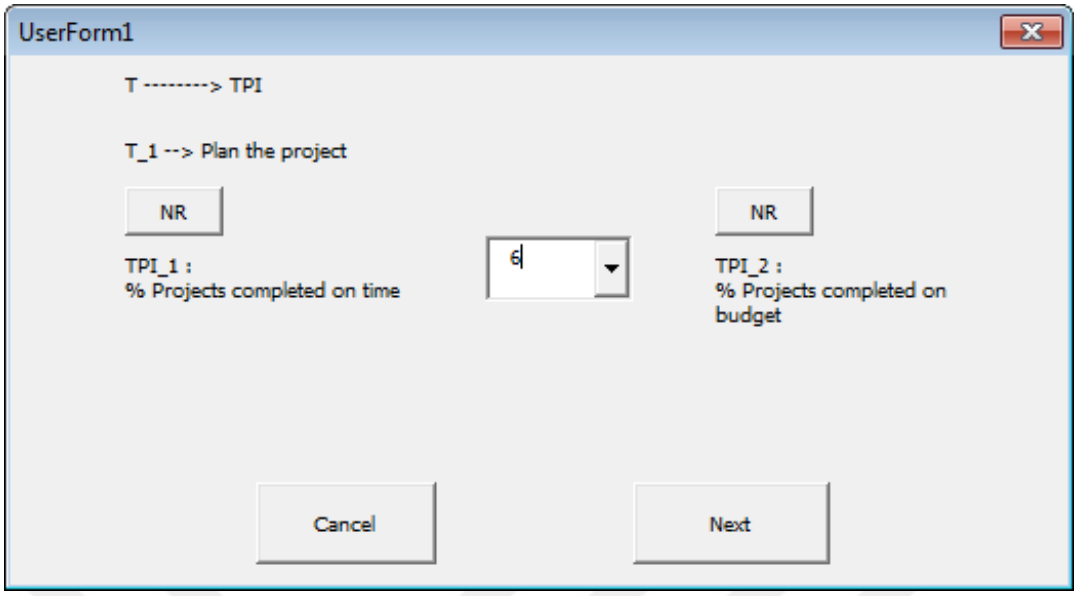


Figure 5.7 A screen shot for pairwise comparisons of TPIs

According to AHP model, the comparison values in the **Table 3.1** are used here. Also in order to define the unrelated items "No Relation (NR)"values are used in this model. The weight coefficients of the items have NR values are defined as "0" in the model.

The weight coefficients are changed according to the users' preferences on an AHP pairwise comparison table. In the **Figure 5.8**, strategic area comparison values and calculated weight coefficients are shown as an example. In this case, Strategic Area 1 performance is not related with the company performance so its weight is calculated as 0.

ID	CP_1
SA_1	0,00
SA_2	0,80
SA_3	0,20

CP1SA	SA_1	SA_2	SA_3
SA_1	NR	NR	NR
SA_2	NR	1	4
SA_3	NR	¼	1

Figure 5.8 A screen shot for strategic area weight coefficients

5.1.1.4.Database for Measured Data

All required data which are measured during real time operations for calculating actual values of the KPIs' within a given measurement period are stored in this database. The

format of this database is given in **Figure 5.9**. These metrics can be collected automatically by using interfaces with the data sources like SAP, JIRA, JAZZ and so on.

ID	NAME	January	February	March	…
M_1	# Customers stating they are satisfied	0	10	20	…
M_2	# Customers surveyed	100	100	100	…

Figure 5.9 Format of the Database for Measured Data

5.1.1.5.Process Database

All required process metrics which are required in calculating the actual values of TPIs' collected within the measurement period are stored in this database. The format of this database is given in **Figure 5.10**. Similar to the measured values, the process metrics can also be collected automatically by using interfaces with the data sources like SAP, JIRA, JAZZ and so on.

ID	NAME	January	February	March	…
PM_1	# Projects completed on time	18	18	18	…
PM_2	# All projects	20	20	20	…

Figure 5.10 Format of the Process Database

5.1.1.6.Rule Base

A "*business rule*" is a statement that defines or constraints some aspect of operations of the agents. As implied by Hay et al. , (2000), it is intended to assert business structure or to control or influence the behaviour of the agents through implementing these rules. All business rules for agents are stored in so called a *"Rule Base*".

In the "*Rule Base*", the knowledge is presented in the form of;

if <antecedent clauses> then <consequent clauses>

statements. Meaning that if the antecedent clauses are true, then the consequent clauses are true (to be implemented).

Some examples of the generic Business Rules already defined for ABPAS are provided below:

Rule 1:

IF (KPI or TPI Actual State>= “Target value” for the last three assessment

AND Tendency = “increasing”)

THEN (Recommendation= “Increase the target value.”)

Rule 2:

IF (KPI or TPI Actual State<= “Target value” for the last three assessment

AND Tendency = “decreasing”)

THEN (Recommendation= “Decrease the target value.”)

Rule 3:

IF (Company Performance Note<= “Expected level of performance”

THEN (Recommendation= “The company performance is not satisfactory enough.”)

Rule 4:

IF (any Process Performance >= 90%)

THEN (Message: “Process performance is PERFECT.”)

Rule 5:

IF (any Process Performance < 90% AND >=80%)

THEN (Message: “Process performance is VERY GOOD.”)

Rule 6:

IF (any Process Performance < 80% AND >=60%)

THEN (Message: “Process performance is GOOD.”)

Rule 7:

IF (any Process Performance <=60%)

THEN (Message: “Process performance is INITIAL.”)

Rule 8:

IF (KPI or TPI Actual State<=Min)

THEN (KPI or TPI Performance=0%)

Where Min indicates “the min point that the performance should be 0%”.

Rule 9:

IF (KPI or TPI Actual State>=Max)

THEN (KPI or TPI Performance=0%)

Where max indicates ““the max point that the performance should be 0%”.

Rule 10:

IF (KPI or TPI Actual State=L_Target or H_Target)

THEN (KPI or TPI Performance=100%)

Where L_Target and H_target indicates lowest and highest acceptable target values respectively.

Rule 11:

IF (KPI or TPI Actual State> L_Target)

AND (KPI or TPI Actual State<H_Target)

THEN (KPI or TPI Performance=100%)

Rule 12:

IF (KPI or TPI Actual State>Min)

AND (KPI or TPI Actual State<L_Target)

THEN (KPI or TPI Performance= (KPI or TPI Actual State-Min)/ (L_Target-Min))

Rule 13:

IF (KPI or TPI Actual State<Max)

AND (KPI or TPI Actual State>H_Target)

THEN (KPI or TPI Performance= 1-((KPI or TPI Actual State-H_Target)/ (Max-L_Target)))

Rule 14:

IF (effect coefficient of KPI is the HIGHEST)

AND (KPI performance is not 100%)

THEN (Recommendation= "This KPI has the most effective indicator on the company performance so it should be improved first.")

Rule 15:

IF (correlation value of TPI with the most effective KPI is the HIGHEST)

AND (TPI performance is not 100%)

THEN (Recommendation= “This TPI has the most effective indicator on the company performance so it should be improved first.”)

Rule 16:

IF (new defined strategic area or goal or KPI= pre-defined strategic area or goal or KPI)

THEN (Msgbox= “It is not a new item.”)

Rule 17:

IF (new defined process or task or TPI= pre-defined process or task or TPI)

THEN (Msgbox= “It is not a new item.”)

In **Table 5.3**, it is shown that the relationship between Business Rule and the respective agent designed to operate these. Note that the Rule definitions are provided above.

Table 5.3 Relationship between business rules and agents

Business Rules	**Respective Agent (s)**	**Related Action of the Agent(s)**
Rule 1	Improvement& Reporting	If the KPI or TPI actual state is higher than or equal to the target value for the last three assessment and the tendecy is increasing, the agent recommends to improve the target value.
Rule 2	Improvement& Reporting	If the KPI or TPI actual state is lower than or equal to the target value for the last three assessment and the tendecy is decreasing, the agent recommends to improve the target value.
Rule 3	Performance	If the company performance is lower than the user defined expected level of performance, the agent gives message that the company performance is not satisfactory enough.
Rule 4	Performance	If any process performance is calculated higher than 90%, the agent identifies the related process quality level as “PERFECT”.
Rule 5	Performance	If any process performance is calculated lower than or equal to 90% and higher than 80%, the agent identifies the related process quality level as “VERY GOOD”.
Rule 6	Performance	If any process performance is calculated lower than or equal to 80% and higher than 60%, the agent identifies the related process quality level as “GOOD”.

Rule 7	Performance	If any process performance is calculated lower than or equal to 60%, the agent identifies the related process quality level as “INITIAL”.
Rule 8	Performance	If the KPI or TPI actual state value is smaller than or equal to Min, the agent calculates the KPI or TPI performance as 0%.
Rule 9	Performance	If the KPI or TPI actual state value is greater than or equal to Max, the agent calculates the KPI or TPI performance as 0%.
Rule 10	Performance	If the KPI or TPI actual state value is equal to L_Target or H_Target, the agent calculates the KPI or TPI performance as 100%.
Rule 11	Performance	If the KPI or TPI actual state value is higher than L_Target and lower than H_Target, the agent calculates the KPI or TPI performance as 100%.
Rule 12	Performance	If the KPI or TPI actual state value is higher than Min and lower than L_Target, the agent uses the formula “(KPI or TPI Actual State-Min)/ (L_Target-Min)” to calculate the KPI or TPI performance.
Rule 13	Performance	If the KPI or TPI actual state value is lower than Max and higher than H_Target, the agent uses the formula “1-((KPI or TPI Actual State-H_Target)/ (Max- L_Target))” to calculate the KPI or TPI performance.
Rule 14	Improvement& Reporting	The KPI that has the highest effect coefficient

		is recommended to be improved firstly.
Rule 15	Improvement& Reporting	The TPI that has the highest correlation value with the most effective KPI is recommended to be improved firstly.
Rule 16	Goal	When a new strategic area, goal or KPI is defined, the agent checks whether it is new one or not. If it is not new, it gives a message.
Rule 17	Quality	When a new process, task or TPI is defined, the agent checks whether it is new one or not. If it is not new, it gives a message.

5.1.2.Model Agents

ABPAS incorporates four agents including:

- Goal Agent
- Quality Agent
- Performance Agent
- Reporting & Improvement Agent.

The structure and functional aspects of each of these agents are provided below.

5.1.2.1.Goal Agent

The Goal Agent facilitates strategic aspect of the process management within an enterpise. As implied earlier, it allows the definition of strategic areas, goals, KPIs and metrics to be incorporated within the system (ABPAS). The required information is managed through Goal Base as explained above.

For a new defined strategic area, goal, KPI or metric, all required fields by the database should be provided by the manager. Note that the agent should take the relationships between the KPIs for the overall goal of the enterprise. For example, having high self-efficacy and performing a large number of projects are related.

The structure of the Goal Agent is shown in **Figure 5.11**.

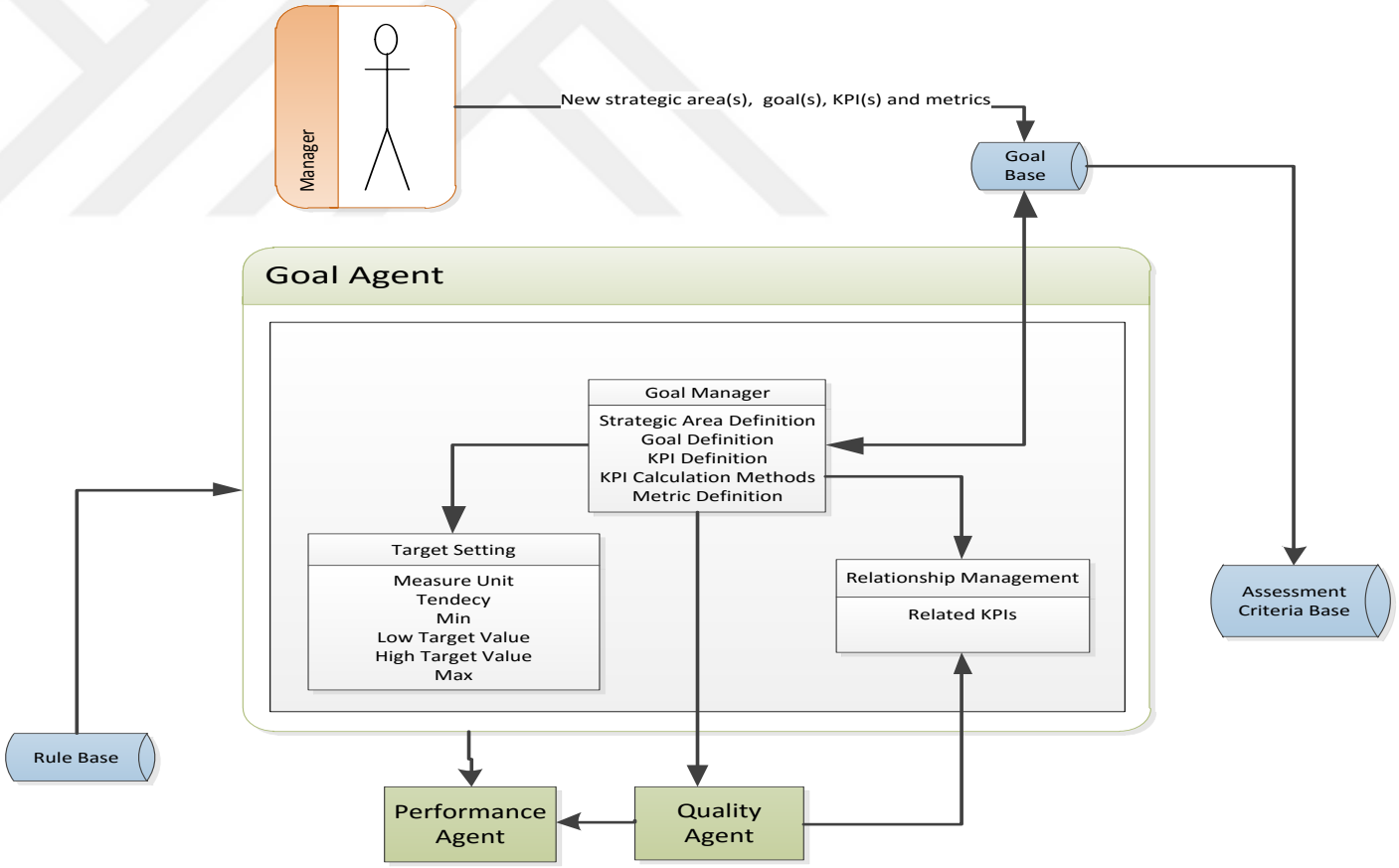


Figure 5.11 The structure of the Goal Agent of ABPAS

Note that, although there is no limitation and strict rule to be implemented, the strategic areas should be defined according to Balanced Score Card (BSC) and the goals will be groupped in the following aspects:

