Enhancement and Implementation of Maturity Model for Software Process Improvement

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APPROVAL

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IN THE NAME OF ALMIGHTY ALLAH
THE MOST BENEFICENT AND THE MOST MERCIFUL

DEDICATED TO
MY FAMILY MEMBERS, TECHERS
AND FRIENDS

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ABSTRACT

To compete in the international market, there is a need to improve both the quality of our software products and our ability to deliver the product within time and budget. These improvements depend strongly on process as well as technology. Software Process Improvement (SPI) is an ongoing effort because the process keeps evolving over time.

The current problem with SPI is not a lack of standard or model, but rather a lack of an effective strategy to successfully implement these standards or models. The importance of SPI implementation demands that it be recognized as a complex process in its own right and that organizations should determine their SPI implementation maturity through an organized set of activities. Niazi et al suggested SPI implementation maturity model that has the potential to help companies assess and improve their SPI implementation processes. This model is extracted from Capability Maturity Model Integration (CMMI) and is based on critical success factors (CSFs) and critical barriers identified through literature and an empirical study. This model has three dimensions; Stage Dimension, Critical Success Factor (CSF) Dimension, and Assessment Dimension. Stage dimension comprises of four maturity levels; initial, aware, defined and optimizing, and set of CSFs and critical barriers for all these levels has been defined in CSF dimension. In assessment dimension each of the CSF and critical barrier is measured in order to assess how well the factor has been implemented in practice of that organization. In order to resolve the conflict of different stakeholder's evaluation standards of same factor, an already tested instrument i.e. the Motorola instrument has been used in this dimension. However, this model has many weak areas and needs improvement.

My work comprises of four phases. In first phase, I identified weaknesses in the model and suggested improvements. In the second phase, I interacted with the experts from local software industry to evaluate suggested enhancement to the model. In phase three, I implemented this model using the .Net (dot net) framework to provide this

model in the shape of a Computer-Aided Software Engineering (CASE) tool to the software industry so that the organizations can evaluate their SPI status. Finally, I conducted a case study in a software development company in order to validate performance of the model and usability of the CASE tool.

Keywords: Software Process Improvement (SPI), Capability Maturity Model Integration (CMMI), CASE Tool, Critical Success Factors, Critical Barriers, Assessment Instrument, Maturity Model

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LIST OF ABBREVIATIONS

AISPI	Assessment Instrument for Software Process Improvement
CASE	Computer Aided Software Engineering
CB	Critical Barriers
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
CSF	Critical Success Factor
IEC	International Electro-technical Commission
ISO	International Organization for Standardization
IT	Information Technology
KPA	Key Process Area
PM	Project Manager
RDM	Relational Data Model
QIP	Quality Improvement Paradigm
SEI	Software Engineering Institute
SEPG	Software Engineering Process Group
SPI	Software Process Improvement
SPICE	Software Process Improvement Capability dEtermination
TQM	Technical Quality Management

CHAPTER 1

INTRODUCTION

In this chapter we will provide an overview of the problem area which will be the focus of our work. We will discuss our research approach and outline structure of the thesis.

1.1 Background

Problems associated with software quality are widely acknowledged to affect the development cost and time [1]. The Standish Group's just-released report, "CHAOS Summary 2009," which reports that "This year's results show a marked decrease in project success rates, with 32% of all projects succeeding which are delivered on time, on budget, with required features and functions. Further it says 44% were challenged which are late, over budget, and/or with less than the required features and functions and 24% failed which are cancelled prior to completion or delivered and never used." These numbers represent a downtick in the success rates from the previous study, as well as a significant increase in the number of failures, says Jim Crear, chairman of Standish Group. This year's results represent the highest failure rate in over a decade [2].

A study, conducted by a group of Fellows of the Royal Academy of Engineering and British Computer Society, shows that despite spending 22.6 billion pounds on IT projects in UK during 2003/2004, significant numbers of projects still fail to deliver key benefits on time and to target cost and specification [3].

There have been increasing calls for the software industry to find solutions to software quality problems [4]. Software organizations are realizing that one of their fundamental problems is to have an effective software development process [5]. In

order to have an effective software development process different methods have been developed, of which Software Process Improvement (SPI) is the one, mostly used.

Surviving in the increasingly competitive software business requires more than hiring smart, knowledgeable software engineers and buying the latest development tools. Effective software development processes are also needed, so those smart software engineers can systematically use the best technical and managerial practices to successfully complete their projects within allotted time and budget. More organizations are looking at software process improvement as a way to improve the quality, productivity, and predictability of their software development, acquisition, and maintenance efforts.

Different models and standards have been developed in order to improve software processes. The CMM is developed by software engineering institute (SEI) at Carnegie Mellon University in Pittsburgh, Pennsylvania in order to improve organizations' software processes. The Capability Maturity Model Integration (CMMI) [6] is the latest SPI model from the SEI. SPICE is a set of international standards for software process assessment [7]. SPICE is intended to harmonize many different approaches to software process assessment and to provide an approach that encourages self-assessment. The ISO 9000 series of standards [8] were developed with the intent of creating a set of common standards for quality management and quality assurance.

The importance of SPI implementation demands that it be recognized as a complex process in its own right and that organizations should determine their SPI implementation maturity through an organized set of activities. In the literature, much attention has been paid to ‘‘what activities to implement’’ instead of ‘‘how to implement’’ these activities. We believe that identification of only ‘‘what’’ activities to implement is not sufficient and that knowledge of ‘‘how’’ to implement is also required for successful implementation of SPI programs.

1.2 Problem Statement

Different advances have been made in the development of software process improvement (SPI) standards and models, e.g. capability maturity model (CMM), more recently CMMI, and ISO's SPICE. However, these advances have not been matched by equal advances in the adoption of these standards and models in software development which has resulted in limited success for many SPI efforts. The current problem with SPI is not a lack of standard or model, but rather a lack of an effective strategy to successfully implement these standards or models. Another problem with SPI is that researchers do suggest solutions but most of these solutions remain in theoretical form and the industry can't benefit from these solutions.

In [9] authors have proposed a maturity model for SPI implementation that has the potential to help companies assess and improve their SPI implementation processes. Specifically, they have adopted a CMMI approach and developed a maturity model for SPI implementation in order to guide organizations in assessing and improving their SPI implementation processes. Our work is greatly influenced by their work and in fact we have physically implemented their work after critically analyzing it. We will briefly discuss their work in chapter 03. This model is now available to the industry in the form of CASE tool.

In the design of this maturity model authors [9] have extended the concept of critical success factors (CSFs) and critical barriers (CSFs). However, the set of practices suggested by Niazi et al, to satisfy each of these CSFs or CBs in the maturity model, are at a very abstract level. Further research is needed to elaborate the model and practices with some fine grain details. Also, if more than one practice have been suggested to achieve one CSF, no mechanism has been detailed how to prioritize these practices. This critical analysis of the maturity model for SPI implementation, for the purpose to enhance it and implement it, is the focus of our work to further enhance.

1.3 Objectives

With this in background, the overall objective of my research is: “Implementation of Assessment Instrument for Software Process Improvement”. To achieve this objective, I had set following few goals for my work:

- Gain in-depth knowledge about software development process with major focus on SPI
- Survey various approaches for SPI
- Identify the shortcomings of the existing efforts taken for SPI
- Survey solutions for SPI implementation
- Practically implement the solution
- Validation of our developed tool
- Identify future research areas

1.4 Research Approach

This research work is based on the combination of two major research methodologies: Theoretical research and an Empirical study.

1.4.1 Theoretical Research

During the theoretical research, several steps are taken to examine the current practice in the field of SPI and identify potential improvement opportunities. The steps are described as follows:

- Firstly, a thorough and exhaustive knowledge about SPI is gained. This step is conducted by reviewing existing literature in this area and analyzing the nature of software development process.
- Secondly, the weaknesses & flaws in the current approaches and efforts taken for SPI are identified. In fact answer to the following question is explored: “What de-motivates practitioners in order to implement SPI initiatives?”

- The maturity model for SPI implementation proposed in [9] is, then, critically analyzed and possible improvements are identified.
- Maturity model for SPI implementation is then physically implemented using .Net framework and provided in the form of CASE tool.

1.4.2 Empirical Study

Following the theoretical research, this work conducts an empirical study to validate our proposed practices and to evaluate the developed CASE tools. This experiment was conducted as follows.

- **Participants:** This experiment was conducted by a manager involved in software development for industrial applications in certain confidential organization. He tested this instrument through his official colleagues and shared his experience which is reported in chapter 06.

1.5 Thesis Structure

This thesis is structured into six chapters. The rest of the document is organized as follows: chapter 02 provides literature review. In this chapter different concepts and models related to software process improvement are discussed, in chapter 03 some details about maturity model for SPI proposed by Niazi et al, and its three dimensions are discussed. Chapter 04 discusses system analysis and design of maturity model. In chapter 05, demonstration of the developed assessment instrument is detailed, while in chapter 06 thesis work is concluded and some future directions for research are discussed.

CHAPTER 2

LITERATURE REVIEW

This chapter gives an introduction to the domain of SPI and includes a review of process frameworks/models and standards which play a vital role in the success of software systems. Exploring SPI-related literature provides valuable insights into the current state of software development research and commercial practices. We consider existing research approaches, particularly with respect to aspects such as the development process of software systems and implementation of improvements in these development processes. From this we can identify aspects which have been missing from current approaches and find that open issues that have not yet been adequately addressed. In particular, it is our contention in this research that the current problem with SPI is not a lack of standard or model, but rather a lack of an effective strategy to successfully implement these standards or models. The aim of this chapter is to provide background material and to put this research into context and to set the scene for the contribution that this work will make to the knowledge of SPI domain.

2.1 Overview

Now-a-days majority of organizations have become more and more dependent on software systems to function efficiently. The development and deployment of software in organizations is creative task, but it is not so easy to manage because it needs skilled and committed management for software development. Too often projects overrun their budget or schedule or do not deliver what was expected. The high risk of software and information system development combined with company executives failing to understand the benefits and complexities of software development has put pressure on IT professionals to improve their performance [24].

To improve the performance of IT, the professionals are pressurized by the management to solve their isolated problems on a project-by-project or a system-by-

system basis. Perhaps this approach will lead to some quick wins on the short run but creates a bit problem. On the long run, by solving problems on a project-by-project or problem-by-problem basis, they run the risk of not solving underlying causes that create the problems in their projects and they has to repeat the problem solving process time and time again [24].

An alternate approach for improving the productivity of projects is to concentrate on the development process instead of on the quality of product itself. Improving the development process for product production will ultimately improve the output of each project within your organization. Therefore, improving the software development process, instead of directly improving individual software systems or projects, is called software process improvement (SPI). For software process improvement to actually deliver results to an organization, it needs to be successfully implemented in that organization. Commitment to SPI from both IT staff and executive management is a crucial factor in successfully implementing SPI [24].

2.2 Software Development Methods

Compulsion of structure on the software engineering and development activities with the intention to organize the activities and make them to successfully provide the intended outputs is being achieved with software development methods. These methods can be considered as the procedures for successfully performing the indentified tasks for achieving the required product using its developing processes.

The development methods can be subdivided into three categories [24]:

- Heuristic methods that focus on a linear set of activities that progress from requirement gathering, designing, coding, debugging, and testing to implementation. Structured, data-oriented, object-oriented, and domain-specific development methods are all examples of heuristic methods because they all capture design decisions in a more or less non formal way.
- Formal methods use mathematical descriptions to define the required functionality of a piece of software. When the specifications are completed, one can use

techniques from mathematics and theoretical computer science to further refine the specification into a working computer program.

- The last category of development methods is called the prototype methods, which use prototypes of the system to clarify functional requirements and subsequently use prototypes to evolve the design of a system. Instead of focusing on upfront work, prototype methods focus on the interaction with the customer and experimenting with technology. Agile methods fall under the category of prototyping methods.

Just as, there exists no “best” software process improvement approach, there is also no “best” development method [24].

2.3 Software Process Improvement

Software process improvement is a strategy to improve the practice implementation in software and information systems engineering and development activities. SPI standardizes work processes, tailored to the organization’s specific circumstances, based on best practices that are derived from the own organization, academia or exemplary, well-performing organizations [24].

SPI comes in two forms [26, 27]: the analytical approach and the benchmarking approach.

- The analytical approach uses both qualitative and quantitative investigations to understand software development and maintenance projects. Based on a thorough understanding of the processes guiding the projects, problems and points of improvement can be identified. Experimentation is used to test whether changes to the development and maintenance processes yield the improvements that were expected. An example of an analytical approach to software process improvement is the Quality Improvement Paradigm (QIP) [25].
- The benchmarking paradigm uses best-practice models for the activities improvement in software development environment. The best features of some reputable organizations that may be management or engineering processes are

identified and ranked according to their necessity for process improvement in other organization. These identified and ranked practices are considered as the part of the best-practice model divided in maturity levels that forms the basis of the improvement activities within an organization [24].

When taking the benchmarking approach to software process improvement, an organization compares its own software development and maintenance processes to a best practice model. When deviations from the best-practice model are identified, an organization either justifies why it deviates from the best-practice model or (when a good reason is lacking) the organization adjusts its own processes to incorporate the missing practices [24].

Examples of best-practice models are the Capability Maturity Model (CMM) and its successor the Capability Maturity Model Integrated (CMMI), both developed by the Carnegie Mellon University's Software Engineering Institute.

Many software process improvement methodologies offer not only a best-practice model, but also an improvement model. These improvement models offer guidance to implement the practices of the best-practice model and offer advice on how to diagnose problems in the current processes. An example of an improvement model is the IDEAL model [24] that is associated with the CMM model. IDEAL stands for Initiating, Diagnosing, Establishing, Acting and Learning.

Maturity Model for SPI by Niazi et al is also a best practice and an improvement model, as it provides the best practices to be compared with and provide guidelines to the organizations to improve their current state of software development processes.