- Financial (an example goal: *To increase revenue*)
- Customer (an example goal: *To increase customer satisfaction*)
- Internal Process (an example goal: *To raise process awareness*)
- Learning & Growth(an example goal: *To increase employee training)*

In the Goal Agent model, there are three tasks as shown in the **Figure 5.11**:

- Goal Manager: This task allows to define new strategic areas, goals, KPIs and metrics.
- Target Setting: This task allows to assign target values of defined KPIs.
- Relationship Management: This task finds the correlation defined KPIs and takes care of this relationships between KPIs when the recommendations are given to the users.

5.1.2.2.Quality Agent

As stated earlier, the Quality Agent is responsible to keep track of the quality level of the processes in accordance with the predefined set of goals. This clearly implies that all processes should be aligned to strategic objectives. The Quality Agent should be capabile of not only checking out the Process-Goal relations but also interprocess activities required to be effectively carried out for the sake of better achievements of the goals.

For example, suppose a set of predefined goals of a “Project Monitoring and Control Process” are listed below (Capability Maturity Model Integration-CMMI V.1.3, 2010):

SG1 (Specific Goal-1) Monitor the Project Against the Plan

SG 2 (Specific Goal-2) Manage Corrective Action to Closure

Quality Agent determines which processes and tasks will meet these goal(s). This agent facilitates to define processes, tasks, TPIs and process metrics.

Keeping this in mind, the Quality Agent looks for the correlation of goals' and processes' performances. It also checks the correlation of TPIs' performances. According to these correlations, it decides which process or processes serve to the defined goals and which TPIs are related with each others. This knowledge effects the system recommendations.

The structure of the Quality Agent is shown in **Figure 5.12**.

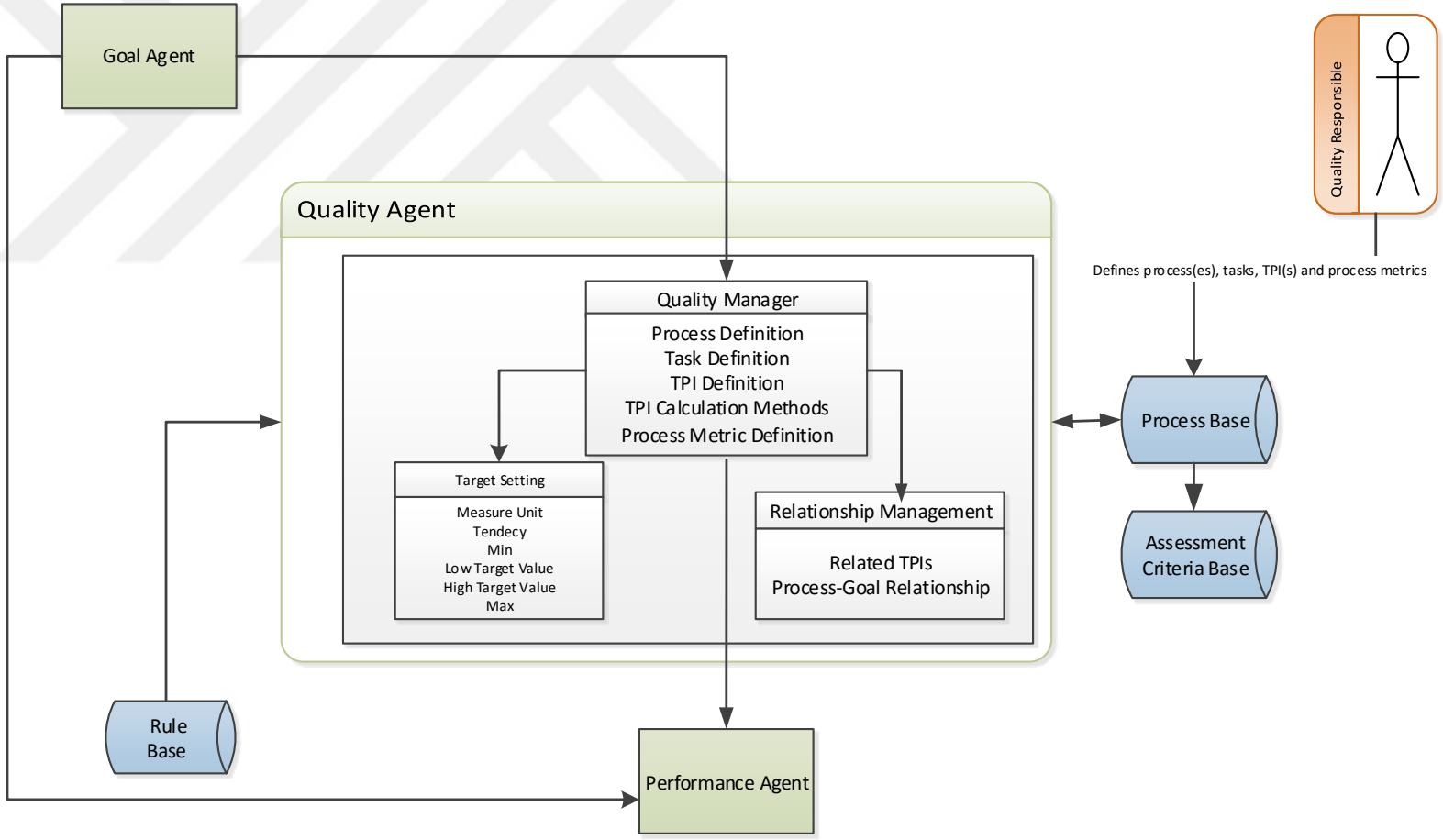


Figure 5.12 The structure of the Quality Agent of ABPAS

In the Quality Agent model, three tasks are carried out. Mainly:

- Task of the Quality Manager: This task allows to define new processes, tasks, TPIs and process metrics.
- Target Setting: This task allows to assign target values of defined TPIs.
- Relationship Management: This task finds the correlation defined goals' and processes' performance and correlation of TPIs. It takes care of this relationships between TPIs when the recommendations are given to the users.

5.1.2.3.Performance Agent

Performance Agent receives input from the Goal and Quality Agent. It obtains respective weight coefficients from Assessment Criteria Base as explained in Section 5.1.1.3. Moreover, it collects the values of the parameters from the Measured Database and Process Database and performs a gap analysis taking the actual and target values into account.

The Performance Agent performs the assessment using the equations given below where n is the number of KPI in the matrix, m is the number of Goal in the matrix, s is the number of Strategic Area in the matrix, np is the number of TPI in the matrix, mp is the number of Task in the matrix, sp is the number of the Process in the matrix;

- Goal performance =

$$\sum_1^n (KPI\ performance\ *\ KPI\ weight\ coefficient) \quad (5.1)$$

- Strategic area performance =

$$\sum_1^m (Goal\ performance\ *\ Goal\ weight\ coefficient) \quad (5.2)$$

- Company performance =

$$\sum_1^s (Strategic\ area\ performance\ * Strategic\ area\ weight\ coefficient) \quad (5.3)$$

- Task performance =

$$\sum_1^{np}(TPI\ performance\ *\ TPI\ weight\ coefficient) \quad (5.4)$$

- Process performance =

$$\sum_1^{mp}(Task\ performance\ *\ Task\ weight\ coefficient) \quad (5.5)$$

- Process-related company performance =

$$\sum_1^{sp}(Process\ performance\ *\ Process\ weight\ coefficient) \quad (5.6)$$

- Company performance note=

(Company performance + process-related performance)/2 (5.7)

The KPI that provides the maximum performance increment on the company performance is chosen in order to give recommendation to the user.

The TPI that has the highest correlation value with the recommended KPI is chosen in order to give recommendation to the user.

The structure of the performance agent is shown in **Figure 5.13**.

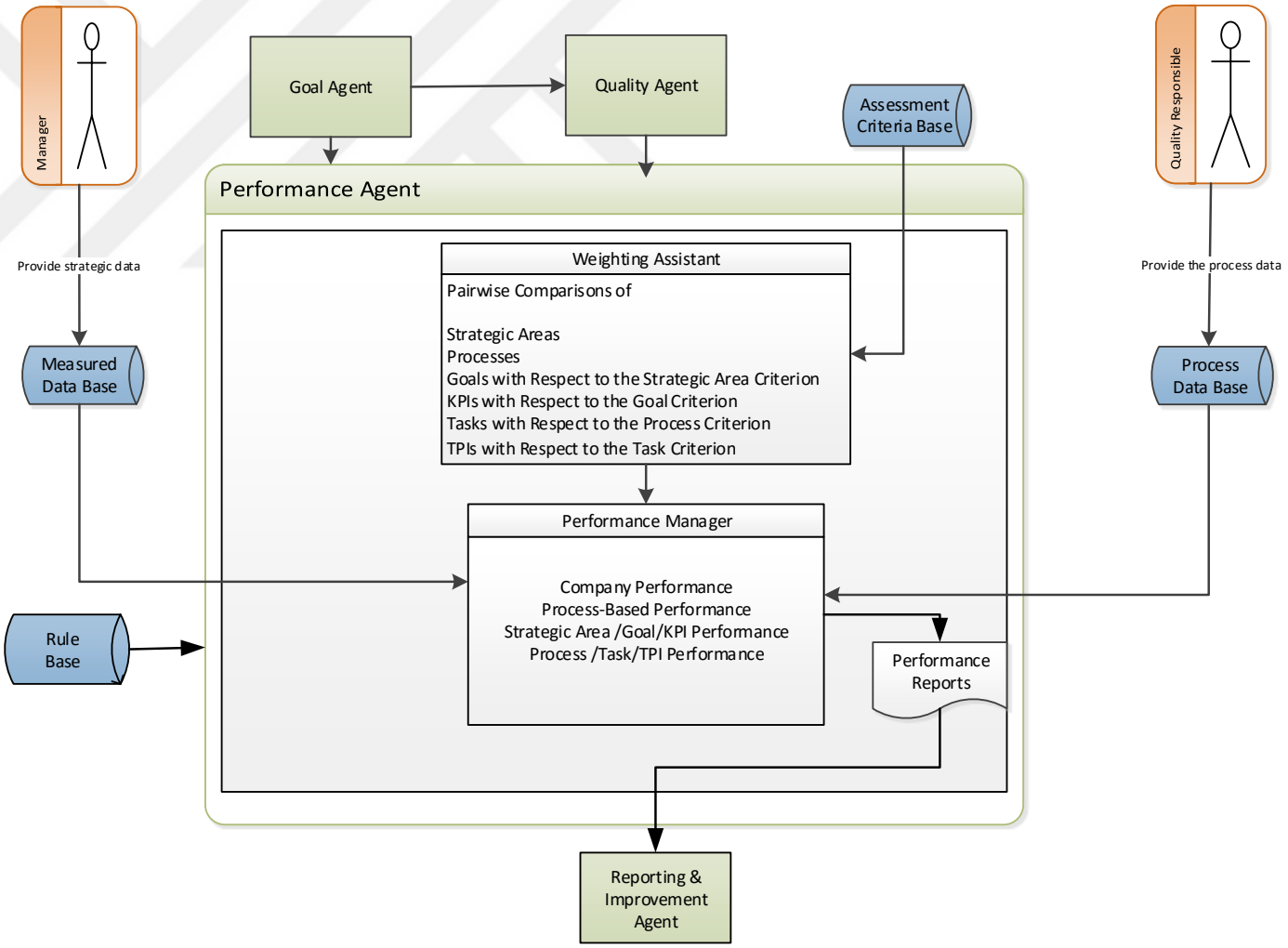


Figure 5.13 The structure of Performance Agent of ABPAS

In the Performance Agent model, two tasks are carried such as:

- Task of weighting assistant: This task calculates the weights of strategic areas, goals, KPIs, processes, tasks and TPIs from the Assessment Base pairwise comparison matrices.
- Task of performance manager: This task calculates all performances (company performance, process-related company performance, strategic area/goal/KPI performance and process/task/TPI performance).