2.4 Software Process Improvement Methodologies

There have been increasing calls for the software industry to find solutions to software quality problems [1]. Software organizations are realizing that one of their fundamental problems is to have an effective software development process [5; 10]. In order to have an effective software development process, different methods have been

developed, of which SPI is the one used mostly. The objective of this section is to discuss and analyze different approaches to SPI in order to identify the issues that undermine these approaches. A number of models and standards have been developed in order to improve software processes. However, we will concentrate on and report in this section, the most widely used and known models, for example IDEAL, SPICE, CMM and CMMI.

2.4.1 IDEAL

IDEAL is a software process improvement (SPI) model, which can be used to guide the development of a long-range, integrated plan for initiating and managing SPI program. It has five phases of SPI initiative, which provide a continuous loop through the steps necessary for SPI. Time interval required to implement the IDEAL model will vary from organization to organization. The IDEAL model is named for the five phases it describes:

I – Initiating: Laying the groundwork for a successful improvement effort

D – Diagnosing: Determining where you are relative to where you want to be

E – Establishing: Planning the specifics of how you will reach your destination

A – Acting: Doing the work according to the plan

L – Learning: Learning from the experience and improving your ability to adopt new technologies in the future.

Following the phases, activities, and principles of the IDEAL model has proven beneficial in many improvement efforts. Following is the brief detail of five phases and their related activities as shown:

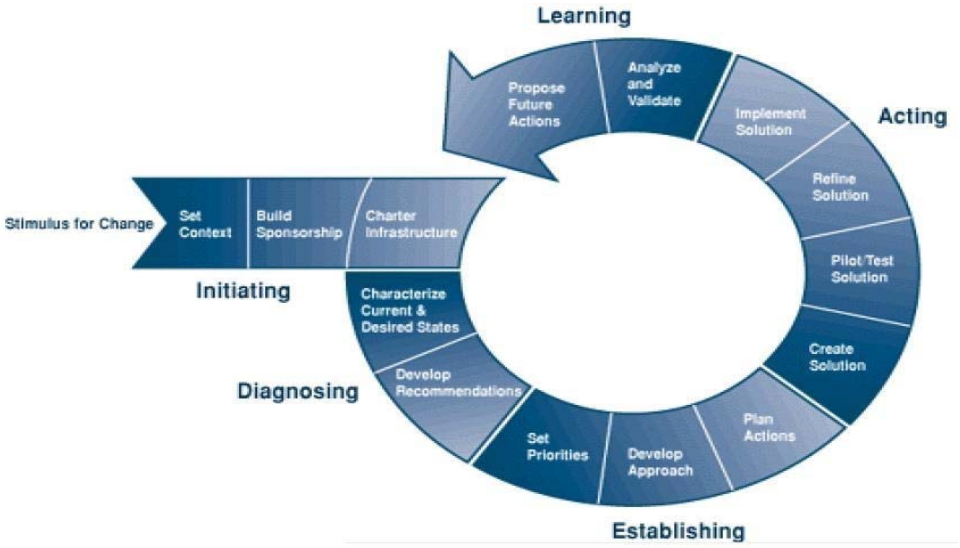

Figure 1: IDEAL Model

2.4.1.1 Initiating Phase

This phase includes learning about process improvement, commitment of initial resources, building process infrastructure and defining roles and responsibilities for the infrastructure [30]. Simply, critical groundwork is completed during this phase for the planning and implementation of software process improvements efforts within an organization. The detail as follows:

Stimulus for change

It is important to recognize the business reasons for changing an organization's practices. The stimulus for change could be unforeseen events or circumstances, an act from someone higher up in the organization, or the information gained from benchmarking activities as part of a continuous improvement approach. In general, when the business reasons for change are clearer, there are greater chances for success.

Set Context

After clearly identifying the reason for change in organization’s practices, the management can set context for the work needed to be done. Context and implication

often become more evident as the effort proceeds, but it is important to be as clear as possible regarding these issues early in the effort [30].

Build Sponsorship

Without strong, informed, and firm commitment and sponsorship from top management, the effort is doomed from the start. It means effective sponsorship is one of the most important factors for improvement efforts to be implemented. The commitment of essential resources is an important element of sponsorship, and sponsors can be most effective if they give personal attention to the effort and stick with it through difficult times [30].

Charter Infrastructure

At the end of this phase, the organization must set up a mechanism for managing the implementation details for the effort. The infrastructure may be temporary or permanent, and its size and complexity may vary substantially depending on the nature of the improvement. For a small effort, the infrastructure may be a single part-time employee; for a large and complex effort, such as software process improvement, it may involve 2-3% of the organization's people across a number of groups [30].

The activities of the initiating phase are critical. If they are done completely and well, subsequent activities can proceed with minimal disruption. If they are done poorly, incompletely, or haphazardly, then time, effort, and resources will be wasted in subsequent phases.

2.4.1.2 Diagnosing Phase

This phase involves the establishment of current levels of process maturity, process descriptions, metrics, etc. and to initiate action plan development. It means current and desired future state of the organization is characterized and these states are being used for the improving business practices.

Characterize Current and Desired States

Characterizing the current and desired states is similar to setting target achievements for improvement efforts. Characterizing these two states can be done more easily using a reference standard such as the CMM for Software. Where such a standard is not available, a good starting point is the factors identified as part of the "stimulus for change" activity.

Develop Recommendations

The recommendations that are developed as a part of this activity suggest a way of proceeding in subsequent activities. The diagnosing phase activities are most often performed by a team with experience and expertise relevant to the task at hand. Their recommendations often weigh heavily in the decisions made by key managers and sponsors.

2.4.1.3 Establishing Phase

This phase includes the formulation of a long term SPI strategic action plan including entire organization’s SPI activities and integrates them with other total quality management (TQM) already planned or in process. The primary output of this step is the SPI strategic action plan and secondary may be revisions to the organization’s vision and business plan [30].

Set Priorities

The first activity of this phase is to set priorities for the change effort. These priorities must take many factors into account: resources are limited, dependencies exist between recommended activities, external factors may interfere, and the Organization's more global priorities must be honored. [30]

Develop Approach

Combining increased understanding of the scope of work with a set of priorities leads to the development of a strategy for accomplishing the work and identifying resource availability. Technical factors might include the specifics of installing the new

technology and new skills and knowledge required for using a technology. Non-technical factors, including the organization's culture, likely sources of resistance, sponsorship levels, and market forces, also must be considered. [30]

Plan Actions

This plan includes schedule, tasks, milestones, decision points, resources, responsibilities, measurement, tracking mechanisms, risks and mitigation strategies, and any other elements required by the organization. [30]

2.4.1.4 Acting Phase

The activities of the acting phase help an organization to implement the work that has been conceptualized and planned in the previous three phases; that will typically consume more calendar time and more resources than all of the other phases combined.

Create Solution

The acting phase begins with bringing all available key elements together to create a "best guess" solution to address the previously identified organizational needs. These key elements might include existing tools, processes, knowledge, and skills, as well as new knowledge, information, and outside help. The solution, which may be quite complex and multi-faceted, is often created by a technical working group.

Pilot/Test Solution

Once a solution has been created, it must be tested, as best guess solutions rarely work exactly as planned. This is often accomplished through a pilot test, but other means may be used.

Refine Solution

Once the paper solution has been tested, it should be modified to reflect the knowledge, experience, and lessons that were gained from the test. Several iterations of the test-refine process may be necessary to reach a satisfactory solution. A solution

should be workable before it is implemented, but waiting for a "perfect" solution may unnecessarily delay the implementation. [30]

Implement Solution

Once the solution is workable, it can be implemented throughout the organization. Various roll-out approaches may be used for implementation, including top-down (starting at the highest level of the organization and working down) and just-in-time (implementing project-by-project at an appropriate time in its life cycle). No one roll-out approach is universally better than another; the approach should be chosen based on the nature of the improvement and organizational circumstances. For a major change, implementation may require substantial time and resources. [30]

2.4.1.5 Learning Phase

Objective of this phase is to make the next pass through the IDEAL model more effective by solutions development, learning lessons, creating metrics on performance and collection of goal achievement. These artifacts are added to the process database that will become a source of information for personnel involved in the next pass through the model [28]. The leveraging phase completes the improvement cycle.

Analyze and Validate

This activity answers several questions: In what ways did the effort accomplish its intended purpose? What worked well? What could be done more effectively or efficiently? Lessons are collected, analyzed, summarized, and documented. The business needs identified during the initiating phase are reexamined to see if they have been met. [30]

Propose Future Actions

During this activity, recommendations based on analysis and validation are developed and documented. Proposals for improving future change implementations are provided to appropriate levels of management for consideration. [30]

2.4.2 SPICE

ISO/IEC 15504, also known as SPICE (Software Process Improvement and Capability dEtermination), is a "framework for the assessment of processes" developed by the Joint Technical Subcommittee between ISO (International Organization for Standardization) and IEC (International Electro-technical Commission) [30].

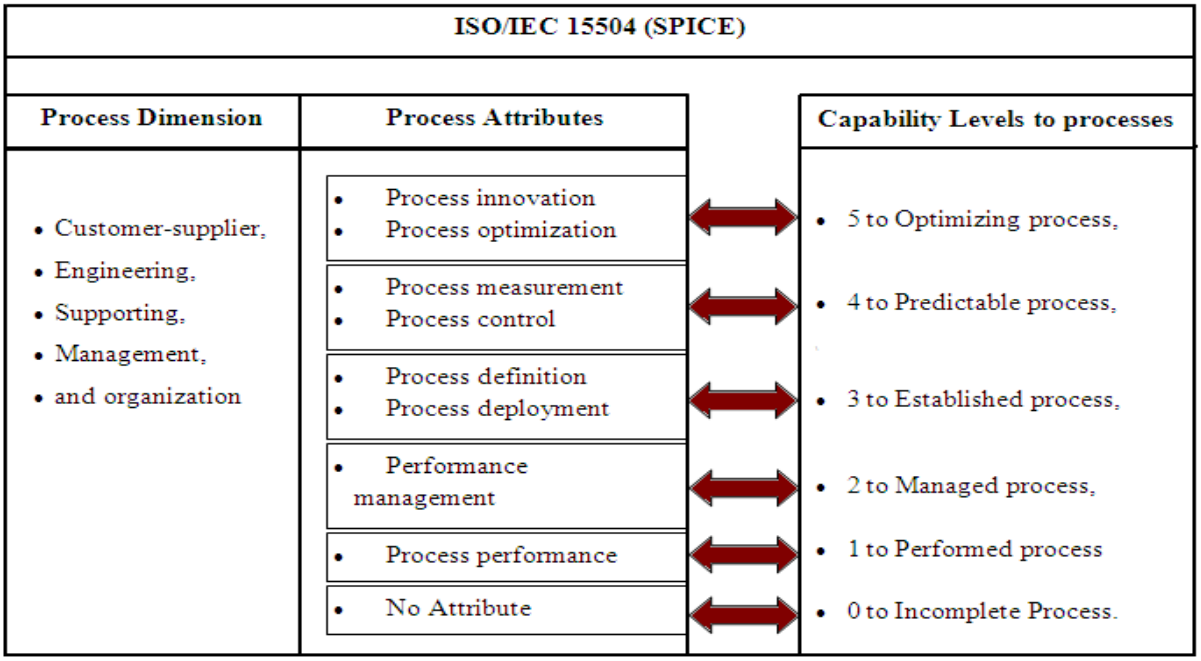

Figure 2: SPICE Model

SPICE contains a reference model that defines a process dimension and a capability dimension. The process dimension defines processes divided into the five process categories of Customer-supplier, Engineering, Supporting, Management, and Organization. The Capability dimension defines capability levels on the following scales. The capability of each process is being measured using process attributes mentioned against each capability level as in above figure.

In addition to this, the scale of ISO/IES 15504 also constitute nine process attributes (which differs it from ISO 9001, having just pass and fail options in scale). These attributes are used to measure process capabilities.

For a given process to achieve a capability level, all lower level process attributes must be fully met and all attributes at the target level must be fully or largely met. Each process attribute is assessed on a four-point (N-P-L-F) rating scale [30]:

- Not achieved (0 - 15%)
- Partially achieved (>15% - 50%)
- Largely achieved (>50%- 85%)
- Fully achieved (>85% - 100%).

SPICE does not provide any specified method but provided general guidance to assessors for process assessment. Assessor collects data on a process by various means, including interviews with persons performing the process, collecting documents and quality records, and collecting statistical process data. The assessor validates this data to ensure it is accurate and completely covers the assessment scope. The assessor assesses this data (using their expert judgment) against a process's base practices and the capability dimension's generic practices in the process rating step. Process rating requires some exercising of expert judgment on the part of the assessor and this is the reason that there are requirements on assessor qualifications and competency [30].

Assessors must have communication skills, specific skills for particular process category and ISO/IEC 15504 related training and experience in process capability assessments. The ISO/IEC 15504 specific training and experience for assessors comprise completion of a 5 day lead assessor training course, performing at least one assessment successfully under supervision of a competent lead assessor, performing at least one assessment successfully as a lead assessor under the supervision of a competent lead assessor. The competent lead assessor defines when the assessment is successfully performed. There exist schemes for certifying assessors and guiding lead assessors in making this judgment [30].

2.4.3 CMM

The Capability Maturity Model (CMM) was originally developed as a tool for objectively assessing the ability of government contractors' processes to perform a contracted software project. CMM is based on the process maturity framework. Though it comes from the field of software development, it is used as a general model to aid in improving organizational business processes in diverse areas; for example in software engineering, system engineering, project management, software maintenance, risk management, system acquisition, information technology (IT), services, business processes generally, and human capital management. The CMM has been used extensively worldwide in government, commerce, industry and software development organizations.

2.4.3.1 Capability Maturity Model Structure

The Capability Maturity Model involves the following aspects:

- Maturity Levels: a 5-Level process maturity band - where the uppermost (5th) level is a notional ideal state where processes would be systematically managed by a combination of process optimization and continuous process improvement.

- Key Process Areas: a Key Process Area (KPA) identifies a cluster of related activities that, when performed collectively, achieve a set of goals considered important.

- Goals: the goals of a key process area summarize the states that must exist for that key process area to have been implemented in an effective and lasting way. The extent to which the goals have been accomplished is an indicator of how much capability the organization has established at that maturity level. The goals signify the scope, boundaries, and intent of each key process area.

- Common Features*:* common features include practices that implement and institutionalize a key process area. There are five types of common features:

commitment to Perform, Ability to Perform, Activities Performed, Measurement and Analysis, and Verifying Implementation.

- Key Practices: the key practices describe the elements of infrastructure and practice that contribute most effectively to the implementation and institutionalization of the KPAs.

2.4.3.2 Levels of Capability Maturity Model

There are following five levels defined along the band of the CMM.

- Level 1 – Initial: Processes at this level are typically not documented and in a state of dynamic change, tending to be driven in an ad hoc, uncontrolled and reactive manner by users or events. It provides a chaotic or unstable environment for the processes and depends on individual heroics.

- Level 2 – Repeatable: Some processes are repeatable, possibly with consistent results and process discipline is unlikely to be rigorous, but where it exists it may help to ensure that existing processes are maintained during times of stress.

- Level 3 – Defined: Here are sets of defined and documented standard processes established and subject to some degree of improvement over time. These standard processes are in place and used to establish consistency of process performance across the organization.

- Level 4 – Managed: Here process metrics are being used. In particular, management can identify ways to adjust and adapt the process to particular projects without measurable losses of quality or deviations from specifications. Process Capability is established from this level.

- Level 5 – Optimized: At this level focus is on continually improving process performance through both incremental and innovative technological changes/improvements. Here, processes are concerned with addressing statistical

common causes of process variation and changing the process to improve process performance.

2.4.4 CMMI

CMMI is the successor of the capability maturity model (CMM), which was developed by the CMMI project, aimed to improve the usability of maturity models by integrating many different models into one framework. CMMI is a process improvement approach that provides organizations or projects with the essential elements of effective processes that ultimately improve their performance. It helps to integrate traditionally separate organizational functions, set process improvement goals, provide guidance for quality processes, and provide a point of reference for assessing the current organization’s processes.

CMMI exists in two representations: continuous and staged [29]. The continuous representation allows the user to focus on the specific processes that are considered important for the organization's immediate business objectives. The continuous approach yields one of six capability levels. The staged representation is defined as a standard sequence of improvements, and can serve as a basis for comparing the maturity of different projects and organizations. The staged approach yields appraisal results as one of five maturity levels

CMMI has three different areas of interest (models); development, services and acquisition. CMMI models are collections of best practices that you can compare to your organization's best practices and guide improvement to your processes.

2.5 What is missing in Current Approaches to SPI?

In order to address the effective management of software process different approaches have been developed, of which SPI is the one most often used. Research shows that the effort put into these model and standards can assist in producing high quality software [10; 15].

Despite these documented benefits, SPI initiatives exhibit low levels of adoption and limited success [16]. Deployment is often not only multi-project, but multi-site and multi-customer type and the whole SPI initiative typically requires a long-term approach. It takes significant time to fully implement an SPI initiative [17]. Such time frames mean that the SPI approach is often considered an expensive approach for many organizations [16] as they need to commit significant resources over an extensive period of time. Even organizations willing to commit the resources and time do not always achieve their desired results. The failure rate of SPI initiatives is very high, estimated as 70% [18; 19]. The significant investment and limited success are reasons for many organizations being reluctant to embark on a long path of systematic process improvement.

In the literature, much attention has been paid to ‘‘what activities to implement’’ instead of ‘‘how to implement’’ these activities. Identification of only ‘‘what’’ activities to implement is not sufficient and that knowledge of ‘‘how’’ to implement is also required for successful implementation of SPI programmes [9].

Despite the importance of SPI implementation process, little empirical research has been carried out on developing ways in which to effectively implement SPI programmes [14; 16]. Much attention has been paid to developing standards and models for SPI. This suggests that the current problems with SPI are not a lack of standards or models, but rather a lack of an effective strategy to successfully implement these standards or models. A thorough literature review [12; 13; 15; 20; 21] and an interviews with 34 Australian practitioners [11] revealed that in general no standard approach has been adopted by practitioners for the implementation of SPI initiatives. Organizations typically adopt ad hoc methods instead of standard, systematic and rigorous methods in order to implement SPI initiatives [22]. So far no approach has been identified that could assist specifically in the design of effective SPI implementation initiatives. There is a great need to develop some mechanism that could assist SPI practitioners in the design and implementation of effective SPI

initiatives. This has the potential to reduce SPI implementation time, cost and failure risks.

Recently Niazi et al [9] have developed a maturity model for SPI implementation in order to guide organizations in assessing and improving their SPI implementation processes. In the design of this maturity model authors [9] have extended the concept of critical success factors (CSFs) and critical barriers (CSFs). However, the set of practices suggested by Niazi et al, to satisfy each of these CSFs or CBs in the maturity model, are at a very abstract level. Further research is needed to elaborate the model and practices with some fine grain details. Also, if more than one practice have been suggested to achieve one CSF, no mechanism has been detailed how to prioritize these practices. Another problem with this solution is that it is still a theoretical model and organization has to work manually if they want to use this model. However, with all these weaknesses, this seems to be an effective solution if enhanced further and if provided in the form of CASE tool, to the software developers. This maturity model is further explained in the next chapter.

2.6 Summary

The analysis of the literature shows that large enterprises using processes based on SPI models and standards can produce higher quality software, reduce development cost and time, and increase development productivity. Identification of only ‘‘what’’ activities to implement is not sufficient and that knowledge of ‘‘how’’ to implement is also required for successful implementation of SPI programmes. There is a great need to develop some mechanism that could assist SPI practitioners in the design and implementation of effective SPI initiatives. One such mechanism has been proposed by Niazi et al [9] in the form of a maturity model for SPI implementation in order to guide organizations in assessing and improving their SPI implementation processes. However, this mechanism still needs some enhancement and physical implementation so that it is available to the organization in the form of a CASE tool.

CHAPTER 3

MATURITY MODEL FOR SPI

This chapter introduces maturity model for SPI implementation, its different dimensions and self evaluation process of an organization with this model using Motorola instrument.

3.1 Introduction

Maturity model has been presented by Mahmood Niazi et al for SPI implementation on CMMI perspective with the intention to guide different organizations/ companies to assess and improve their SPI implementation processes. This model is extracted from Capability Maturity Model Integration (CMMI) and is based on critical success factors (CSFs) and critical barriers identified through literature review and an empirical study. The structure of this model is built upon the following three dimensions.

1. Maturity Stage Dimension
2. Critical Success Factor Dimension
3. Assessment Dimension

Different maturity levels have been designed on the categorization of CSFs and critical barriers. These CSFs and critical barriers are identified through literature and CSF interviews held by Niazi et al. Following figure shows that organization should address each factor in order to achieve a certain maturity level. Under each factor different practices have been designed that guide how to assess and implement each factor. Maturity means that extent to which an implementation process is explicitly defined, managed and measured. The maturity level is defined as a well-defined stage towards achieving a mature implementation process. [31]

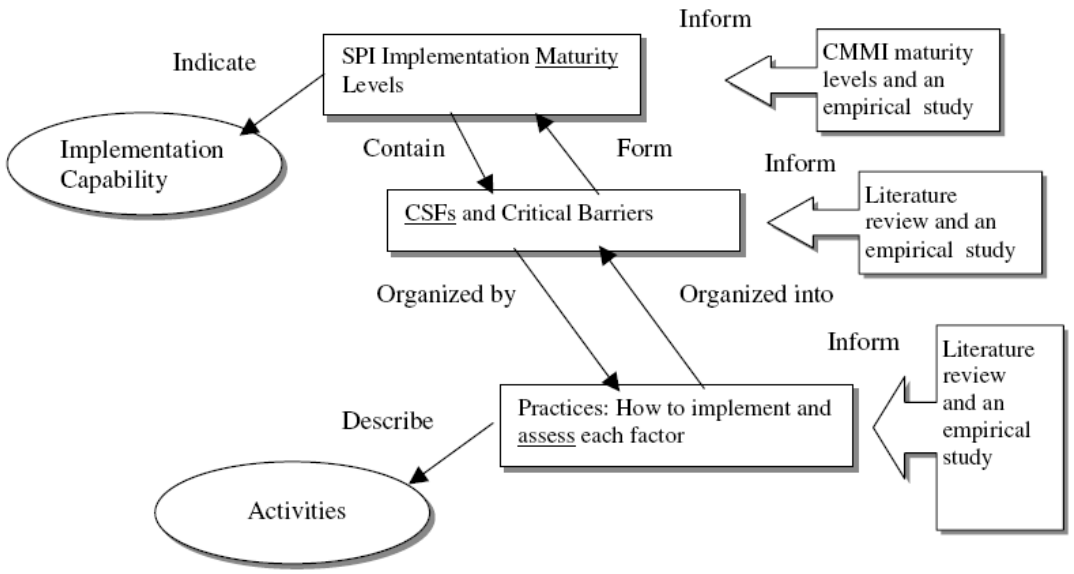

Figure 3: SPI Implementation Maturity Model Structure [9]

3.1.1 Maturity Stage Dimension

Maturity model is based on CMMI perspective; therefore, several adjustments to the staged structure of CMMI are made to take account of SPI implementation characteristics. This dimension comprises of following four maturity levels; initial, aware, defined and optimizing.

Maturity model adopted level-01 directly from CMMI that is “Initial” where the SPI implementation process is chaotic and few processes are defined.

Level-02 of this model is “Aware” which is merged from the empirical study as an important factor for SPI implementation i.e. cited 43% of CSF interviews [9]. SPI implementation is the adoption of new practices in the organization; therefore, it is very important to promote awareness of SPI and to share knowledge among different practitioners within organization. It is being promoted through arranging high level training sessions for practitioners to fully understand the benefits of SPI. The necessary investment of time and money, and the need to overcome staff resistance are as a potential barrier to SPI implementation. Hence, to overcome these obstacles and in order to get support of management and practitioners, sufficient SPI awareness is necessary.

Maturity level-03 and level-04 are adopted from CMMI-Level-03 “Defined” and CMMI-Level-05 “Optimizing” respectively. In level-03 SPI implementation processes are documented, standardized and integrated into standard implementation process for the organization. Level-04 is where organization establishes structures for continuous improvements. All these maturity levels are shown in the table below:

Maturity Level	Description
Level 1: **Initial**	The implementation of SPI is not planned and changes randomly. This maturity level can be best described as one of chaotic processes.
Level 2: **Aware**	Awareness to SPI implementation process has been gained at staff as well as at management level.
Level 3: **Defined**	This level focuses on the systematic structure and definition of SPI implementation process. SPI implementation methodology is defined.
Level 4: **Optimizing**	The focus of this level lies on establishing structures or continuous improvement

Table 1: Maturity levels with description

Two levels of CMMI that are not being adopted are: CMMI-Level-02 “Managed” focuses on project management, because the literature and empirical study of Niazi at el does not identify any factor that relates to project management. CMMI-Level-04 “Quantitatively Managed” focuses on establishing quantitative measures of software processes. Again, Niazi et al did not find any factor that directly relates to this maturity level.

The maturity levels describe an evolutionary path from an immature, ad-hoc SPI implementation process to a disciplined and mature SPI implementation process. Each readiness level comprises a predefined set of factors that play positive or negative roles

in SPI implementation. Factors positively affecting SPI implementation are known as Critical Success Factors and those affecting negatively are known as Critical Barriers.

3.1.2 CSF Dimension

CMMI consists of process areas (PAs) categorized across five maturity levels but Niazi et al believe that successful SPI implementation process should be viewed in terms of CSFs rather than PAs. This is because they identified the importance of CSF from literature. Implementation of SPI programs requires real life experiences where one learns from mistakes and continuously improves the implementation process. CSFs are often identified after successful completion of certain activities. Hence, these factors are near to real life experiences.

In this dimension of maturity model, some CSFs and critical barriers are identified from literature and empirical study. For identifying a factor frequency analysis and the importance of each factor is calculated in CSFs interviews.

The PAs of CMMI are split into four categories [31]. In this model, CSFs and critical barriers are categorized into three i.e. Awareness, Organizational and Support. This distribution is show in the following table:

Category	CSFs & Critical Barriers
Awareness	SPI Awareness, Staff involvement, Training and monitoring Senior management commitment
Organizational	Time pressure, Lack of support, Experienced staff Formal methodology, Organizational politics, Staff time and resources, Creating process action team
Support	Review

Table 2: Categories of CSFs & Critical Barriers

These factors are not necessarily mutual exclusive and there may be a certain degree of overlap among them. The awareness category is directly linked to Maturity Level-2 i.e. Aware of the maturity model. While organizational is directly linked to maturity level-03 i.e. defined where the focus is on the systematic definition of SPI implementation process. Similarly support is linked to maturity level-04 i.e. optimizing where focus is completely on continuous improvement. To achieve a specific maturity level its factor category as well as its earlier maturity level category must be implemented in the practice of considerable organization. So the current factor category for implementation is called "Front-End-Category" and the previously implemented category is called "Back-End-Category". This factor categorization is shows in the table below:

Maturity Level	Front-end-category	Back-end-category
4 – Optimizing	Support	Organizational, Awareness
3 – Defined	Organizational	Awareness
2 – Aware	Awareness	-
1 – Initial	-	-

Table 3: CSFs Dimension

In CSF dimension, set of CSFs and critical barriers for all the four maturity levels has been defined. Appendix – A has all the factors along with their concerned practices.