5.1.2.4.Reporting &Improvement Agent

Reporting and Improvement Agent is responsible to report as well as to keep track of the areas open to improvements.

After a comprehensive process measurement and analysis based on the set of performance criteria set up beforehand, a performance report is generated and respective improvement suggestions and recommendations related to the lack of performance are provided.

The structure of the improvement agent is shown in **Figure 5.14**.

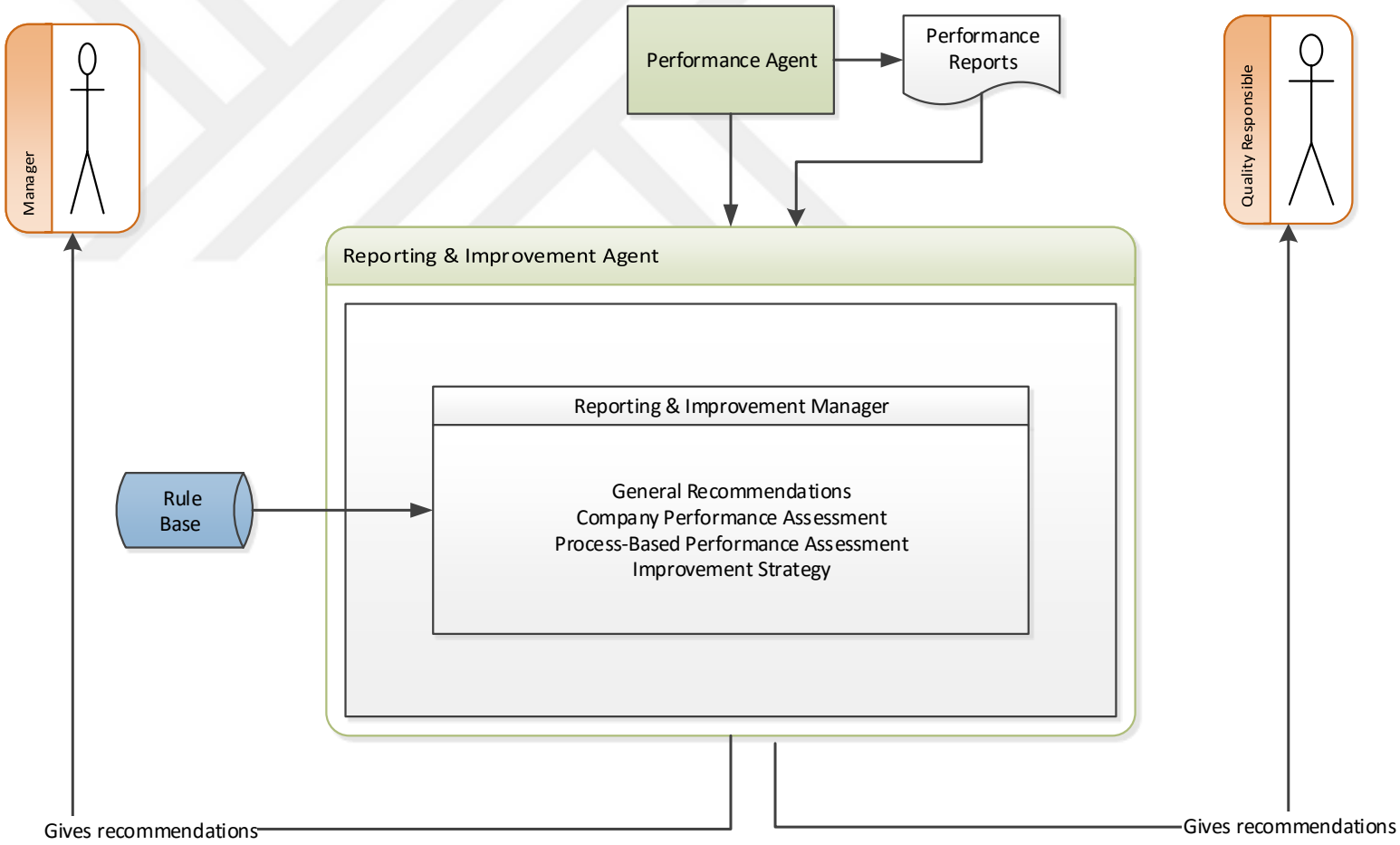


Figure 5.14 The structure of Reporting & Improvement Agent of ABPAS

In the Reporting and Improvement Agent model, there is only one task to be performed. That is:

- The task of Reporting and Improvement Manager: This task reports all performances (company performance, process-related company performance, strategic area/goal/KPI performance and process/task/TPI performance) and also gives recommendations to the user according to the performance reports.

5.2.Adaptivity of the ABPAS Agents

The ABPAS achieves adaptivity in the following areas:

- Agents are associated with business rules. The behavior of agents can be configured dynamically with rules. Agents retrieve and update their knowledge from the business rules and behave accordingly.
- The calculated company performance and system recommendations change according to the company strategies and quality needs. For example, a company that thinks the most important thing is customer and a company that thinks the most important thing is money are so different. Their performances are not same under the same data because of different weight coefficients.
- The system is adaptable enough to be implemented for different purposes like manufacturing, education, IT etc.
- The number of related processes differentiates for each goal. For example, Project Management and Marketing processes has to be monitored whereas for the goal defined as “to improve quality of employee” goal is related to Human Resources Management process is to be in the monitoring state.

6. IMPLEMENTING ABPAS: A CASE STUDY

6.1.Case Study

The model was implemented in a company from IT sector. In the company, the Strategic Management Department describes the strategic areas, goals, KPIs and related metrics depending on the company culture and managers' opinions. The Quality Assurance Department defines the processes, tasks, TPIs and related process metrics depending on the pre-defined strategic areas and goals. The aim of the Quality Assurance Department is to design processes aligned with corporate strategies in order to reach the target values of KPIs that are described by high level managers. At the end of the pre-determined periods, the performance values of the goals are measured and the goals which do not reach their target values are defined.

For this company, a set of goal and a set of process (that are defined below) were provided to system by the enterprise management and quality repsonsibles. The required data was obtained from the actual system (measured data base and process data base) defined by a high level manager and a quality responsible and the performance reports were shown.

The system starts with a main screen shown in the **Figure 6.1**.

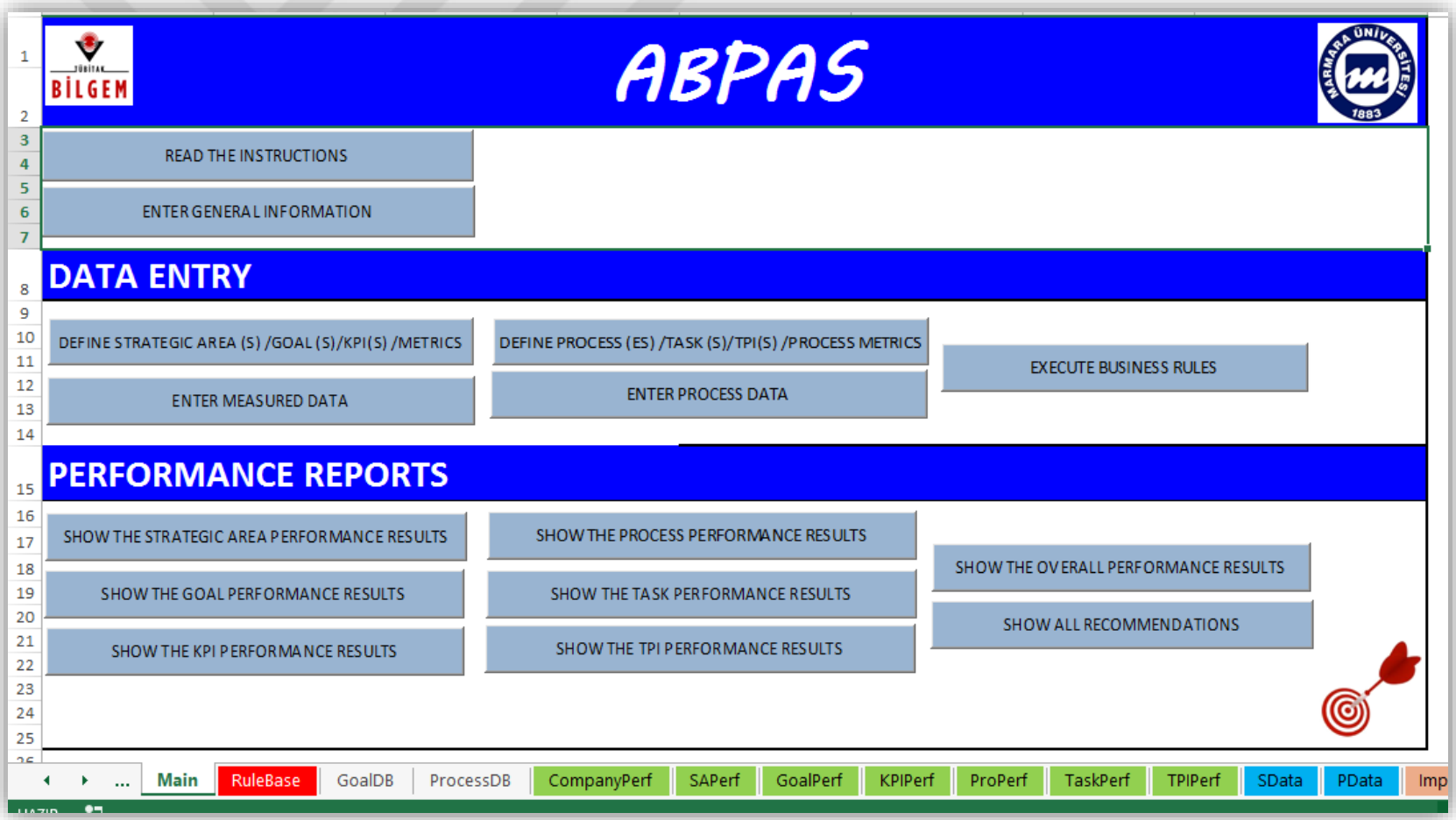


Figure 6.1 Main screen of ABPAS

The goal scenario used in this case study is described below:

Step1: The strategic areas, goals, related KPIs and metrics are identified as shown in **Table 6.1**, **Table 6.2**, **Table 6.3** and **Table 6.4**. These are defined by the Strategic Management Department of the enterprise.

Table 6.1 Strategic area definition

ID	Name
SA_1	Customer
SA_2	Financial

Table 6.2 Goal definition

ID	Name
G_1	To increase customer satisfaction score
G_2	To respond to customers within 2 days
G_3	To increase revenue
G_4	To decrease expenses

Table 6.3 KPI definition

ID	Name	Measure Unit	Min	L_Target	H_Target	Max	Formula
KPI_1	% Customer satisfaction score	Ratio	0,3	0,8			M_1/M_2
KPI_2	% Calls answered within service level time	Ratio	0,2	0,8			M_3/M_4
KPI_3	TL Total revenue	Number	100	250			M_5
KPI_4	TL Total expenses	Number			180	200	M_6

Table 6.4 Metric definition

ID	Name
M_1	# Customers stating that they are satisfied
M_2	# Customers surveyed
M_3	# Calls answered within the determined time frame
M_4	# Calls answered
M_5	TL Revenue by product i + ….+ TL Revenue by product n
M_6	TL Expenses by category i +…+TL Expenses by category n

Step2: The pairwise comparisons of strategic areas, goals and related KPIs are defined by using AHP method by the Strategic Management Department and the weights are calculated as shown in **Table 6.5**, **Table 6.6** and **Table 6.7** respectively.

Table 6.5 Pairwise comparisons and the weights of strategic areas

ID	CP_1
SA_1	0,67
SA_2	0,33

CP1SA	SA_1	SA_2
SA_1	1	2
SA_2	½	1

Table 6.6 Pairwise comparisons and the weights of goals with respect to the strategic area criterion

SA1G	G_1	G_2	G_3	G_4
G_1	1	2	5	5
G_2	1/2	1	2	2
G_3	1/5	1/2	1	1
G_4	1/5	1/2	1	1

SA2G	G_1	G_2	G_3	G_4
G_1	1	1	1/3	1/3
G_2	1	1	1/3	1/3
G_3	3	3	1	1
G_4	3	3	1	1

ID	SA_1	SA_2
G_1	0,53	0,13
G_2	0,24	0,13
G_3	0,11	0,38
G_4	0,11	0,38

Table 6.7 Pairwise comparisons and the weights of KPIs with respect to the goal criterion

G1KPI	KPI_1	KPI_2	KPI_3	KPI_4
KPI_1	1	2	9	9
KPI_2	½	1	9	9
KPI_3	1/9	1/9	1	1
KPI_4	1/9	1/9	1	1

G2KPI	KPI_1	KPI_2	KPI_3	KPI_4
KPI_1	1	1/2	9	9
KPI_2	2	1	9	9
KPI_3	1/9	1/9	1	1
KPI_4	1/9	1/9	1	1

G3KPI	KPI_1	KPI_2	KPI_3	KPI_4
KPI_1	1	1	1/9	1/9
KPI_2	1	1	1/5	1/4
KPI_3	9	5	1	3
KPI_4	9	4	1/3	1

G4KPI	KPI_1	KPI_2	KPI_3	KPI_4
KPI_1	1	1	1/2	¼
KPI_2	1	1	1/2	1/5
KPI_3	2	2	1	½
KPI_4	4	5	2	1

ID	G_1	G_2	G_3	G_4
KPI_1	0,58	0,32	0,06	0,13
KPI_2	0,32	0,58	0,09	0,11
KPI_3	0,05	0,05	0,61	0,25
KPI_4	0,05	0,05	0,24	0,51

Step3: The required data measured is provided to the system by the Strategic Management Department as shown in **Table 6.8** .