3.1.3 Assessment Dimension

In this dimension each of the CSF and critical barrier is measured in order to assess how well the factor has been implemented in practice. In order to resolve the conflict of different stakeholder's evaluation standards of same factor, an already tested instrument (Motorola Instrument shown in Appendix – B) is being used. This instrument is used to assess the current status of organization relative to CMM and identify weak areas that need to be improved. For each CSF and critical barrier five

practices has been defined through literature review and empirical study. These practices of each CSF and critical barrier are measured using three different dimensions of Motorola instrument:

1. Approach: Organization commitment and management support for the practice as well as the organization's ability to implement the practice.
2. Deployment: The breadth and consistency of practice implementation across project areas.
3. Results: The breadth and consistency of positive results over time and across project areas.

Following are the steps adopted for the assessment of SPI implementation through maturity model.

Step-01: First of all CSF and critical barriers are being assigned to the concerned stakeholders within organization.

Step-02: For each practice of CSF and critical barriers, the concerned stakeholder to whom it is being assigned for evaluation will calculates the three dimensional scores of Motorola instruments using its key activities.

Step-03: The three dimensional score for each CSF and critical barriers are added and divided by 3 and round up to get the score of that practice.

Step-04: For each CSF and critical barrier, add together the score of each of its practice and average it to gain overall score of CSF.

Step-05: Following the Motorola instrument usage at Motorola, a score of 7 or above for each CSF and critical barrier will indicate that it is successfully being implemented, otherwise considered as a weak area that need to be improved.

Step-06: For achieving a maturity levels, all the CSFs and critical barriers of its back-end-category and front-end-category must have average score 7 or above. For example

to achieve level-02-Aware of maturity level, all CSFs and critical barriers of Awareness category that is assigned to this maturity level must have score equal or higher than 7.

3.3 Weakness of Maturity Model

After reviewing and implementing this model by automating its assessment dimension, we feel that following are some weaknesses that need to be improved by redesigning some aspects of this maturity model in its next version.

1. Practices of each factor are at abstract level that does not completely reflect the affect of that factor in the company/ organization
2. Each factor is divided into fix number of (five) practices, which may be very few for assessing the true implementation of that factor in the company
3. All practices of each factor are of the same importance in the assessment process. But we think that there may be few practices those are of more importance over others and mandatory for true implementation of that factor. Therefore a mechanism should be set to consider those practices with preference in the evaluation process.

CHAPTER 4

SYSTEM ANALYSIS AND DESIGN

This chapter covers the system analysis and design of assessment instrument for SPI (AISPI) in the form of use case and activity diagrams, descriptive use cases, relational data model and data dictionary.

4.1 Use Case Diagram

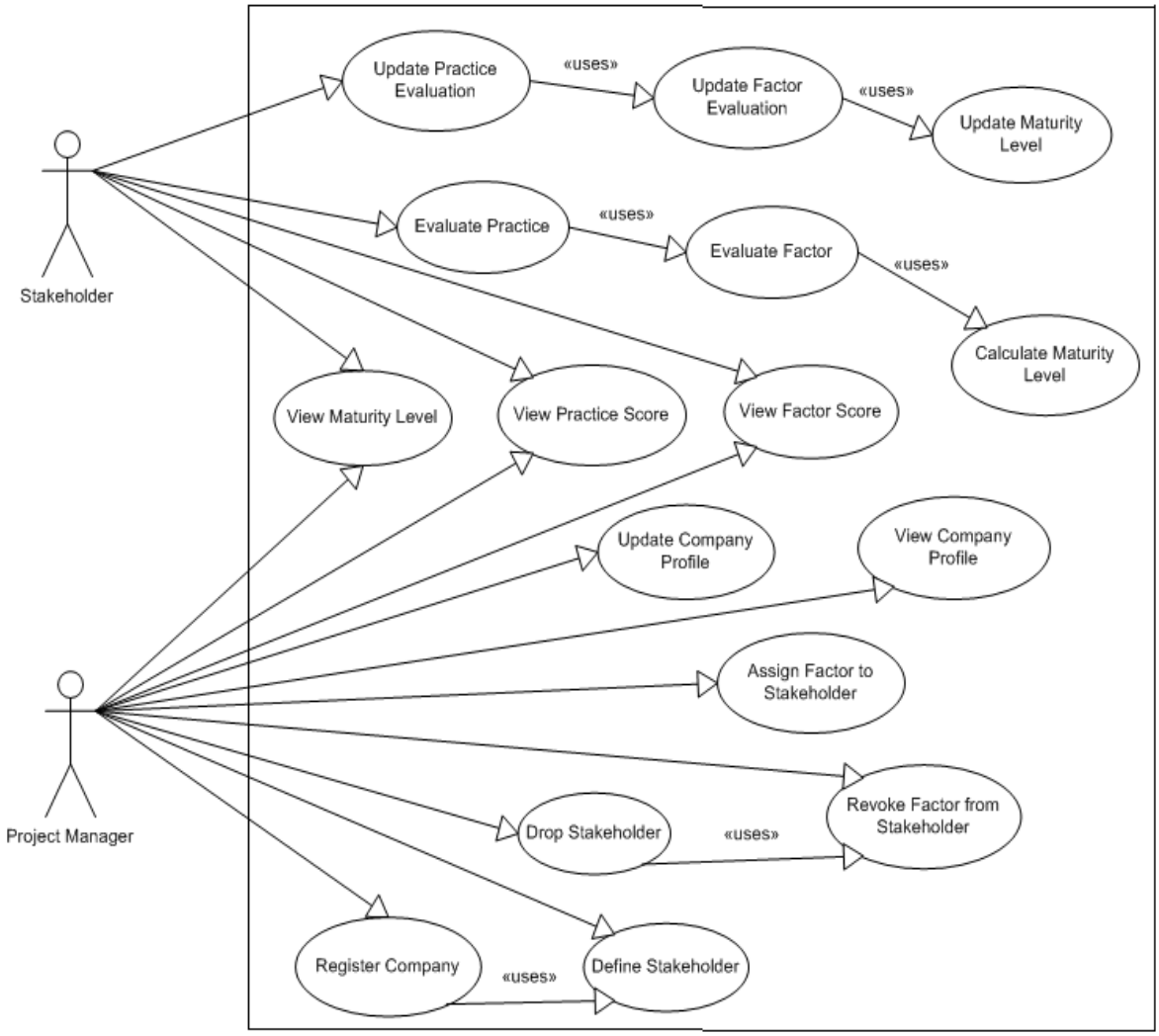

Figure 4: Use Case Diagram of AISPI

Functional requirement of any system are primarily recorded in the use cases. All functionalities and the related actors are being plotted in the use case model of a system. Above figure briefly shows all the functionalities and actors of our assessment instrument.

4.2 Activity Diagram

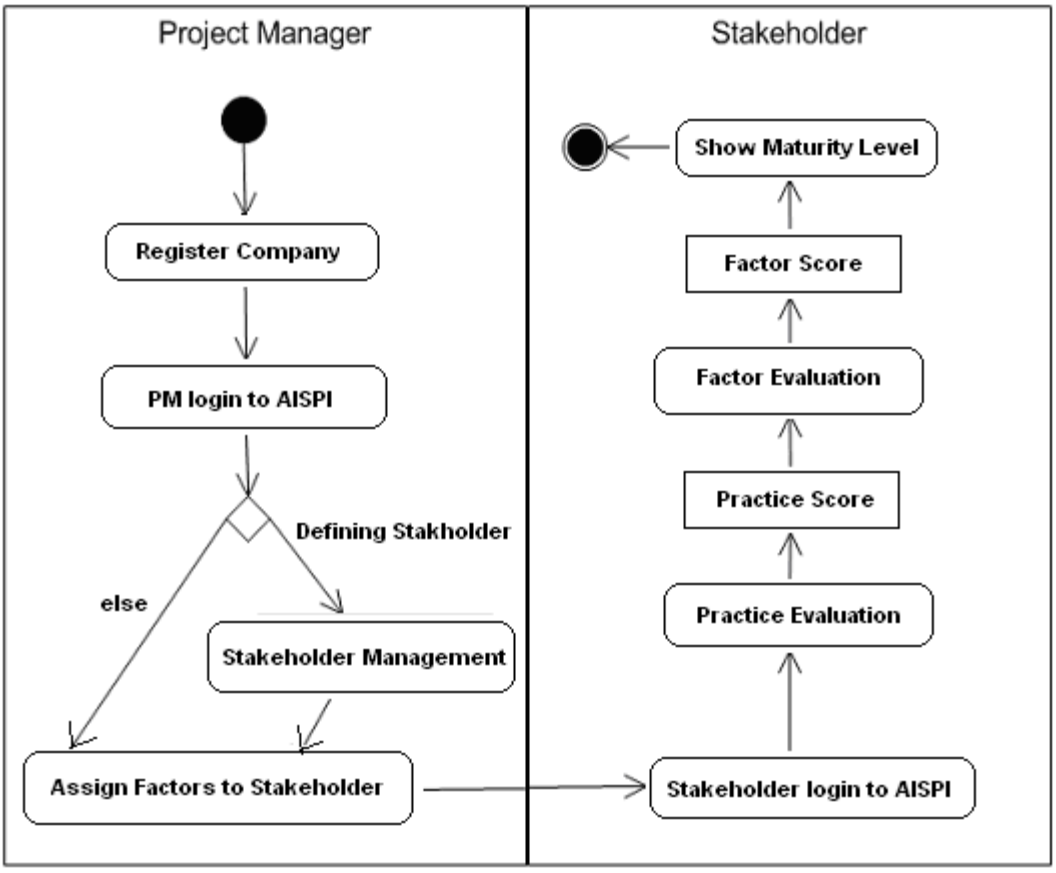

Figure 5: Activity Diagram of AISPI

Use cases show what our system will do, but activity diagram will elaborates how our system will accomplish the specified goal. I am not plotting the activity diagram for each individual activity in our instrument; instead I am considering the system as a whole and drawing the sequence of its all activities at abstract level to depict the execution and sequence of flow in our assessment instrument.

4.3 Assessment Instrument Flow Diagram

Following figure shows the general flow of this assessment instrument and the sequence of the functionalities to be automated as reflected by the activity diagram as well.

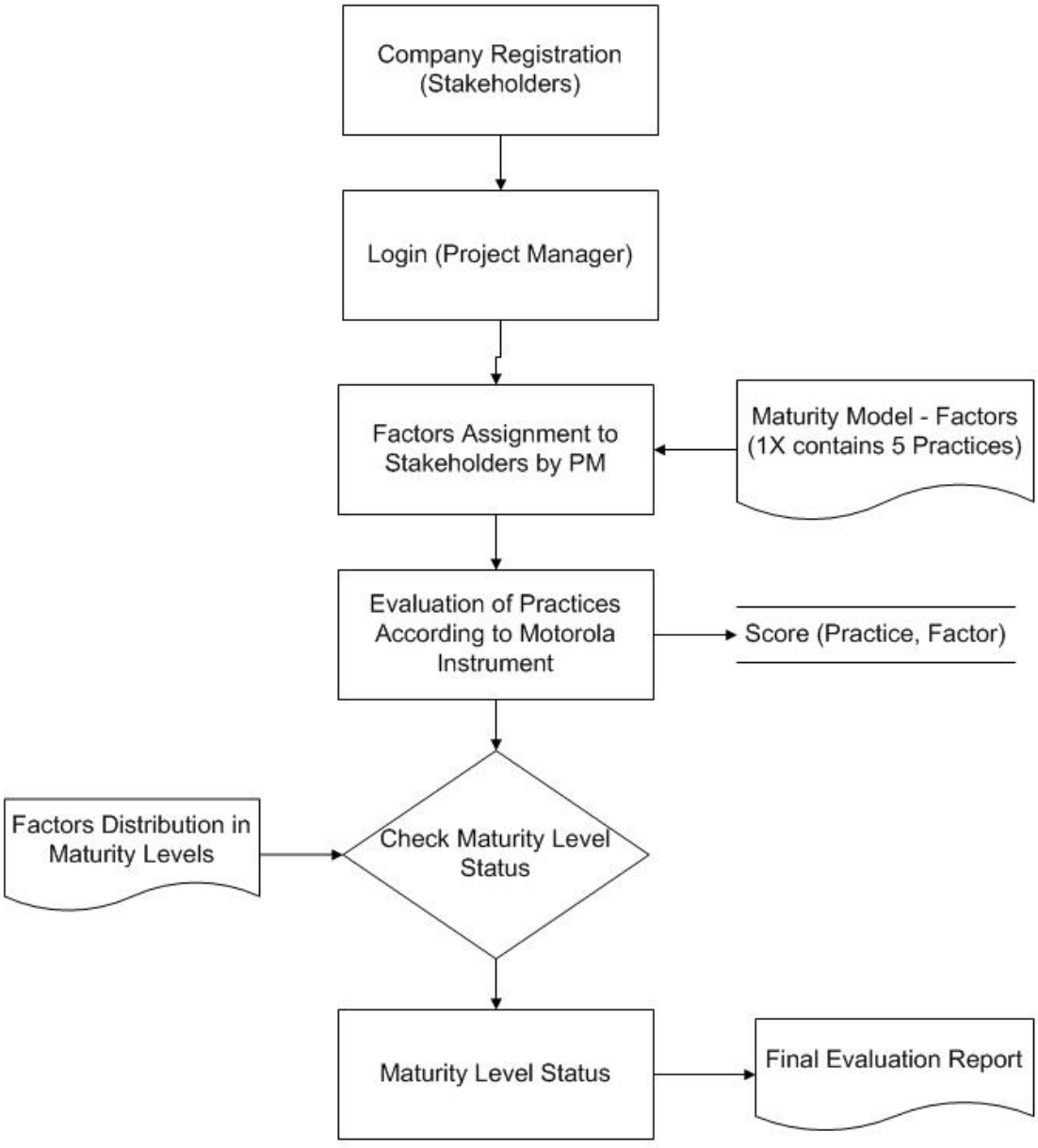

Figure 6: Flow Chart of AISPI

4.3 Relational Data Model

A relation data model shows all the relations along with their relationship that are being used for the data management of a specific system. Following is the relational data model for this assessment instrument. Figure is taken from the diagram of database developed for instrument using SQL Server 2005.