Table 6.8 Required data mesaured and collected

ID	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
M_1	# Customers stating they are satisfied	31	40	41	50	50	55	60	65	71	80	82	90
M_2	# Customers surveyed	100	100	100	100	100	100	100	100	100	100	100	100
M_3	# Calls answered within the determined time frame	15	18	22	20	25	27	30	22	25	25	26	27
M_4	# Calls answered	26	26	26	26	26	28	46	29	29	29	29	29
M_5	TL Revenue by product i + ….+ TL Revenue by product n	150	180	190	190	200	200	200	210	210	210	220	350
M_6	TL Expenses by category i +…+TL Expenses by category n	120	140	160	160	170	180	180	190	190	190	190	300

Step4: The business rules are executed by the Strategic Management Department without any change in the Rule Base. Expected level of performance is determined as 70% for Rule 3.

For example:

Rule 3:

IF (Company Performance Note<= "70%"

THEN (Recommendation= "The company performance is not satisfactory enough.")

Rule 11:

IF (KPI or TPI Actual State> L_Target)

AND (KPI or TPI Actual State<H_Target)

THEN (KPI or TPI Performance=100%)

Step5: The processes, tasks, related TPIs and metrics are determined by the Quality Responsible as shown in **Table 6.9**,**Table 6.10**, **Table 6.11 Table 6.12**.

As listed in **Table 6.9**, The Quality Manager defined three main processes from three areas (management, support and operational) to the system.

Table 6.9 Process definition

ID	Name	Related Item
P_1	Project Management	Management
P_2	Verification and Validation	Support
P_3	Requirements Management	Operational

In **Table 6.10**, the main tasks of the determined processes are listed.

Table 6.10 Task definition

ID	Name	Related Item
T_1	Plan the Project	Project Management
T_2	Monitor the Project	Project Management
T_3	Review	Verification and Validation
T_4	Test	Verification and Validation
T_5	Develop requirements	Requirements Management
T_6	Manage requirements	Requirements Management

In **Table 6.11**, the TPIs, calculation methods belonging to the defined tasks and their target values are shown.

Table 6.11 TPI definition

ID	Name	Related Item	Measure Unit	Min	L_Target	H_Target	Max	Formula
TPI_1	% Projects completed on time	Plan the project	Ratio	0,5	0,9			PM_1/PM_2
TPI_2	% Projects completed on budget	Plan the project	Ratio	0,5	0,9			PM_3/PM_2
TPI_3	% Actual project monitoring meetings/planned project monitoring meetings	Monitor the project	Ratio	0,5	0,85			PM_4/PM_5
TPI_4	# Finding obtained during the reviews	Review	Number	1	6	10	20	PM_6
TPI_5	% Actual review/planned review	Review	Ratio	0,3	0,95			PM_7/PM_8
TPI_6	# Error found during the test	Test	Number	1	21	46	250	PM_9
TPI_7	% Actual test/planned test	Test	Ratio	0,3	0,95			PM_10/PM_11
TPI_8	# Project unique requirements	Develop requirements	Number	100	100	180	180	PM_12
TPI_9	% Actual requirements development time /planned requirements development time	Develop requirements	Ratio	0,5	0,95			PM_14/PM_13
TPI_10	% Stability of requirements	Manage requirements	Ratio	0,4	0,9			(PM_12-PM_15)/PM_12

In **Table 6.12** , the process metrics for the calculation of TPIs are presented.

Table 6.12 Process metric definition

ID	Name
PM_1	# Projects completed on time
PM_2	# All projects
PM_3	# Projects completed on budget
PM_4	# Actual project monitoring meetings
PM_5	# Planned project monitoring meetings
PM_6	# Finding obtained during the reviews
PM_7	# Actual review
PM_8	# Planned review
PM_9	# Error found during the test
PM_10	# Actual test
PM_11	# Planned test
PM_12	# Project unique requirements
PM_13	# Actual requirements development time (month)
PM_14	# Planned requirements development time (month)
PM_15	# Requirements that have been added, deleted or modified, from the baseline requirements

Step6: The pairwise comparisons of the processes, tasks and related TPIs are calculated using AHP method by the Quality Responsible and the weights are calculated as shown in **Table 6.13**, **Table 6.14**, and **Table 6.15**. NR means "No Relation"in the pairwise comparisons.

Table 6.13 Pairwise comparisons and the weights of processes

ID	PP_1
P_1	0,26
P_2	0,40
P_3	0,34

PP1P	P_1	P_2	P_3
P_1	1	1/2	1
P_2	2	1	1
P_3	1	1	1

Table 6.14 Pairwise comparisons of tasks and the weights with respect to the process criterion

P1T	T_1	T_2	T_3	T_4	T_5	T_6
T_1	1	2	NR	NR	NR	NR
T_2	1/2	1	NR	NR	NR	NR
T_3	NR	NR	NR	NR	NR	NR
T_4	NR	NR	NR	NR	NR	NR
T_5	NR	NR	NR	NR	NR	NR
T_6	NR	NR	NR	NR	NR	NR

P2T	T_1	T_2	T_3	T_4	T_5	T_6
T_1	NR	NR	NR	NR	NR	NR
T_2	NR	NR	NR	NR	NR	NR
T_3	NR	NR	1	1/2	NR	NR
T_4	NR	NR	2	1	NR	NR
T_5	NR	NR	NR	NR	NR	NR
T_6	NR	NR	NR	NR	NR	NR

P3T	T_1	T_2	T_3	T_4	T_5	T_6
T_1	NR	NR	NR	NR	NR	NR
T_2	NR	NR	NR	NR	NR	NR
T_3	NR	NR	NR	NR	NR	NR
T_4	NR	NR	NR	NR	NR	NR
T_5	NR	NR	NR	NR	1	2
T_6	NR	NR	NR	NR	1/2	1

ID	P_1	P_2	P_3
T_1	0,67	0,00	0,00
T_2	0,33	0,00	0,00
T_3	0,00	0,34	0,00
T_4	0,00	0,66	0,00
T_5	0,00	0,00	0,67
T_6	0,00	0,00	0,33

Table 6.15 Pairwise comparisons and the weights of TPIs with respect to the task criterion

T1TPI	TPI_1	TPI_2	TPI_3	TPI_4	TPI_5	TPI_6	TPI_7	TPI_8	TPI_9	TPI_10
TPI_1	1	½	NR	NR	NR	NR	NR	NR	NR	NR
TPI_2	2	1	NR	NR	NR	NR	NR	NR	NR	NR
TPI_3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_7	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_8	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_9	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_10	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

T2TPI	TPI_1	TPI_2	TPI_3	TPI_4	TPI_5	TPI_6	TPI_7	TPI_8	TPI_9	TPI_10
TPI_1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_3	NR	NR	1	NR	NR	NR	NR	NR	NR	NR
TPI_4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_7	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_8	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_9	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_10	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

T3TPI	TPI_1	TPI_2	TPI_3	TPI_4	TPI_5	TPI_6	TPI_7	TPI_8	TPI_9	TPI_10
TPI_1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_4	NR	NR	NR	1	2	NR	NR	NR	NR	NR
TPI_5	NR	NR	NR	1/2	1	NR	NR	NR	NR	NR
TPI_6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_7	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_8	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_9	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_10	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

T4TPI	TPI_1	TPI_2	TPI_3	TPI_4	TPI_5	TPI_6	TPI_7	TPI_8	TPI_9	TPI_10
TPI_1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_6	NR	NR	NR	NR	NR	1	2	NR	NR	NR
TPI_7	NR	NR	NR	NR	NR	½	1	NR	NR	NR
TPI_8	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_9	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_10	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

T5TPI	TPI_1	TPI_2	TPI_3	TPI_4	TPI_5	TPI_6	TPI_7	TPI_8	TPI_9	TPI_10
TPI_1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_7	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_8	NR	NR	NR	NR	NR	NR	NR	1	1/2	NR
TPI_9	NR	NR	NR	NR	NR	NR	NR	2	1	NR
TPI_10	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

T6TPI	TPI_1	TPI_2	TPI_3	TPI_4	TPI_5	TPI_6	TPI_7	TPI_8	TPI_9	TPI_10
TPI_1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_7	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_8	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_9	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TPI_10	NR	NR	NR	NR	NR	NR	NR	NR	NR	1

ID	T_1	T_2	T_3	T_4	T_5	T_6
TPI_1	0,33	0,00	0,00	0,00	0,00	0,00
TPI_2	0,67	0,00	0,00	0,00	0,00	0,00
TPI_3	0,00	1,00	0,00	0,00	0,00	0,00
TPI_4	0,00	0,00	0,67	0,00	0,00	0,00
TPI_5	0,00	0,00	0,33	0,00	0,00	0,00
TPI_6	0,00	0,00	0,00	0,67	0,00	0,00
TPI_7	0,00	0,00	0,00	0,33	0,00	0,00
TPI_8	0,00	0,00	0,00	0,00	0,33	0,00
TPI_9	0,00	0,00	0,00	0,00	0,67	0,00
TPI_10	0,00	0,00	0,00	0,00	0,00	1,00

Step7: The required process data for each month is fed to the system by the Quality Responsible as shown in **Table 6.16**.

Table 6.16 Process data

ID	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PM_1	# Projects completed on time	10	15	14	18	18	19	19	19	19	19	19	19
PM_2	# All projects	20	20	20	20	20	21	22	22	22	22	22	22
PM_3	# Projects completed on budget	9	15	15	17	17	18	15	18	18	18	19	20
PM_4	# Actual project monitoring meetings	6	5	10	4	10	13	12	12	10	9	12	8
PM_5	# Planned project monitoring meetings	10	10	13	8	12	14	14	13	12	11	11	10
PM_6	# Finding obtained during the reviews	3	11	7	9	10	9	11	10	9	8	5	4
PM_7	# Actual review	5	9	13	17	20	10	3	1	3	2	8	5
PM_8	# Planned review	10	11	16	20	18	9	6	2	3	4	10	11
PM_9	# Error found during the test	20	45	30	10	35	32	39	40	50	55	45	51
PM_10	# Actual test	5	4	9	10	12	12	11	12	5	6	8	9
PM_11	# Planned test	10	10	11	12	12	12	15	15	9	9	9	9
PM_12	# Project unique requirements	120	110	120	250	300	180	130	200	180	170	180	190
PM_13	# Actual requirements development time (month)	3	2	4	4	8	5	2	9	12	22	4	3
PM_14	# Planned requirements development time (month)	2	1	6	4	3	2	1	10	11	20	3	4
PM_15	# Requirements that have been added, deleted or modified, from the baseline requirements	2	3	4	10	25	12	30	1	23	25	12	23

Step8: When the "Show Performance Results" button is clicked, the results as shown in **APPENDIX 1-Figure 1**, **APPENDIX 1-Figure 2**, **APPENDIX 1-Figure 3**, **APPENDIX 1-Figure 4**,**APPENDIX 1-Figure 5**,**APPENDIX 1-Figure 6** and **APPENDIX 1-Figure 7** are produced.

In **APPENDIX 1-Figure 1**, it is seen that the average corporate performance value at the end of the year is 72,91% and the most important strategic area is SA-1 Customer. On the other side of the process, it is seen that the average process-based performance value is 75,67% and the most important process is P-**2** Verification and Validation.

The corporate performance note is the average of the corporate and process-based performance value, so it is 74%. If it is under 70%, then the system will be giving a message as "The corporate performance is not satisfactory enough".

In **APPENDIX 1-Figure 2** and **APPENDIX 1-Figure 3**, the strategic area performance values with the most related goals and goal performance values with the most related KPIs are shown.

In **APPENDIX 1-Figure 4**, the calculated KPI actual state and performance values are shown according to the pre-determined target values and provided measured data.

The performance calculations are made as shown in the example below:

For KPI-1, target values are min=0,3 and L_target=0,8 and the formula is M_1 (# Customers stating that they are satisfied)/M_2 (# Customers surveyed). In January measured data of M_1=31 and M_2=100. So KPI-1 actual state is 0,31 and the performance value of KPI-1 is calculated by the equation "(X-Min)/ (L_Target-Min)". So the KPI-1 performance value is (0,31-0,3)/(0,8-0,3)=0,02.

In **APPENDIX 1-Figure 5**, the process performance report is shown with the performance values with the most related tasks and the quality levels. According to the report, Verification and Validation Process is the most successful process and its quality level is "Very Good" at the end of the year.

In **APPENDIX 1-Figure 6**, the task performance values with the most related TPIs are shown.

In **APPENDIX 1-Figure 7**, the TPI performance values calculated by TPI actual states and target values.

In **APPENDIX 1-Figure 8** Improvement & recommendation report-KPI, and in **APPENDIX 1-Figure 8** and **APPENDIX 1-Figure 9**, the improvement & recommendation reports are shown. In the first report, the most effective KPI on the corporate performance value is recommended to be firstly improved. According to the report, KPI-1 should be firstly improved until October. Then, in October performance of KPI-1 improves from 0% to 82 % and the system recommends KPI-4 to improve.

In the second report, the TPI has the highest correlation with the recommended KPI should be improved firstly by the Quality Assurance Department. TPI-1 (% Projects completed on time) has the highest correlation with KPI-1 (% Customer satisfaction score) so it is recommended to be firstly improved.

If the recommended KPI or TPI reaches 100% performance value, next most effective KPI or TPI will be recommended.

At the same time, the most effective TPI on the process-based corporate performance value is also recommended to the user as shown in the **APPENDIX 1-Figure 9**.

6.2.Discussion

Within this study, while the strategic areas, related goals, KPIs and metrics are defined by the Strategic Management Department; the processes, related tasks, TPIs and process metrics are defined by the Quality Assurance Department. Step by step, the pairwise comparisons of all defined performance criteria and indicators are determined. Business rules are executed. Lastly, the required measured and process data are provided to the system.

After the system is run, the performance results of all indicators are shown in the performance reports. The most efficient KPI on the corporate performance is selected to be improved. The correlation between the KPIs and TPIs are calculated and the related TPI with the first to be improved KPI is decided and recommended. So the goals of managerial and quality areas will be in the same direction.

The benefits of the proposed system is listed below:

- The system presents managers with four different strategic areas which to choose performance measures: the financial, the customer, the internal business process, and the learning and growth according to the BSC, so the companies which use the financial and non-financial indicators together, can provide the opportunity to perform performance evaluation and process management activities more effectively.
- The business processes and related tasks are aligned to the strategical goals. So the processes will help to catch the goal target values.
- The managers can make more healtier decisions because the system provides to see the performance value of the corporate instantly or in a defined time interval.
- The system recommends the KPI and TPI which should be firstly improved, thus creating a new year’s process improvement plan will be easier and more efficient than before.
- The users provide weights of each performance indicators to the system, so the assessment of the performance values are calculated according to the importance of indicators. Even though all data are the same for two companies, the

performance assessment results and recommendations can be different because of the user-defined weights.

- The weights of the all performance indicators are calculated by AHP method so the importance levels of them are objective.
- The user can see the minimum value-added TPIs. So it can be decided to update the related process involving the mentioned TPI.
- The more reliable measurements and accurate assessments are made.
- It can adapt itself in accordance with the conditions of the day so the strategic areas or importance levels of them are changed, the performance assessment will be done according to the new strategic management plan.

7. CONCLUSIONS

7.1.Conclusions

A performance assessment system is an important tool for managers to satisfy organizational objectives. In this thesis, an adaptive performance assessment and monitoring system is designed that helps to improve the quality level of the business processes based on the pre-defined criteria with respect to pre-defined goals. The system shows the completion percentage of defined goals, the efficiency of related processes and primary improvement areas.

The system makes a relationship between the Strategic Management Department and the Quality Assurance Department in a corporate. The performance indicators are associated with respective quality level. So more healtier and accurate improvement decisions are made by managers.

The system that is enriched by methodologies of Artificial Intelligence and rule-based decision support technologies has the ability to adapt itself in accordance with the current progress. Due to the importance of strategic areas and goals determined, the system is designed to be adaptable and take the attention to the respective recommendations. It provides to see the real time performance of a factory, institution, school, hotel or any other corporate in any sector.

7.2.Future Work

There are still several ways to improve this adaptive performance assessment system as listed below:

- Strategical objectives can be suggested from a predefined goal database to the user.
- Process effectiveness, efficiency and productivity can be calculated.
- Prioritization of the process improvements can be specified by the help of analyses.

- It can be determined which process(es)/task(s) provides benefits to the organizational performance but the unbeneficial process(es)/task(s) can be redesigned.
- Processes can be optimized by taking into consideration available resources and organizational objectives.
- Fuzzy-based assessment model can be used for uncertain conditions.
- Instead of Microsoft Office Visual Basic Application (VBA), a professional tool can be designed with another programming language.

REFERENCES

Aalst W. M. P. (2003) Business Process Management Demystified: A Tutorial on Models, Systems and Standards for Workflow Management, Lectures on Concurrency and Petri Nets, Springer, The Netherlands (ISBN: 978-3-540-22261-3).

Antonie D. R. (1998) A Framework for Business Process Management. The 23rd International Conference on Computers and Industrial Engineering, March 28-April 2, New York, USA, 217-220.

Aran, H. (2002) Süreç Yönetimi ve Müşteri Odaklı Bankacılık Yaklaşımını Destekleyen Bilgi Teknolojileri Modeli. Master of Science Thesis, Başkent University Institute of Social Sciences, İstanbul, Turkey, 9-21.

Axelsson M., Sonesson J. (2004) Business Process Performance Measurement for Rollout Success. Master of Science Thesis, School of Engineering Blekinge Institute of Technology, Software Engineering Department, Ronneby, Sweden.

Bennis W., Bische, M. (1997) The 21 Century Organization : Reinventing Through Reengineering. San Francisco: Josey-Baas Publishers, 21 – 23 (ISBN: 978-0787909390).

Bentes A.V., Carneiro J., Ferreira da Silva J., Kimura H. (2011) Multidimensional assessment of organizational performance: Integrating BSC and AHP. Journal of Business Research, Brazil, 65 (2012) 1790–1799.

Bond A.H., Gasser L. editors.(1988). Readings in Distributed Artificial Intelligence. Morgan Kaufman Publishers: San Mateo, CA (ISBN: 978-0934613637).

Bosilj-Vuksic V., Milanovic L., Skrinjar R., Indihar-Stemberger M. (2008) Organizational Performance Measures for Business Process Management: a Performance Measurement Guideline. 10th International Conference on Computer Modeling and Simulation, 1-3 April, Cambridge, UK, 94 – 99.

Boroushaki, S. and Malczewski, J., (2008), Implementing an extension of the analytical hierarchy process using ordered weighted averaging operators with fuzzy quantifiers in ArcGIS, Computer and Geosciences, Vol. 34, 399-410.

Bourguignon A., Chiapello E. (2005) The Role of Criticism in the Dynamics of Performance Evaluation Systems. Critical Perspectives on Accounting, Volume: 16 Issue: 6, 665-700.

Bozkurt, R.(2002) Süreç İyileştirme, MPM Yayınları, Yayın No: 661, Ankara, Turkey.

Camp R.C. (1989) Benchmarking. 1st Edition, ASQC Press, Milwaukee, USA.

Cantürk M. (2005) Misyon ve Vizyona Ulaşmada Süreç Yönetimi ve Posta ve Telgraf Teşkilatı (PTT) Genel Müdürlüğü'nde Bir Uygulama. Master of Science Thesis, Gazi University, Institute of Pure and Applied Sciences, Ankara, Turkey.

Cao Y., Zhao K., Yang J. and Xiong W. (2015) Constructing The Integrated Strategic Performance Indicator System for Manufacturing Companies. International Journal of Production Research, Vol. 53, No. 13, 4102–4116.

Cheng C.(2008) Performance Evaluation for a Balanced Scorecard System by Group Decision Making with Fuzzy Assessments. International Journal of Applied Science and Engineering, Vol. 6, No.1: 53-69.

CMMI for Development, Version 1.3 (2010) http://www.sei.cmu.edu/reports/10tr033.pdf (available on 14.05.2013).

Davenport T. H. (1993) Process Innovation – Reengineering Work through Information Technology. R&D Management, Harvard Business School Press, Volume:25, Issue:4, page:5, (eISBN:9780875843667).

Del-R´ıo-Ortega A., Resinas M., Ruiz-Cort´es A. (2010) Defining Process Performance Indicators:An Ontological Approach. OTM 2010 - Confederated International Conferences: CoopIS, IS, DOA and ODBASE, October 25-29, Hersonissos, Crete, Greece 555-572.

Doğan, Ö., Topoyan, M. , Tütüncü, Ö. (2004) Süreçlerle Yönetim ve Bir Hizmet İşletmesi Uygulaması. The 4th Ulusal Üretim Araştırmaları Sempozyumu, 08-10 October, Selçuk University, Konya, Turkey.

Elzinga D. J., Horak T., Lee C., Bruner C. (1995) Business Process Management: Survey and Methodology. IEEE Transactions on Engineering Management, Vol. 42, 2, 119-128.

Erkılıç T. A. (2007) Toplam Kalite Yönetimi İkelerinin Yönetim Yaklaşımları Bağlamıda Tartışılması, Girne American University, Social GAU Journal and Applied Sciences (4), 50-62.

Folan P., Browne J., Jagdev H. (2007) Performance: Its meaning and content for today's business research. Computers in Industry Volume: 58, Issue: 7, 605–620.

Garvin, D. A.(1998) The Process of Organization and Management, Sloan Manegement Review Association, 33-50.

Gu Y., Guo L., Sun Q. (2009) The application of Balanced Scorecard and Neural Network on the Performance Evaluation for Enterprises, International Symposium on Intelligent Ubiquitous Computing and Education, Chengdu, 105 – 108.

Guclu T. K. (2006) An Infrastructure and a Methodology for Business Process Management. Master of Science Thesis, The Institute of Science and Engineering Of Işık University, The Department of Computer Engineering, İstanbul, Turkey.

Hammer M. and Champy J.(1993) Reengineering the Corporation: A Manifesto for Business Revolution, 1st Edition, Harper Business, New York, USA (ISBN: 978-0060559533).

Harmon P. (2003) Business Process Change-A Guide for Business Managers and BPM and Six Sigma Professionals, 2nd Edition, Elseiver, Burlington, USA (ISBN: 978-0123741523).

Hay D. , Kolber A., Healy K.A. (2000) Defining Business Rules-What They are Really are, Technical Report, Business Rules Group.

Işılay, O.(1998) İşletmelerde Süreç Yönetimine Geçiş ve Uygulama Sonuçları, 7th Ulusal Kalite Kongresi, İstanbul, Turkey.

Jennings N. R., Norman T. J., Faratin P., O'Brien P., Johnson M.J.and Wiegand M.E. (1996) Agent-Based Business Process Management. International Journal of Cooperative Information Systems, Volume: 5, Issue: 2, Publisher: Citeseer, 105-130.

Kaplan R. S., Norton D.P. (1996) Using the Balanced Scorecard as a Strategic Management System, Harward Business Review, USA. 74 (1): 75-85.

Karaman R. (2008) İşletmelerde Performans Ölçümünün Önemi ve Modern Bir Performans Ölçme Aracı Olarak Balanced Scorecard, Selçuk University, The Journal of Social and Economic Research issue: 16.

Kim J.A., Choi S.Y. (2007) Process Management Agent. International Conference on Multimedia and Ubiquitous Engineering, 26-28 April, Seoul, South Korea. Page: 402-408.

Lee A. H. I., Chen, W. C. and Chang, C. J., (2008), A fuzzy AHP and BSC approach for evaluating performance of IT department in manufacturing industry in Taiwan, Expert Systems `with Application, Vol. 34, pp. 96-107.

Michalewicz Z., Schmidt M., Michalewicz M., Chiriac C. (2007). Adaptive Business Intelligence. Springer, Berlin Heidelberg (ISBN: 978-3-540-32928-2).

Milanovic Glavan L. (2011) Understanding Process Performance Measurement Systems, University of Zagreb, Faculty of Economics and Business, Business Systems Research - Vol.2, No.2, 1-56, Zagreb, Croatia.

Nobre, F. F., Trotta, L. T. F., Gomes, L. F. A. M., (1999), Multi-criteria decision making: an approach to setting priorities in health care, Symposium on statistical bases for public health decision making, Vol. 18, No. 23, 3345-3354.

Odell J. (2010) Agent Technology: An Overview, Ann Arbor MI USA.

Özay H.E.(2003) Süreçlerle Yönetim Sistemi ve Küçük ve Orta Ölçekli Bir İşletmede Uygulanması, Master of Thesis, Dokuz Eylül University Institute of Social Science, İzmir, Turkey.

Tekez E, Arslankaya S., Polat T.K, (2009) Endüstri Mühendisliğine Giriş, 1st Edition, 8th Chapter-Total Quality and Process Management, Papatya Yayıncılık, İstanbul, Turkey.

Reichert M., Rinderle S., Kreher U., Dadam P.(2005) Adaptive Process Management with ADEPT2. 21st International Conference on Data Engineering, 5-8 April, Tokyo, Japan, 1113-114.

Rossiter J. (1998) Total quality management: Mastering your small business. Redwood Books, Wiltshire, UK, (ISBN: 9780852974865).

Russell S., Norvig P. (1995) Artificial Intelligence: A Modern Approach (1st edition). Upper Saddle River, New Jersey: Prentice Hall, Chapter 2 (ISBN 0-13-103805-2).

Russell S., Norvig P. (2003) Artificial Intelligence: A Modern Approach (2nd edition). Upper Saddle River, New Jersey: Prentice Hall, Chapter 2 (ISBN: 978-0137903955).