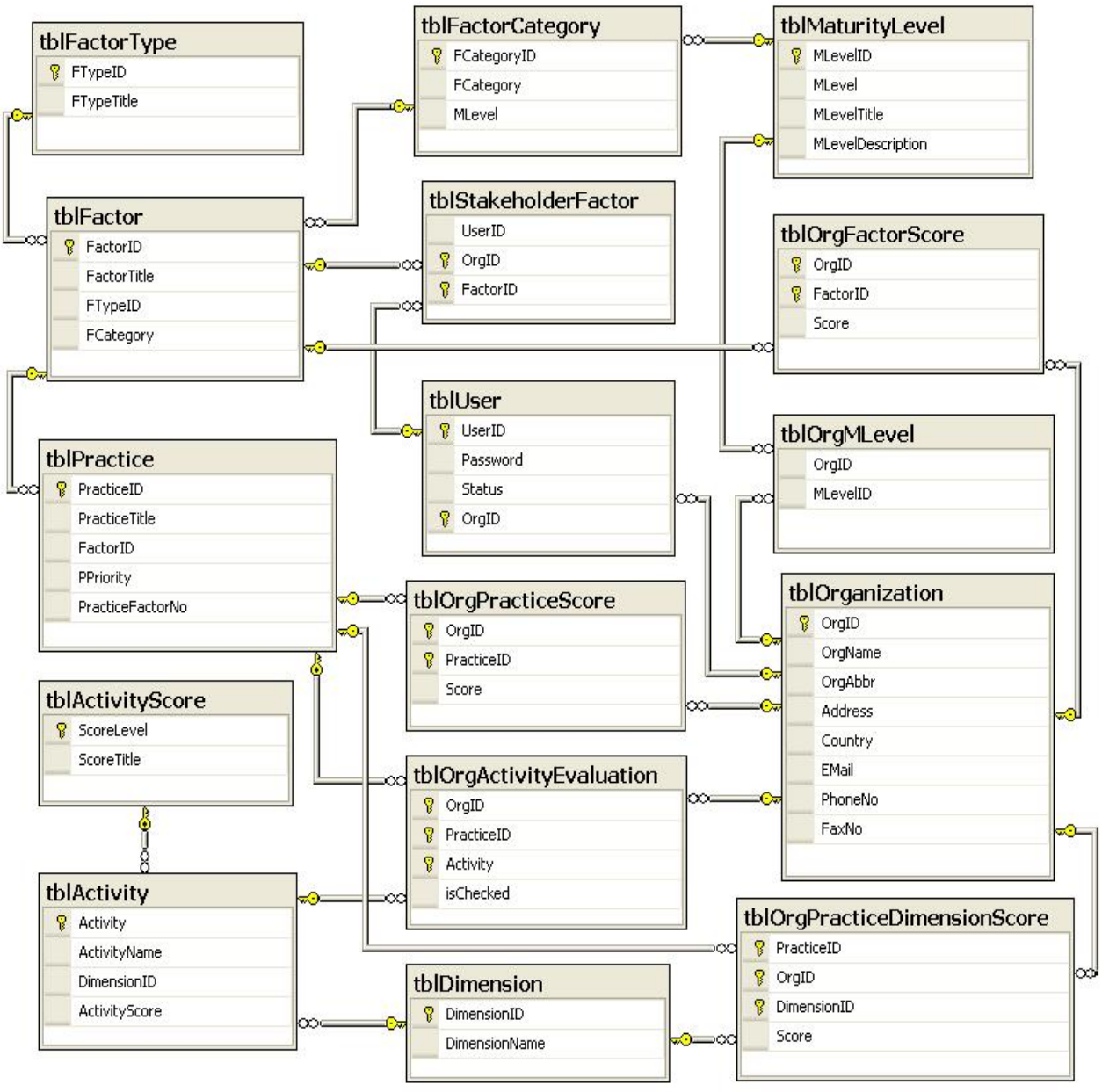

Figure 7: Relational Data Model for AISPI

4.4 Relational Data Model

4.4.1 Register Company

Primary Actors

Company Project Manager

Stockholders and Interests:

- Company Project Manager: If a company wants to be evaluated by this maturity model then first of all its project manager must have to register his/her company by providing some basic information along with minimum three stakeholders that will be required for the evaluation of different factors.

Preconditions

N/A

Main Success Scenario

Company Project Manager will enter the basic information of his company along with identifying any three stakeholders for their company evaluation considering all the factors of this maturity model. When company is registered then four accounts are being created; first account login as the abbreviation of the company for project manager, and the remaining three are as the names of stakeholders. All these logins will have the same passwords that can be changed on login.

Extensions

N/A

4.4.2 Update Company Information

Primary Actors

Company Project Manager

Stockholders and Interests:

- Company Project Manager: If project manager feels that the registered information for the company needs to be updated, then he can do it using this functionality.

Preconditions

It is necessary for a company to be registered earlier for being its information modified by the project manager.

Main Success Scenario

Project manager will login to the assessment instrument using his authentic login. Interface of the company profile will make able the project manager to make amendments in the available company information as required.

4.4.3 Manage Stakeholders for Specific Company

Primary Actors

Company Project Manager

Stockholders and Interests:

- Company Project Manager: If a company wants to be evaluated by this maturity model then project manager must have to define minimum three stakeholders at the time of company registration. After that the project manager has the privileges to define new stakeholder or delete current stakeholder as per requirement.

Preconditions

Company must be registered earlier and has a valid account for its project manager.

Main Success Scenario

The concerned project manager can define a new stakeholder or deleting the current stakeholder of a specific company by using the “stakeholder management” link. When a new stakeholder is being defined then the stakeholder will be able to evaluate some factors for his company; after being assigned to him by the project manager. But in case of deleting a specific stakeholder, his/her evaluated factors for the company are not being affected. Therefore, if those factors need some re-evaluation then those should be reassigned to other stakeholder.

4.4.4 Manage factor assignment to stakeholder

Primary Actors

Company Project Manager

Stockholders and Interests:

- Company Project Manager: Only this actor will have the privilege to assign a factor or revoke a factor from a stakeholder of his/ her own company.

Preconditions

Company and the concerned stakeholders must be registered earlier to whom the factors are supposed to be assigned by the project manager. Similarly all model information must be available in the instrument.

Main Success Scenario

The most important functionality of a Project manager is to assign factors to the relevant stakeholder. Project Manager can assign a new factor to the stakeholder or can revoke an already assigned factor from stakeholder. To operate this functionality project manager will have to follow the "manage stakeholder" link available on the "manage stakeholder" web form of this assessment instrument. After factor assignment, all concerned stakeholders will be in a position to evaluate their factors.

4.4.5 Evaluate a Practice

Primary Actors

Stakeholder to whom the factor of concerned practice is assigned

Stockholders and Interests:

- Company Stakeholder: Only this actor will have the privilege to evaluate this practice for his/ her company

Preconditions

Company must be registered earlier along with its stakeholders and factor of this practice must be assigned to the stakeholder by project manager.

Main Success Scenario

Stakeholder will get login to the assessment instrument for practice evaluation. Stakeholder will select the link "evaluate your assigned factors" available on "company evaluation" web form of the instrument. This interface will show him/ her all assigned factors in a combo-box, from where he/ she selects the one want to evaluate. After factor selection from a combo, all its concerned practices will be made available in another combo for evaluation. Now stakeholder will evaluate all these practices using Motorola Instrument with three dimensions; Approach, Deployment, and Results. After all dimensional evaluation, practice score will be calculated and stored in database automatically .

4.4.6 Evaluate a Factor

Primary Actors

Stakeholder to whom the factor is assigned

Stockholders and Interests:

- Company Stakeholder: Only this actor will have the privilege to evaluate this factor for his/ her company

Preconditions

Company must be registered earlier along with its stakeholders and this factor must be assigned to the stakeholder by project manager. All practices of this factor must be evaluated by stakeholder using Motorola Instrument with all three dimensions.

Main Success Scenario

Stakeholder evaluates all practices of this factor using Motorola Instrument. After practice evaluation, factor score will be evaluated and stored in database automatically.

4.4.7 Re-evaluate a Practice

Primary Actors

Stakeholder to whom the factor of concerned practice is assigned

Stockholders and Interests:

- Company Stakeholder: Only the stakeholder to whom the concerned factor has been assigned.

Preconditions

Company must be registered earlier along with its stakeholders and factor of this practice must be assigned to the stakeholder by project manager.

Main Success Scenario

Stakeholder will get login to the assessment instrument for practice evaluation. He/ she will select the link “evaluate your assigned factors” available on “company evaluation” web form of the instrument. This interface will show him/ her all assigned factors in a combo-box, from where he/ she selects the one want to re-evaluate. Now stakeholder can re-evaluate the already evaluated practice. After re-evaluation, new score for practice and concerned factor will be calculated and store to the database.

4.4.8 Re-evaluate a Factor

Primary Actors

Stakeholder to whom the factor is assigned

Stockholders and Interests:

- Company Stakeholder: Only the stakeholder to whom the concerned factor has been assigned.

Preconditions

Company must be registered earlier along with its stakeholders and this factor must be assigned to the stakeholder by project manager. All practices of this factor must be evaluated by stakeholder using Motorola Instrument with all three dimensions.

Main Success Scenario

When stakeholder re-evaluates all practices of a specific factor, then factor score will be re-evaluated and stored in database automatically.

4.4.9 View maturity level of company

Primary Actors

Project manager and concerned stakeholders

Stockholders and Interests:

- Project Manger/ Company Stakeholder: All these stakeholders are able to view the maturity level of their company after complete evaluation.

Preconditions

Company must be registered earlier along with its stakeholders and all factors of the model must be assigned to concerned stakeholders by project manager and evaluated by the stakeholders.

Main Success Scenario

Anyone of the stakeholder or project manager can view the maturity level of company along with the detail information of calculated scores of all factors and practices. This can be done by following the links Company evaluation→ Company status → Maturity level of company

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4.4.10 View weak factors

Primary Actors

Project manager and concerned stakeholders

Stockholders and Interests:

- Project Manger/ Company Stakeholder: All these stakeholders are able to view the weak factors of their company after partial/ complete evaluation.

Preconditions

Company must be registered earlier along with its stakeholders and all or some of the factors of the model must be assigned to and evaluated by the stakeholders.

Main Success Scenario

Anyone of the stakeholder or project manager can view the weak factors that need to be improved for SPI. This can be done by following the links Company evaluation→ Company status → View factors that need to be improved

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4.4.11 View practice-wise factor score

Primary Actors

Project manager and concerned stakeholders

Stockholders and Interests:

- Project Manger/ Company Stakeholder: All these stakeholders are able to view the weak factors of their company after partial/ complete evaluation.

Preconditions

Company must be registered earlier along with its stakeholders and all or some of the factors of the model must be assigned to and evaluated by the stakeholders.

Main Success Scenario

Anyone of the stakeholder or project manager can view the scores being calculated for each evaluated factor. This can be done by following the links Company evaluation→ Company status → practice-wise factor score

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4.5 Data Dictionary

Data dictionary covers all relations along with domain definitions, referential integrities and entity integrities being implemented. Following details shows the all entities involved and their relevant relations:

4.5.1 Maturity Level Entity

Relation: tblMaturityLevel

Entity Integrity: MLevelID

Description: Data of each maturity level of maturity model is being stored in this relation along with its title and description.

tblMaturityLevel

Column Name	Data Type	Allow Nulls
MLevelID	uniqueidentifier	☐
MLevel	numeric(1, 0)	☐
MLevelTitle	varchar(20)	☐
MLevelDescription	varchar(200)	☐
		☐

Figure 8: Relation tblMaturityLevel

4.5.2 Organization Entity

Relation: tblOrganization

Entity Integrity: OrgID

Description: Information of software companies that are interested to be evaluated by this instrument will be stored in this relation

tblOrganization

Column Name	Data Type	Allow Nulls
OrgID	uniqueidentifier	☐
OrgName	varchar(100)	☐
OrgAbbr	varchar(12)	☐
Address	varchar(100)	☐
Country	varchar(50)	☐
EMail	varchar(50)	☑
PhoneNo	varchar(18)	☑
FaxNo	varchar(18)	☑
		☐

Figure 9: Relation tblOrganization

4.5.3 Organizational Maturity Level Entity

Relation:	tblOrgMLevel
Entity Integrity:	OrgID, MLevelID
Referential Integrity:	OrgID referring tblOrganization
	MLevelID referring tblMaturityLevel
Description	Information regarding the maturity level of each software company is being stored in this relation after being evaluated by assessment instrument.

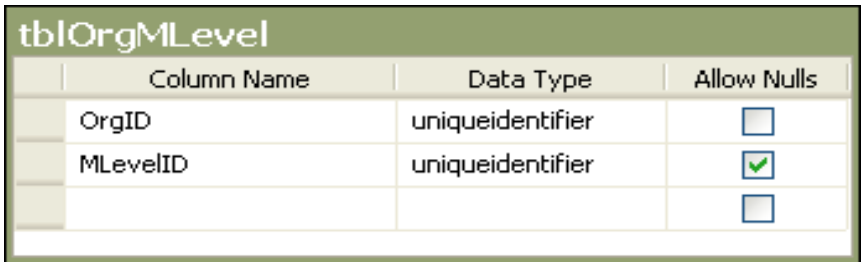

Figure 10: Relation tblOrgMLevel

4.5.4 User Entity

Relation:	tblUser
Entity Integrity:	UserID
Referential Integrity:	OrgID referring tblOrganization
Description:	Login Information of all stakeholders from different software companies will be stored in this relation and mapped to their concerned company through tblOrganization relation.