Saaty, T.L. (1980). "The Analytic Hierarchy Process." McGraw-Hill, New York.

Sandholm T., (2015). AI as the Design of Agents, Carnegie Mellon University Computer Science Department. https://www.cs.cmu.edu/~sandholm/cs15-381/Agents.ppt (available at 01.01.2016).

Sharp A., Dermott P. (2001) Workflow Modeling: Tools for Process Improvement and Application Development, 2nd Edition, Artech House Inc., Norwood MA, USA.

Tan W., Shen W., Xu L., Zhou B., Li L. (2008) A Business Process Intelligence System for Enterprise Process Performance Management. IEEE Transactıons on Systems, Man, and Cybernetıcs—Part C: Applications and Reviews, Vol. 38, 6, 745-756.

Tekeli B (2003). Performans Ölçüm Aracı Olarak Dengeli Ölçüm Kartı Tekniği. [Balanced Scorecard Technique as a Tool of Performance Measurement]. Unpublished Master Thesis, Anadolu University Social Sciences Institute, Eskisehir, Turkey.

Tian G. and Quan L. (2008) An Improved Framework of Business Process Management System Which Integrating the Strategy Management. 15th International Conference on Management Science & Engineering, 10-12 September, Long Beach, USA.

TRADE, Training Resources and Data Exchange (TRADE) Performance-Based Management Special Interest Group (1995) How to Measure Performance: A Handbook of Techniques and Tools, U.S. Departmant of Energy Defense Programs, http://www.orau.gov/pbm/documents/handbook1a.html (avaliable on 11.04.2013).

Tütüncü Ö., Doğan Ö., Topoyan M. (2004) Süreçlerle Yönetim ve Bir Hizmet İşletmesi Uygulaması, Selçuk University, IV.National Manufacturing Research Symposium, Konya, Turkey, 354-360.

Weske M. (2007) Business Process Management-Concepts, Languages, Architectures, Springer, New York, USA.

Wooldridge, M., Jennings, N. R. (1995) Intelligent agents: Theory and practice. The

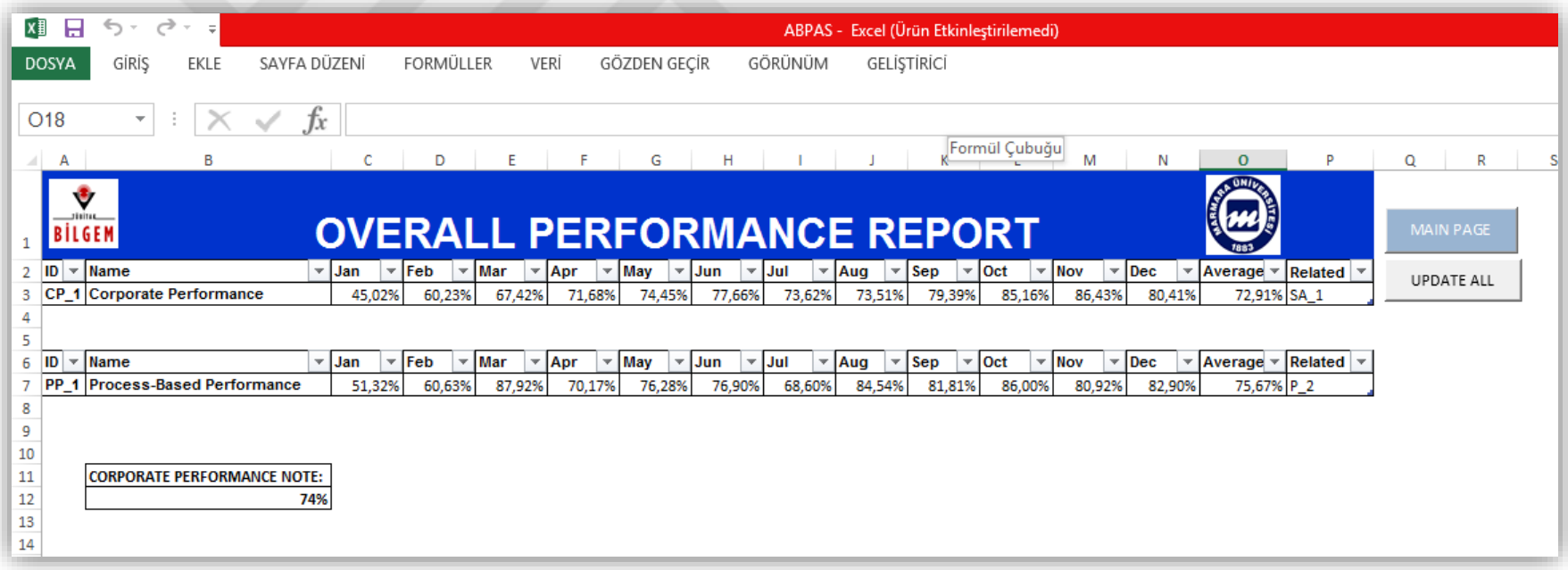
Knowledge Engineering Review, 10(2), 115–152.

Wu B., Wang M., Yun H., Jiang H. (2009) An Agent-based Cognitive Approach for Healthcare Process Management. 8th IEEE International Conference on Cognitive Informatics, 15-17 June, Kowloon, Hong Kong, 441-447.

APPENDICES

APPENDIX I: ABPAS Performance Reports

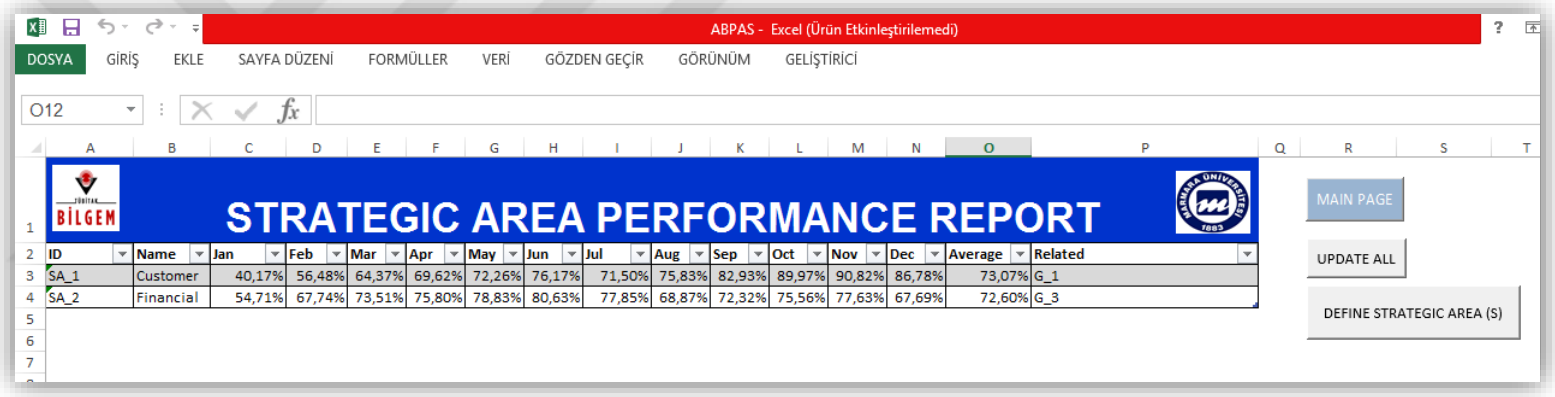
APPENDIX I: ABPAS Performance Reports



ID	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Related
CP_1	Corporate Performance	45,02%	60,23%	67,42%	71,68%	74,45%	77,66%	73,62%	73,51%	79,39%	85,16%	86,43%	80,41%	72,91%	SA_1

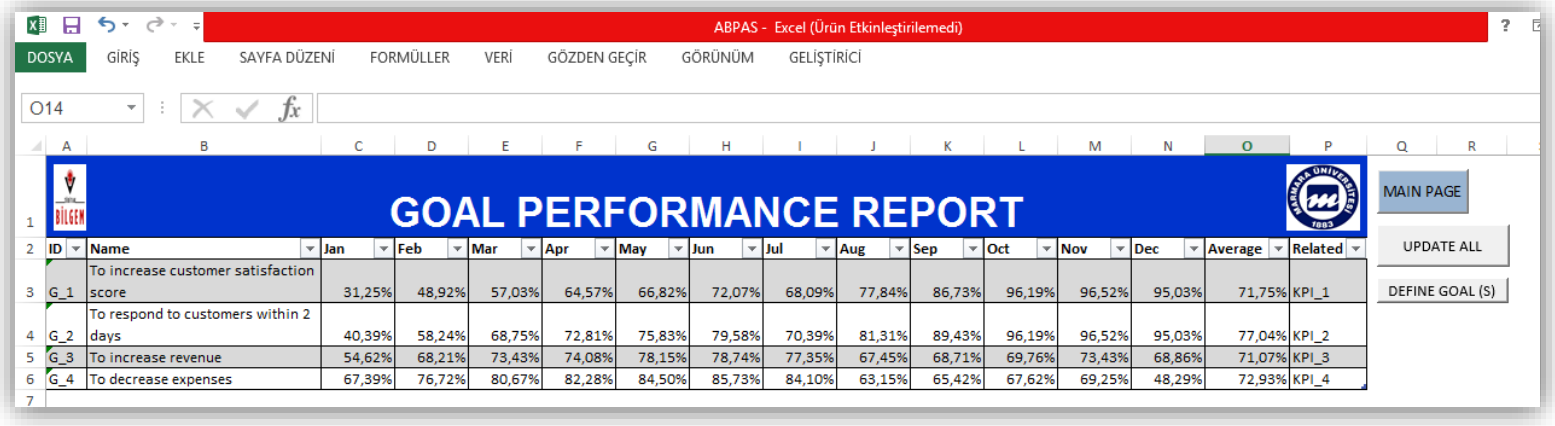
ID	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Related
PP_1	Process-Based Performance	51,32%	60,63%	87,92%	70,17%	76,28%	76,90%	68,60%	84,54%	81,81%	86,00%	80,92%	82,90%	75,67%	P_2

APPENDIX 1-Figure 1 Corporate performance report



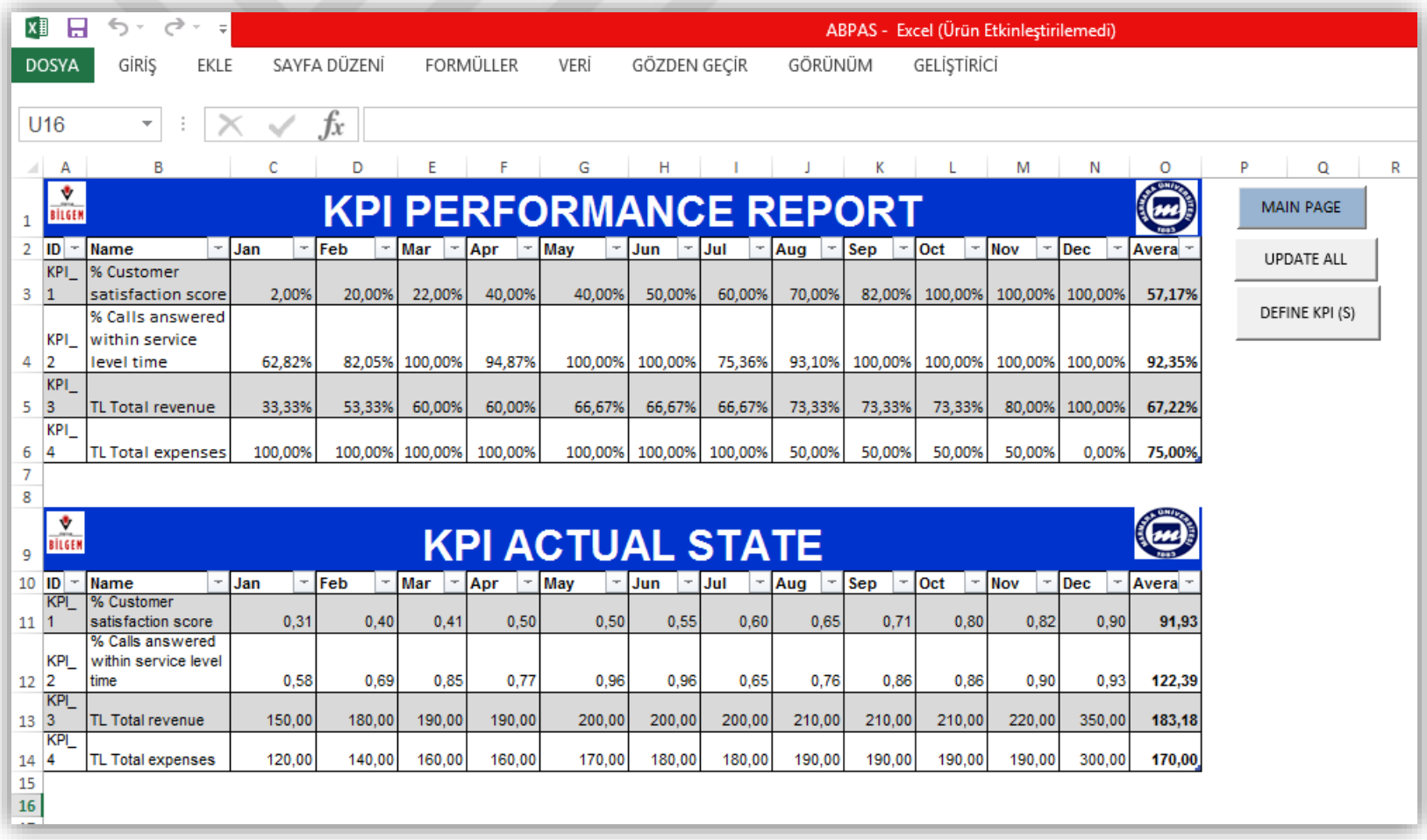
ID	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Related
SA_1	Customer	40,17%	56,48%	64,37%	69,62%	72,26%	76,17%	71,50%	75,83%	82,93%	89,97%	90,82%	86,78%	73,07%	G_1
SA_2	Financial	54,71%	67,74%	73,51%	75,80%	78,83%	80,63%	77,85%	68,87%	72,32%	75,56%	77,63%	67,69%	72,60%	G_3