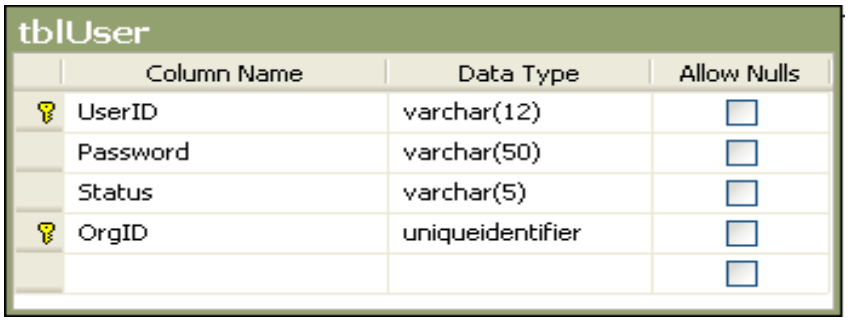

Figure 11: Relation tblUser

4.5.5 Dimension Entity

Relation:	tblDimension
Entity Integrity:	DimensionID
Description:	This relation has the titles of all three dimensions that have a set of activities from Motorola Instrument for each practice evaluation by different stakeholders.

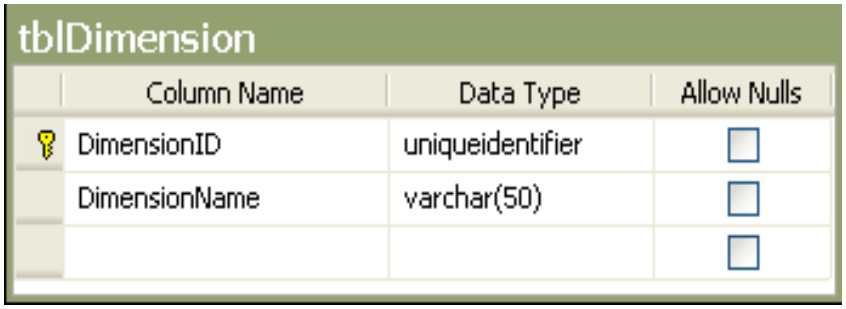

Figure 12: Relation tblDimension

4.5.6 Motorola Instrument Activity Entity

Relation:	tblActivity
Entity Integrity:	ActivityID
Referential Integrity:	DimensionID referring tblDimension
Description:	It stores the information of all activities of Motorola instrument being divided in to three different dimensions

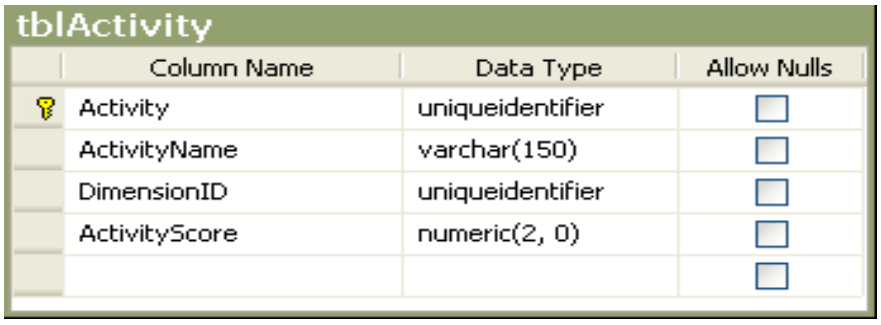

Figure 13: Relation tblActivity

4.5.7 Activity Score Entity

Relation: tblActivityScore

Entity Integrity: ScoreLevel

Description: It stores the score of each activity

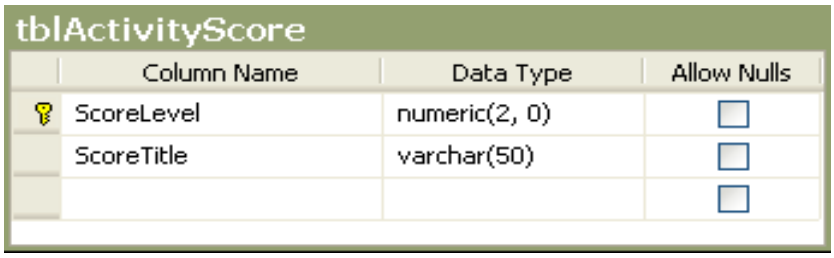

Figure 14: Relation tblActivityScore

4.5.8 Practice Entity

Relation: tblPractice

Entity Integrity: PracticeID

Referential Integrity: FactorID referring tblFactor

Description: It stores the information of practices of all factors

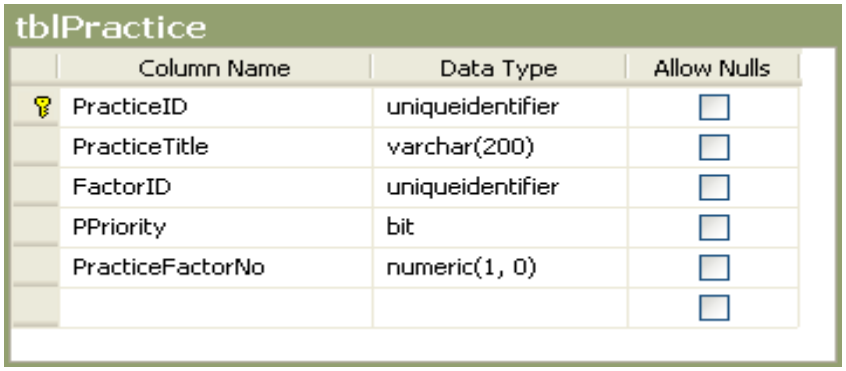

Figure 15: Relation tblPractice

4.5.9 Factor Category Entity

Relation:	tblFactorCategory
Entity Integrity:	FCategoryID
Referential Integrity:	MLevelID referring tblMaturityLevel
Description:	It stores detail of factor categories along with their concerned maturity level

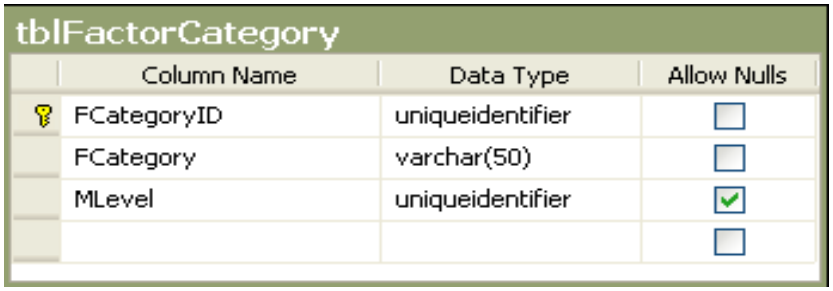

Figure 16: Relation tblFactorCategory

4.5.10 Factor Entity

Relation:	tblFactor
Entity Integrity:	FactorID
Referential Integrity:	FTypeID referring to tblFactorType
	FCategory referring to tblFactorCategory
Description:	It stores information of each factor assigned to a specific maturity level.

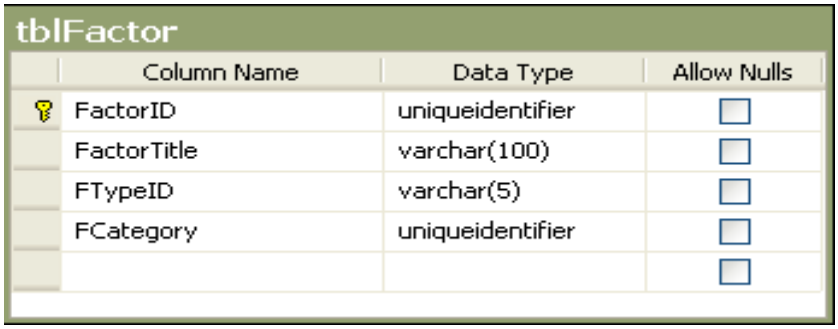

Figure 17: Relation tblFactor

4.5.11 Organizational Activity Evaluation Entity

Relation:	tblOrgActivityEvaluation
Entity Integrity:	OrgID, PracticeID, Activity
Referential Integrity:	OrgID referring tblOrganization
	PracticeID referring tblPractice
	Activity referring tblActivity
Description:	It stores the status of all activities of Motorola instruments for all practices of each factor

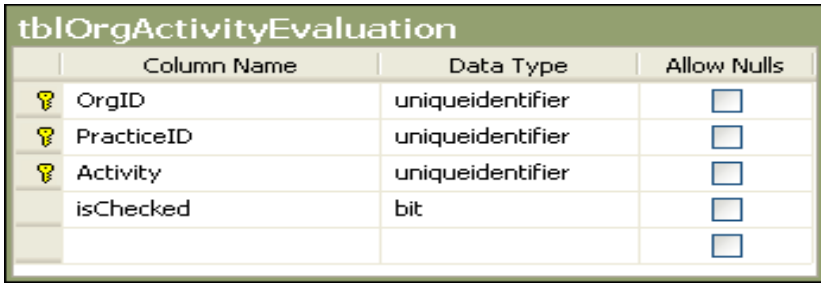

Figure 18: Relation tblOrgActivityEvaluation

4.5.12 Organizational Practices Dimension Score

Relation:	tblOrgPracticeDimensionScore
Entity Integrity:	PracticeID, OrgID, DimensionID
Referential Integrity:	OrgID referring tblOrganization
	PracticeID referring tblPractice
	DimenstionID referring tblDimension
Description:	It stores the practice dimensional score for each organization.

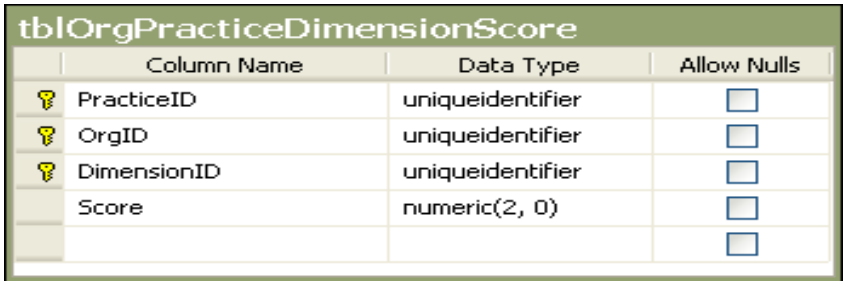

Figure 19: Relation tblOrgPracticeDimensionScore

4.5.13 Organizational Practice Score Entity

Relation:	tblOrgPracticeScore
Entity Integrity:	OrgID, PracticeID
Referential Integrity:	OrgID referring tblOrganization
	PracticeID referring tblPractice
Description:	It stores the score of all practices of each factor for a specific organization evaluated by their concerned stakeholders.

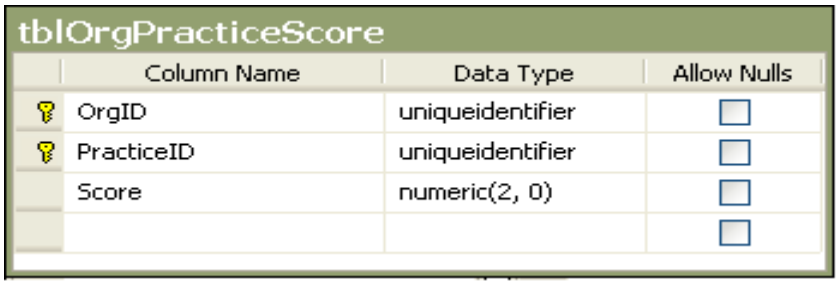

Figure 20: Relation tblOrgPracticeScore

4.5.14 Organizational Factor Score Entity

Relation:	tblOrgFactorScore
Entity Integrity:	OrgID, FactorID
Referential Integrity:	OrgID referring tblOrganization
	FactorID referring tblFactor
Description:	It stores score of organizational factors after evaluation.

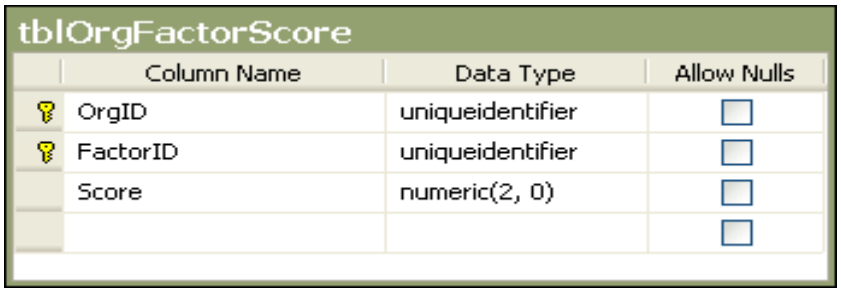

Figure 21: Relation tblOrgFactorScore

4.5.15 Stakeholder's Factors Entity

Relation:	tblStakeHolderFactor
Entity Integrity:	OrgID, FactorID
Referential Integrity:	OrgID referring tblOrganization
	FactorID referring tblFactor
	UserID referring tblUser
Description:	It stores the detail of all stakeholders of a specific company along with their assigned factors.