APPENDIX 1-Figure 2 Strategic Area performance report



ID	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Related
G_1	To increase customer satisfaction score	31,25%	48,92%	57,03%	64,57%	66,82%	72,07%	68,09%	77,84%	86,73%	96,19%	96,52%	95,03%	71,75%	KPI_1
G_2	To respond to customers within 2 days	40,39%	58,24%	68,75%	72,81%	75,83%	79,58%	70,39%	81,31%	89,43%	96,19%	96,52%	95,03%	77,04%	KPI_2
G_3	To increase revenue	54,62%	68,21%	73,43%	74,08%	78,15%	78,74%	77,35%	67,45%	68,71%	69,76%	73,43%	68,86%	71,07%	KPI_3
G_4	To decrease expenses	67,39%	76,72%	80,67%	82,28%	84,50%	85,73%	84,10%	63,15%	65,42%	67,62%	69,25%	48,29%	72,93%	KPI_4

APPENDIX 1-Figure 3 Goal performance report



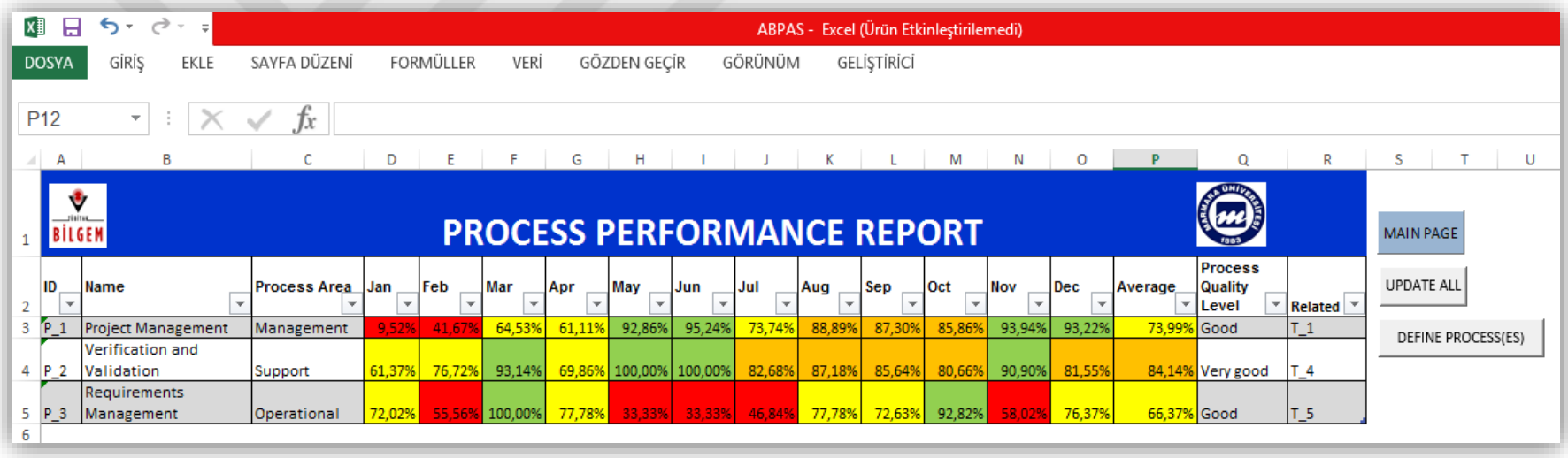
KPI PERFORMANCE REPORT

ID	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avera
KPI_1	% Customer satisfaction score	2,00%	20,00%	22,00%	40,00%	40,00%	50,00%	60,00%	70,00%	82,00%	100,00%	100,00%	100,00%	**57,17%**
KPI_2	% Calls answered within service level time	62,82%	82,05%	100,00%	94,87%	100,00%	100,00%	75,36%	93,10%	100,00%	100,00%	100,00%	100,00%	**92,35%**
KPI_3	TL Total revenue	33,33%	53,33%	60,00%	60,00%	66,67%	66,67%	66,67%	73,33%	73,33%	73,33%	80,00%	100,00%	**67,22%**
KPI_4	TL Total expenses	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	50,00%	50,00%	50,00%	50,00%	0,00%	**75,00%**

KPI ACTUAL STATE

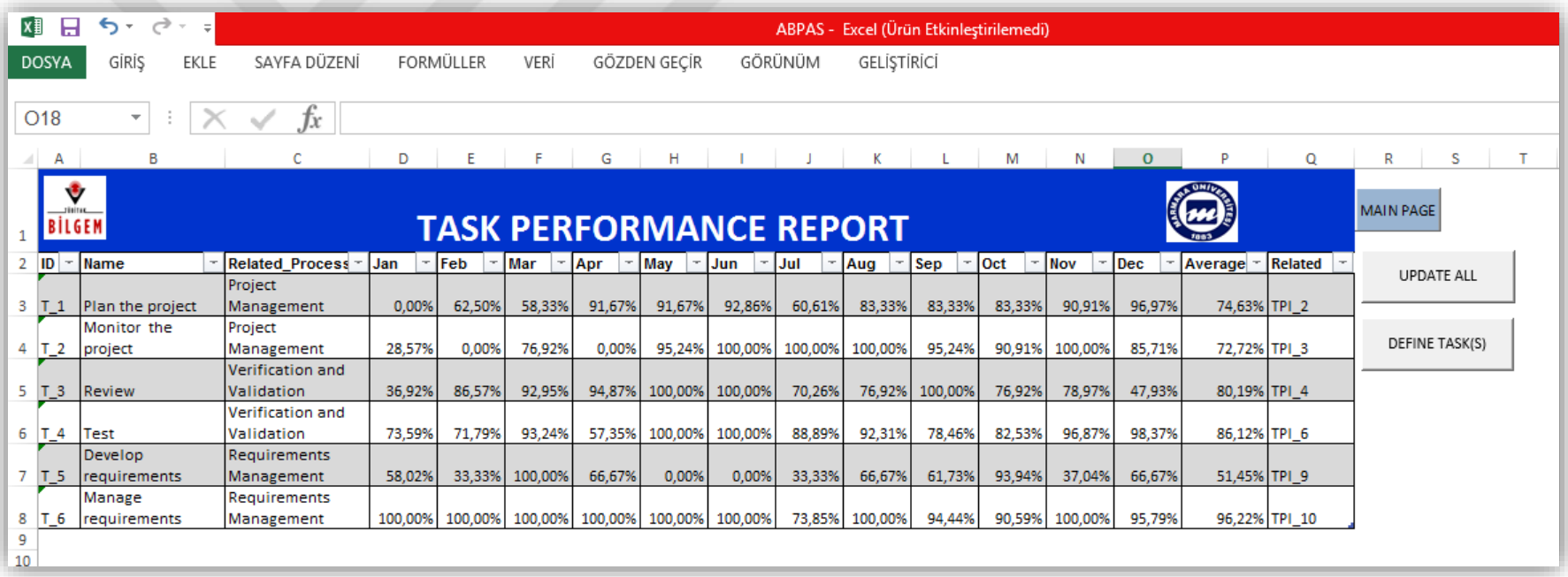
ID	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avera
KPI_1	% Customer satisfaction score	0,31	0,40	0,41	0,50	0,50	0,55	0,60	0,65	0,71	0,80	0,82	0,90	**91,93**
KPI_2	% Calls answered within service level time	0,58	0,69	0,85	0,77	0,96	0,96	0,65	0,76	0,86	0,86	0,90	0,93	**122,39**
KPI_3	TL Total revenue	150,00	180,00	190,00	190,00	200,00	200,00	200,00	210,00	210,00	210,00	220,00	350,00	**183,18**
KPI_4	TL Total expenses	120,00	140,00	160,00	160,00	170,00	180,00	180,00	190,00	190,00	190,00	190,00	300,00	**170,00**

APPENDIX 1-Figure 4 KPI performance report



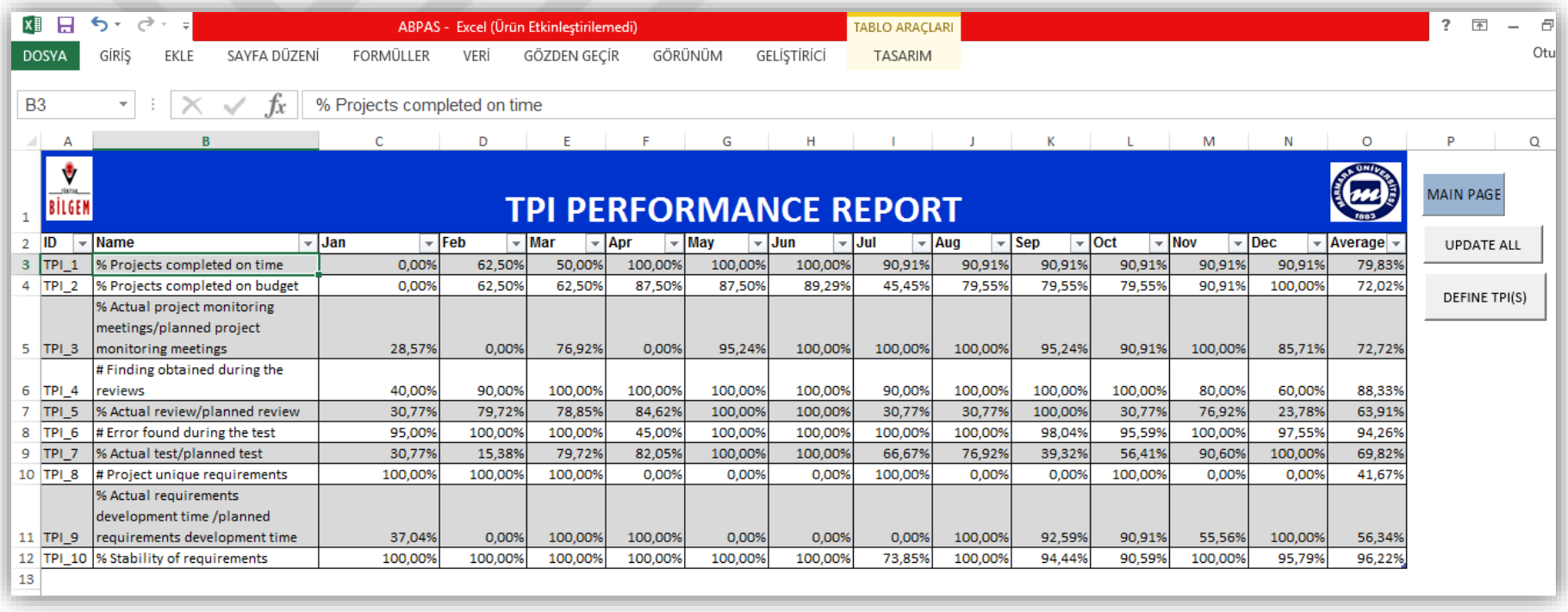
ID	Name	Process Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Process Quality Level	Related
P_1	Project Management	Management	9,52%	41,67%	64,53%	61,11%	92,86%	95,24%	73,74%	88,89%	87,30%	85,86%	93,94%	93,22%	73,99%	Good	T_1
P_2	Verification and Validation	Support	61,37%	76,72%	93,14%	69,86%	100,00%	100,00%	82,68%	87,18%	85,64%	80,66%	90,90%	81,55%	84,14%	Very good	T_4
P_3	Requirements Management	Operational	72,02%	55,56%	100,00%	77,78%	33,33%	33,33%	46,84%	77,78%	72,63%	92,82%	58,02%	76,37%	66,37%	Good	T_5

APPENDIX 1-Figure 5 Process performance report



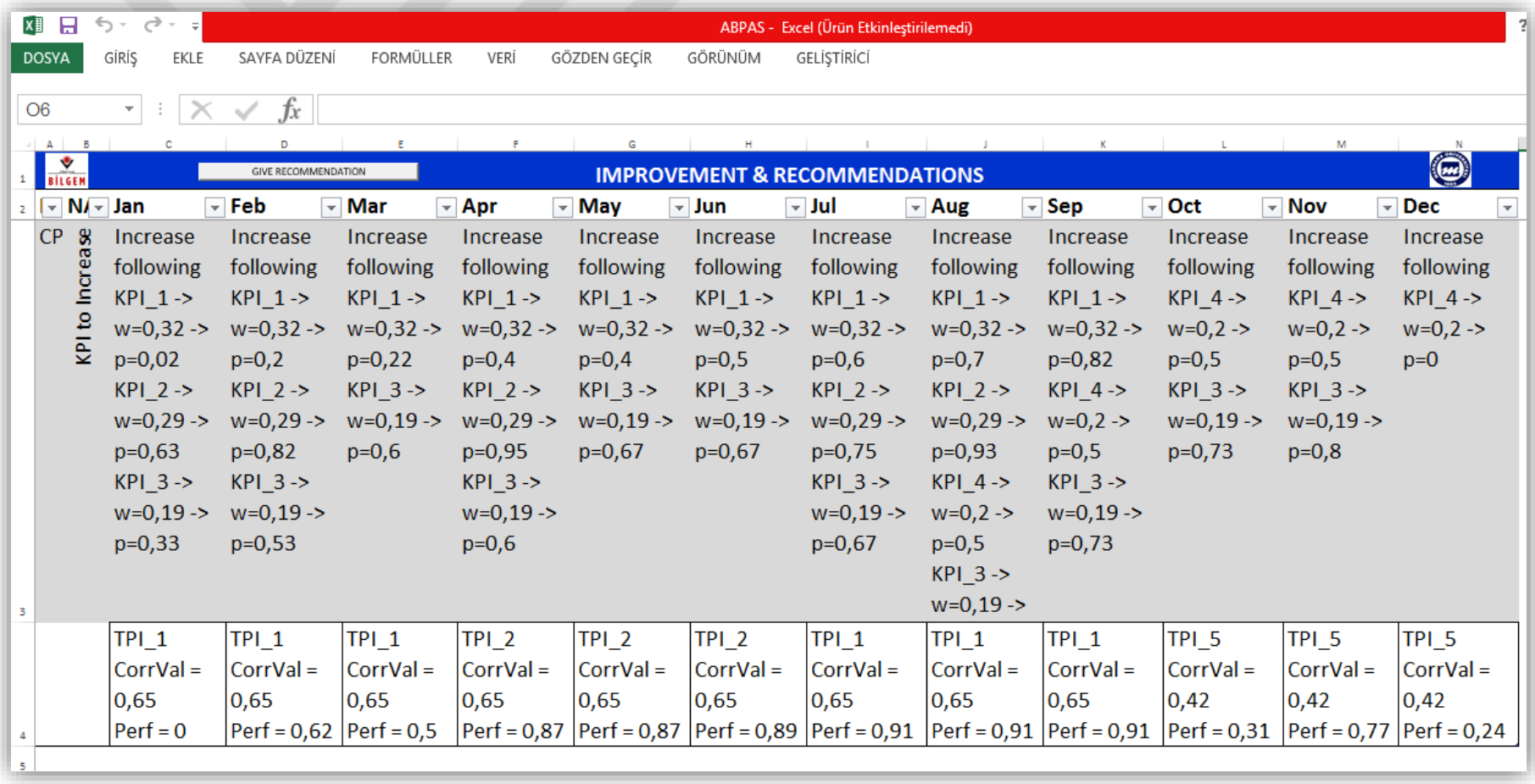
ID	Name	Related_Process	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Related
T_1	Plan the project	Project Management	0,00%	62,50%	58,33%	91,67%	91,67%	92,86%	60,61%	83,33%	83,33%	83,33%	90,91%	96,97%	74,63%	TPI_2
T_2	Monitor the project	Project Management	28,57%	0,00%	76,92%	0,00%	95,24%	100,00%	100,00%	100,00%	95,24%	90,91%	100,00%	85,71%	72,72%	TPI_3
T_3	Review	Verification and Validation	36,92%	86,57%	92,95%	94,87%	100,00%	100,00%	70,26%	76,92%	100,00%	76,92%	78,97%	47,93%	80,19%	TPI_4
T_4	Test	Verification and Validation	73,59%	71,79%	93,24%	57,35%	100,00%	100,00%	88,89%	92,31%	78,46%	82,53%	96,87%	98,37%	86,12%	TPI_6
T_5	Develop requirements	Requirements Management	58,02%	33,33%	100,00%	66,67%	0,00%	0,00%	33,33%	66,67%	61,73%	93,94%	37,04%	66,67%	51,45%	TPI_9
T_6	Manage requirements	Requirements Management	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	73,85%	100,00%	94,44%	90,59%	100,00%	95,79%	96,22%	TPI_10

APPENDIX 1-Figure 6 Task performance report



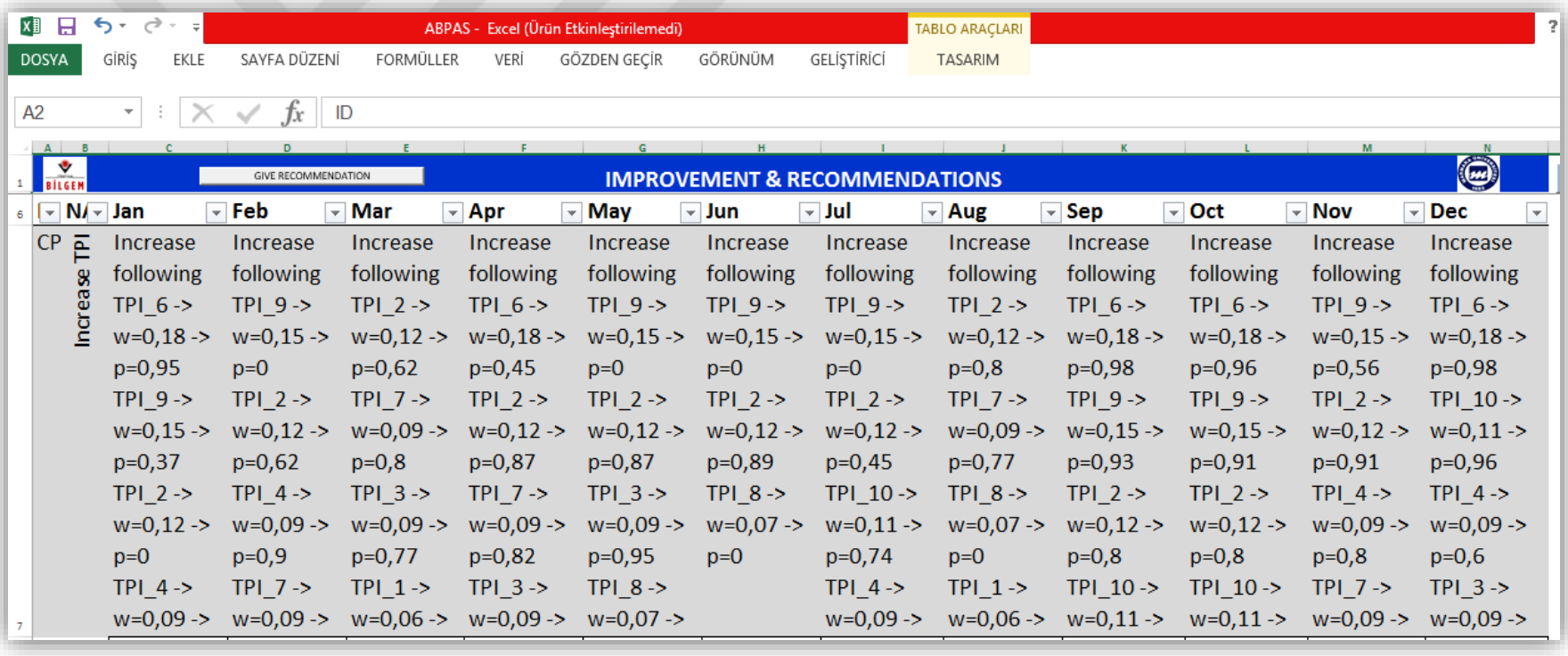
ID	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
TPI_1	% Projects completed on time	0,00%	62,50%	50,00%	100,00%	100,00%	100,00%	90,91%	90,91%	90,91%	90,91%	90,91%	90,91%	79,83%
TPI_2	% Projects completed on budget	0,00%	62,50%	62,50%	87,50%	87,50%	89,29%	45,45%	79,55%	79,55%	79,55%	90,91%	100,00%	72,02%
TPI_3	% Actual project monitoring meetings/planned project monitoring meetings	28,57%	0,00%	76,92%	0,00%	95,24%	100,00%	100,00%	100,00%	95,24%	90,91%	100,00%	85,71%	72,72%
TPI_4	# Finding obtained during the reviews	40,00%	90,00%	100,00%	100,00%	100,00%	100,00%	90,00%	100,00%	100,00%	100,00%	80,00%	60,00%	88,33%
TPI_5	% Actual review/planned review	30,77%	79,72%	78,85%	84,62%	100,00%	100,00%	30,77%	30,77%	100,00%	30,77%	76,92%	23,78%	63,91%
TPI_6	# Error found during the test	95,00%	100,00%	100,00%	45,00%	100,00%	100,00%	100,00%	100,00%	98,04%	95,59%	100,00%	97,55%	94,26%
TPI_7	% Actual test/planned test	30,77%	15,38%	79,72%	82,05%	100,00%	100,00%	66,67%	76,92%	39,32%	56,41%	90,60%	100,00%	69,82%
TPI_8	# Project unique requirements	100,00%	100,00%	100,00%	0,00%	0,00%	0,00%	100,00%	0,00%	0,00%	100,00%	0,00%	0,00%	41,67%
TPI_9	% Actual requirements development time /planned requirements development time	37,04%	0,00%	100,00%	100,00%	0,00%	0,00%	0,00%	100,00%	92,59%	90,91%	55,56%	100,00%	56,34%
TPI_10	% Stability of requirements	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	73,85%	100,00%	94,44%	90,59%	100,00%	95,79%	96,22%

APPENDIX 1-Figure 7 TPI performance report



	NA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
KPI to Increase	CP	Increase following KPI_1 -> w=0,32 -> p=0,02 KPI_2 -> w=0,29 -> p=0,63 KPI_3 -> w=0,19 -> p=0,33	Increase following KPI_1 -> w=0,32 -> p=0,2 KPI_2 -> w=0,29 -> p=0,82 KPI_3 -> w=0,19 -> p=0,53	Increase following KPI_1 -> w=0,32 -> p=0,22 KPI_3 -> w=0,19 -> p=0,6	Increase following KPI_1 -> w=0,32 -> p=0,4 KPI_2 -> w=0,29 -> p=0,95 KPI_3 -> w=0,19 -> p=0,6	Increase following KPI_1 -> w=0,32 -> p=0,4 KPI_3 -> w=0,19 -> p=0,67	Increase following KPI_1 -> w=0,32 -> p=0,5 KPI_3 -> w=0,19 -> p=0,67	Increase following KPI_1 -> w=0,32 -> p=0,6 KPI_2 -> w=0,29 -> p=0,75 KPI_3 -> w=0,19 -> p=0,67	Increase following KPI_1 -> w=0,32 -> p=0,7 KPI_2 -> w=0,29 -> p=0,93 KPI_4 -> w=0,2 -> p=0,5 KPI_3 -> w=0,19 ->	Increase following KPI_1 -> w=0,32 -> p=0,82 KPI_4 -> w=0,2 -> p=0,5 KPI_3 -> w=0,19 -> p=0,73	Increase following KPI_4 -> w=0,2 -> p=0,5 KPI_3 -> w=0,19 -> p=0,73	Increase following KPI_4 -> w=0,2 -> p=0,5 KPI_3 -> w=0,19 -> p=0,8	Increase following KPI_4 -> w=0,2 -> p=0
		TPI_1 CorrVal = 0,65 Perf = 0	TPI_1 CorrVal = 0,65 Perf = 0,62	TPI_1 CorrVal = 0,65 Perf = 0,5	TPI_2 CorrVal = 0,65 Perf = 0,87	TPI_2 CorrVal = 0,65 Perf = 0,87	TPI_2 CorrVal = 0,65 Perf = 0,89	TPI_1 CorrVal = 0,65 Perf = 0,91	TPI_1 CorrVal = 0,65 Perf = 0,91	TPI_1 CorrVal = 0,65 Perf = 0,91	TPI_5 CorrVal = 0,42 Perf = 0,31	TPI_5 CorrVal = 0,42 Perf = 0,77	TPI_5 CorrVal = 0,42 Perf = 0,24

APPENDIX 1-Figure 8 Improvement & recommendation report-KPI



APPENDIX 1-Figure 9 Improvement & recommendation report-TPI

CURRICULUM VITAE

Nilgün GÖKMEN was born in Gebze on June 28. She completed her primary and secondary school education in Şile Demirtaşpaşa Elementary School in 1998. In 2002, high school diploma, as a first grade winner, was awarded by Şile 50.Yıl Super High School.

Then in 2006, she was graduated from Sakarya University Industrial Engineering Department as a third grade student. After graduation, she took an advanced English course in SUNY Plattsburgh University in the USA as a scholarship student. In the same year, she worked in Işık University Industrial Engineering Department as a Research Assistant.

From 2007, she have been working in TUBITAK Informatics and Information Security Research Center (BILGEM) Information Technologies Institute (ITI) as Configuration and Quality Manager. At the same time, she completed her master study in Marmara University Industrial Engineering Department in 2009.