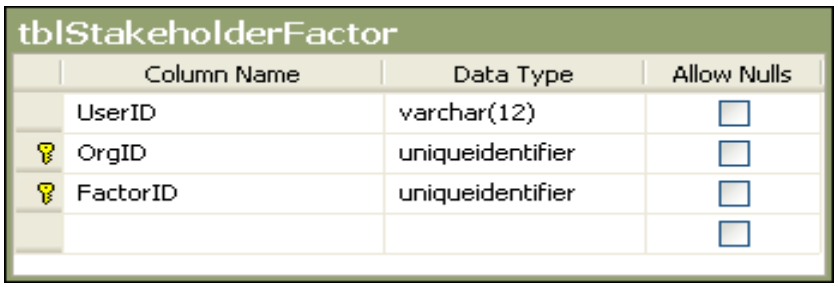

Figure 22: Relation tblStakeHolderFactor

4.5.16 Factor Type Entity

Relation:	tblFactorType
Entity Integrity:	FTypeID
Referential Integrity:	N/A
Description:	It store the information of factor types like CSF or CB

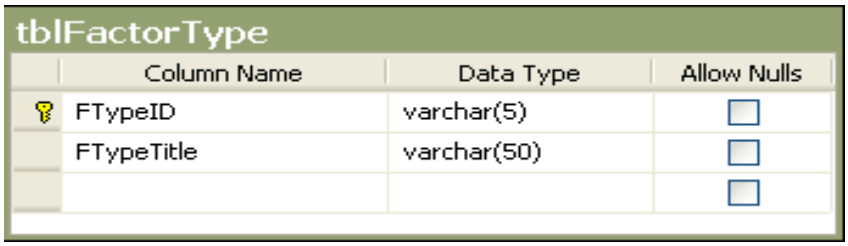

Figure 23: Relation tblFactorType

CHAPTER 5

ASSESSMENT INSTRUMENT: DEMONSTRATION

This chapter covers a brief description about the assessment process and demonstration of the developed assessment instrument along with all snap shots.

5.1 Sample Assessment Process

In the assessment process, first the company will have to register on this instrument and the project manager will create concerned stakeholders for the assessment process. All CSF and critical barriers of maturity model for SPI implementation will be measured by these stakeholders using Motorola instrument, which ultimately determines the maturity stage of organization. The role of project manager and stakeholders in this process are elaborated as follow.

5.1.1 Role of Project Manger

First of all, the project manger of a company will register his company by providing its basic information along with stakeholder's definition for factor evaluation process. Project manager distributes all factors mentioned in the maturity model among stakeholders; it is very important for project manager to assign each CSF or critical barrier to the stakeholder who is experienced or have enough knowledge about that factor to evaluate it intelligently. If he/ she want to define more stakeholders, then he/ she can do so by stakeholder management. Project manager can view the status of all evaluation factors at a certain time. He/ she can view the maturity level of his company with detail report about the status of SPI implementation within the practices of his/ her company.

5.1.2 Role of Stakeholder

The main responsibility of a stakeholder is to evaluate his/ her own assigned factors. Each factor is being divided into five practices, mentioned in Appendix-A. Therefore

stakeholders have to evaluate all the practices using an already tested instrument i.e. Motorola instrument shown in Appendix-B.

5.1.3 Sample factor evaluation

This part of the document will show the sample evaluation process of a specific factor. Let us suppose we have the following CSF along with its five practices.

Staff involvement

1. Work has been done to facilitate staff members during SPI implementation
2. The SPI implementation effort has been staffed by people who indicated interest and commitment in the effort
3. Work has been done to allocate the time necessary to make staff participation successfully
4. Local process teams and forums for exchange of ideas have been established
5. Conflict resolution plan has been established

To evaluate this CSF by a key stakeholder, all of these given practices must be evaluated by all three dimension of the Motorola instrument. Procedure for practice and factor evaluation is as below:

- First of all three separate dimensional scores of a practice are calculated.
- Key stakeholder has to mention the status of each dimensional activity, activity in Motorola Instrument, for each practice by mentioning a Boolean value.
- Dimensional score of a practice is the score of the TRUE activity just before the first FALSE activity of that specific dimension for considering practice.
- Score of a practice is the average of these three dimensional scores.
- Score of a factor is the average of the scores of all its practices.

Let us consider the first practice of Staff involvement for calculating its score using above mentioned procedure.

Score	Activities of Approach Dimension	Stakeholder Selection
Poor (0)	No management recognition of need	True
	No organizational ability	True
	No organizational commitment	True
	Practice not evident	True
	Higher management is not aware of investment required and long term benefits of this practice	True
Weak (2)	Management begins to recognize need	True
	Support items for the practice start to be created	True
	A few parts of organization are able to implement the practice	True
	Management begins to aware of investment required and long term benefits of this practice	True
Fair (4)	Wide but not complete commitment by management	True
	Roadmap for practice implementation defined	True
	Several supporting items for the practice in place	True
	Management has some awareness of investment required and long term benefits of this practice	True
Marginally Qualified (6)	Some management commitment and some management becomes proactive	True
	Practice implementation well under way across parts of the organization	True
	Supporting items in place	True
	Management has wide but not complete awareness of investment required and long term benefits of this practice	True
Qualified (8)	Total management commitment	True
	Majority of management is proactive	True
	Practice established as an integral part of organization	False
	Supporting items encourage and facilitate the use of practice	True
	A mechanism has been established to use and monitor this practice on continuing basis	False
	Management has wide and complete awareness of investment required and long term benefits of this practice	False
Outstanding (10)	Organizational excellence in the practice recognized even outside the organization	False
	Management provides zealous leadership and commitment	False

Table 4: Practice evaluation, Approach dimension of Motorola Instrument

Score of last TRUE activity before first FALSE activity is 08 therefore it's the score of this practice for "Approach" dimension.

Score	Activities of Deployment Dimension	Stakeholder Selection
Poor (0)	No part of the organization uses the practice	True
	No part of the organization shows interest	True
Weak (2)	Fragmented use	True
	Inconsistent use	True
	Deployed in some parts of the organization	True
	Limited to monitoring/ verification of use	True
Fair (4)	Less fragmented use	True
	Some inconsistency in use	True
	Deployed in some major parts of the organization	True
	Monitoring/ verification of use for several parts of the organization	True
	No mechanism to distribute the lessons learned to the relevant staff members	True
Marginally Qualified (6)	Deployed in some parts of the organization	True
	Mostly consistent use across many parts of organization	True
	Monitoring/ verification of use for many parts of the organization	True
	A mechanism has been established, and use in some parts of the organization, to distribute the lessons learned to the relevant staff members	True
Qualified (8)	Deployed in almost all parts of the organization	False
	Consistent use across almost all parts of the organization	False
	Monitoring/ verification of use for almost all parts of organization	False
	A mechanism has been established and used in all parts of the organization, to distribute the lessons learned to the relevant staff members	False
Outstanding (10)	Pervasive and consistent deployed across all parts of the organization	False
	Consistent use over time across all parts of the organization	False
	Monitoring/ verification for all parts of the organization	False

Table 5: Practice evaluation, Deployment dimension of Motorola Instrument

Score of last TRUE activity before first FALSE activity is 06 therefore it's the score of this practice for "Deployment" dimension.

Score	Activities of Results Dimension	Stakeholder Selection
Poor (0)	Ineffective	True
Weak (2)	Spotty results	True
	Inconsistent results	True
	Some evidence of effectiveness for some parts of the organization	True
Fair (4)	Consistent and positive results for several parts of the organization	True
	Inconsistent results of other parts of the organization	True
Marginally Qualified (6)	Positive measurable results in most of parts of organization	True
	Consistently positive results over time across many parts of the organization	True
Qualified (8)	Positive measurable results in almost all parts of the organization	True
	Consistently positive results over time across almost all parts of the organization	False
Outstanding (10)	Requirements exceeded	False
	Consistently world-class results	False
	Counsel sought by others	False

Table 6: Practice evaluation, Results dimension of Motorola Instrument

Score of last TRUE activity before first FALSE activity is 08 therefore it's the score of this practice for the "Results" dimension.

Practices score = (Approach Score + Deployment Score + Results Score) / 03

Practices score = (08 + 06 + 08) / 03 = 7.33 = 07

Therefore the score of this practice is 07.

Let following the same procedure for all five practices of CSF "staff involvement", we get the following score for each practice.

Work has been done to facilitate staff members during SPI implementation	07
SPI implementation effort has been staffed by people who indicated interest and commitment in effort	08
Work has been done to allocate the time necessary to make staff participation successfully	06
Local process teams and forums for exchange of ideas have been established	07
Conflict resolution plan has been established	08

Table 7: List of practices of a factor along with evaluated score

Factor score = (Practice01+Practice02+Practice03+Practice04+Practice05) / 05

Factor score = (07+08+06+07+08) / 05 = 7.2 = 07

Therefore CSF “Staff involvement” has score 07, means it is strongly implemented within the company.

5.2 Instrument Demonstration

This instrument is designed and developed with intention of self evaluation of software companies that will tell them their maturity level regarding their software process improvement activities.

5.2.1 Home Page

Following is the home page of this assessment instrument including the title and abstract of research along with researcher’s name and his supervising team. It has following link with functionalities:

Login: Login that enables the stakeholder or project manager to enter to the assessment instruments.

Company Evaluation: It provides the interface to operate available functionalities like practice evaluation, viewing company status and evaluation guidelines etc.

Instrument Management: It provides the interface to project manager to operate his/ her available functionalities like practice evaluation, viewing company status and evaluation guidelines, factor assignment, stakeholder management and company profile editing etc.

Contact Us: It provides the interface to show the detail of whole research team.

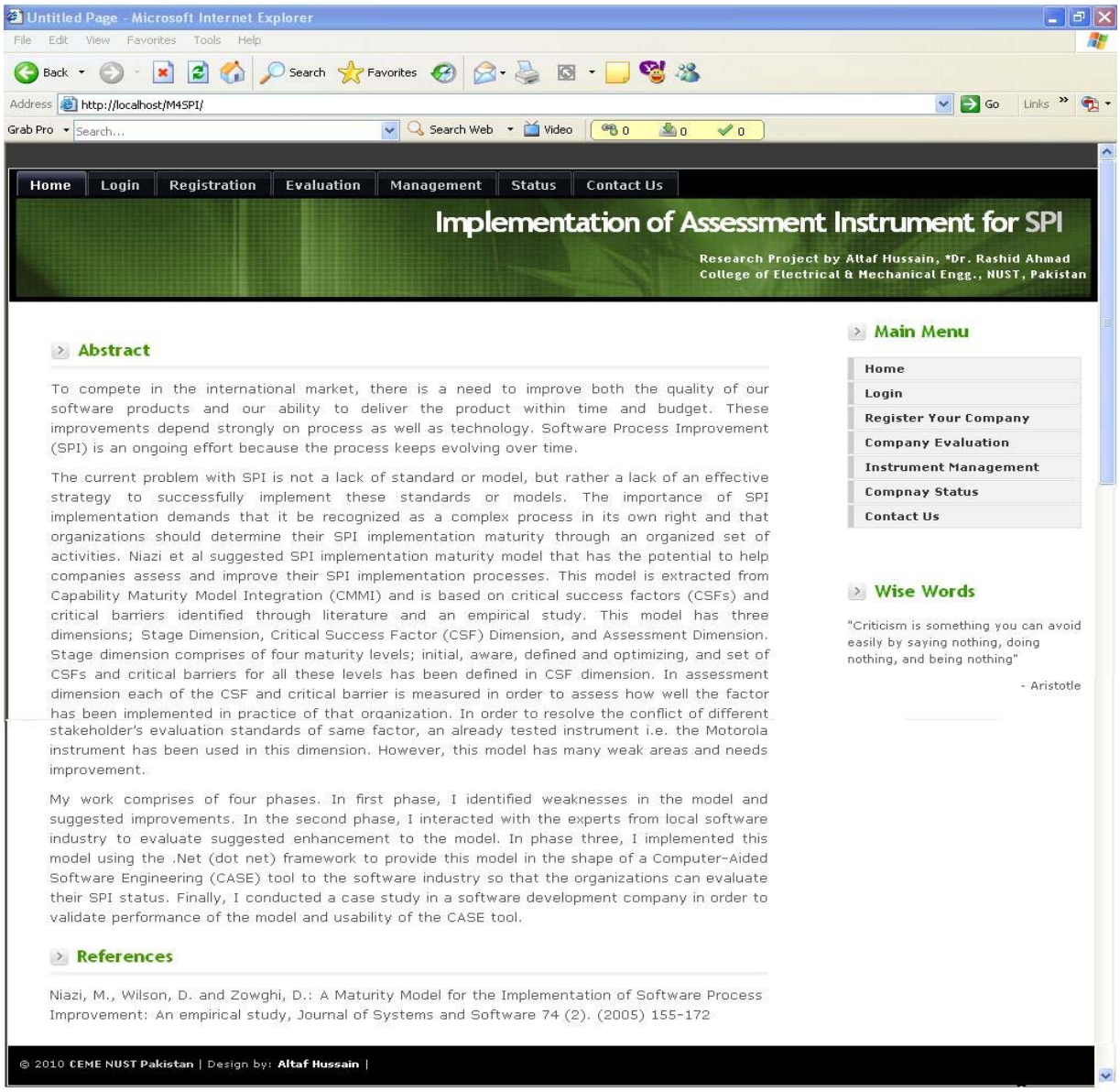

Figure 24: Main Abstract Page

5.2.2 Company Registration Page

Project manager wants to evaluate his company, or software organization using our assessment instrument for SPI, will have to register his organization. Following interface will be used for company registration. For this purpose the basic information is required like company address, country, telephonic and Email contacts along with the definition of three stakeholders to the factors will be assigned for evaluation.

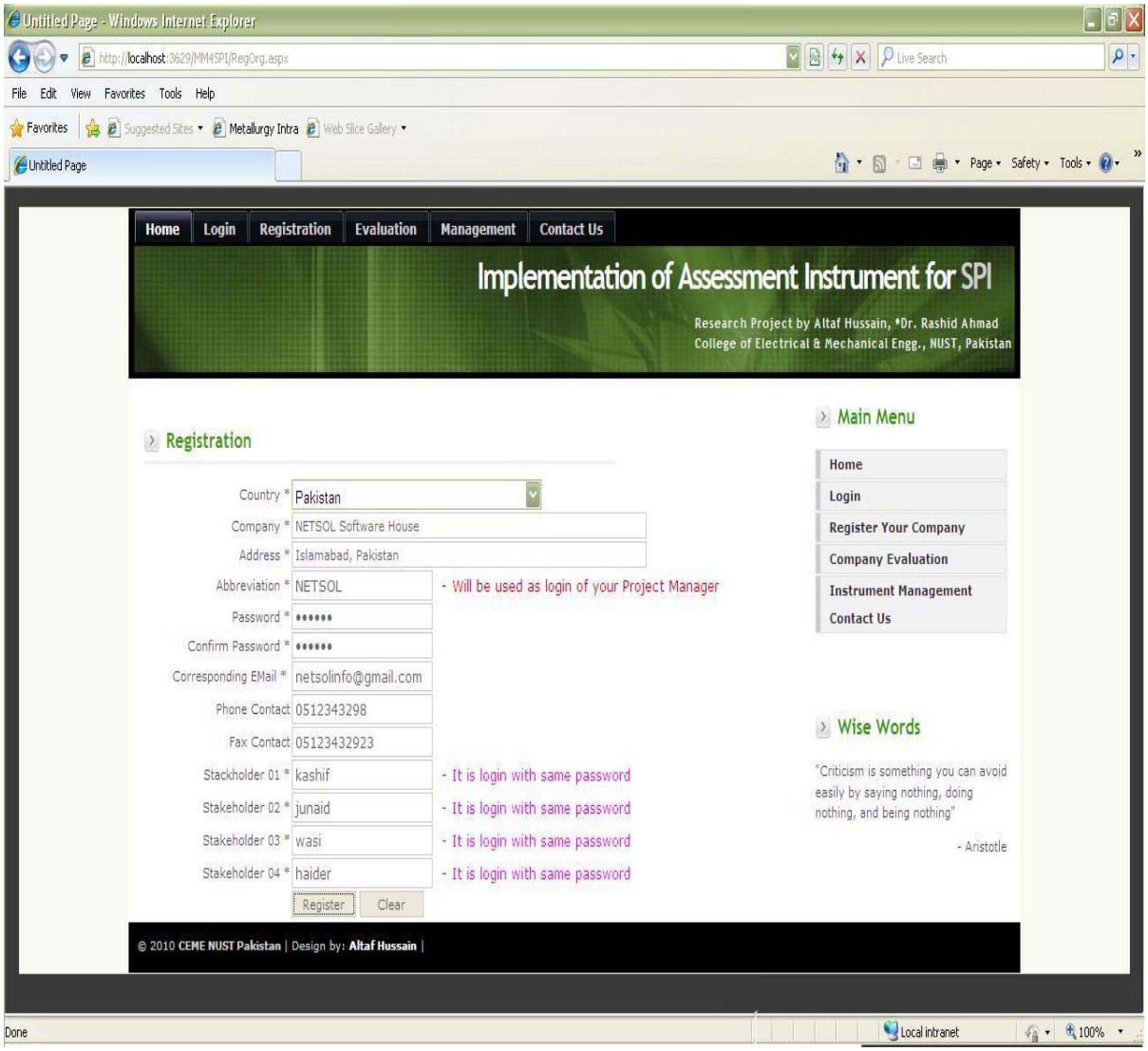

Figure 25: Organization Registration Page

5.2.3 Login Page

This is the login page for project manager or stakeholder of a specific company. For login you will have to use your login information alongwiht your own company name.

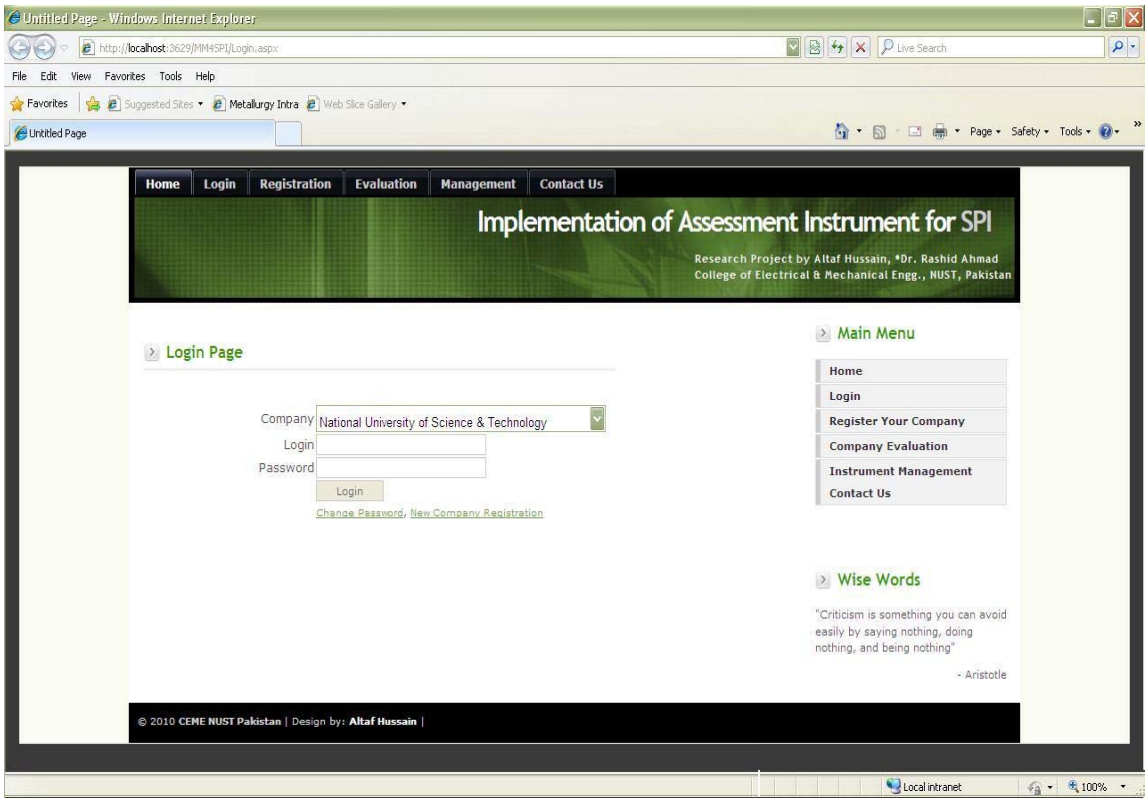

Figure 26: Instrument Login Page

5.2.4 Stakeholder Management Page

This page can only be used by project manager for stakeholder management. It includes the functionalities of defining new stakeholder or dropping an existing stakeholder. If a stakeholder is being dropped then it will never affect the evaluation done by him/ her. All the stakeholders defined by the project manager are being displayed in a list as shown.

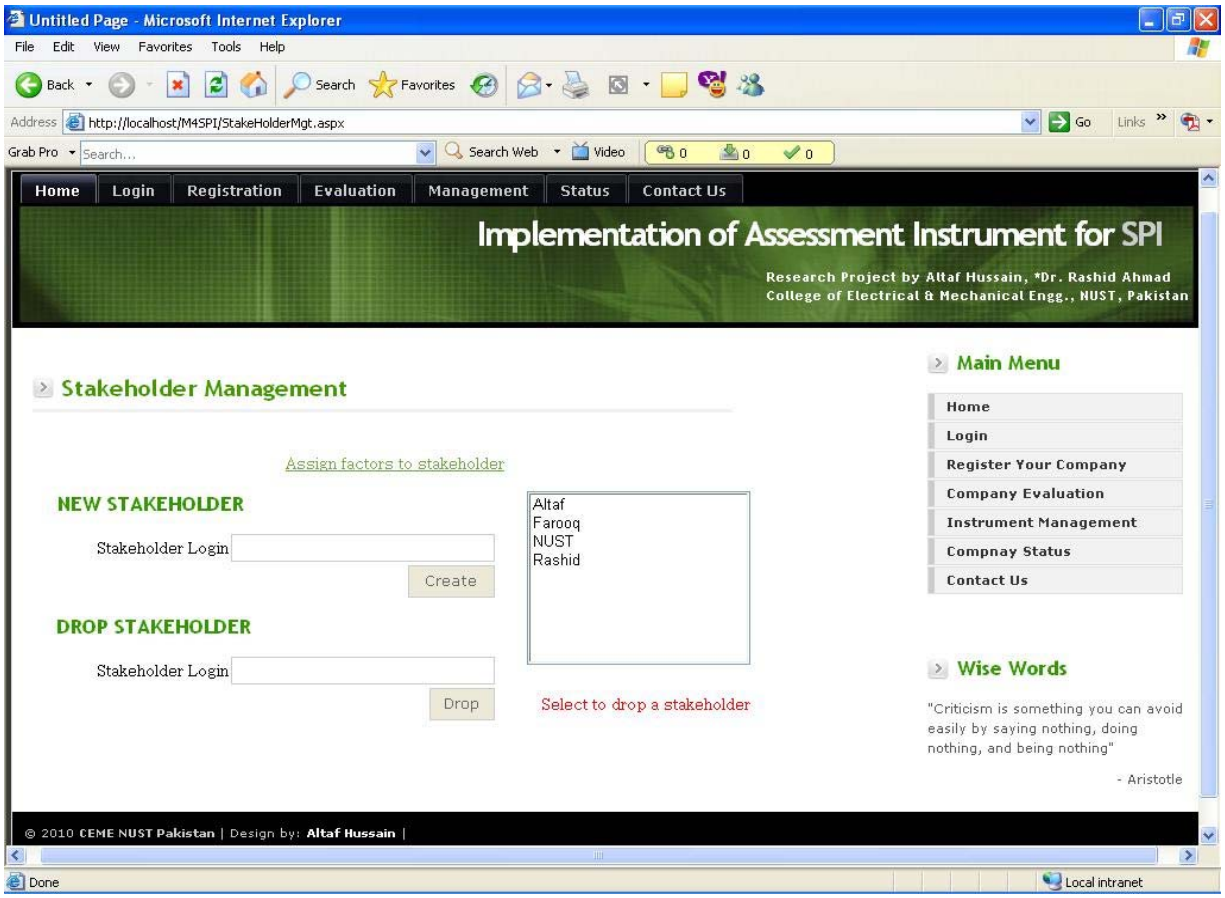

Figure 28: Stakeholder Management Page

5.2.5 Factors Assignment Page

This page can only be used by project manager for the assignment of factors to stakeholder for evaluation. First, he will have to select the stakeholder to whom factors are to be assigned. Assigning factors and removing factors to and from a specific stakeholder as:

- For factor assignment, each factor to be assigned will be selected from the unassigned factors list and then by clicking “Assign Factor” button, the selected factor will be assigned to the selected stakeholder.
- For removing already assigned factor, first the factor to be removed will be selected from the assigned factors list and then by clicking “Remove Factor”

button the factor will be removed and will be available for assignment to other stakeholder.

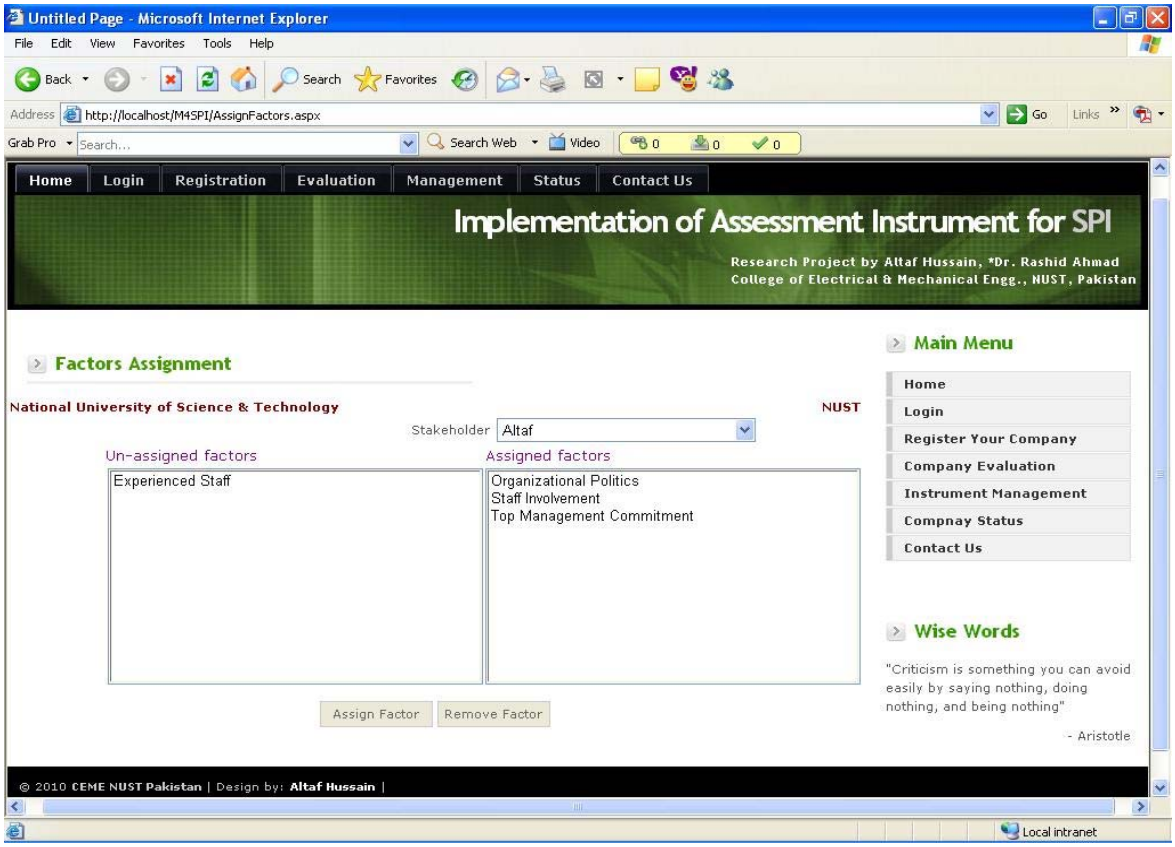

Figure 29: Factor assignment Page

5.2.6 Company Evaluation Page

This page can only be accessible to the concerned project manager. It provides following functionalities to project manager.

- Editing the company information
- Viewing the guidelines for evaluating your company using this instrument and finding the maturity level of your company
- Stakeholder management as we discussed earlier

- Viewing Motorola instrument that is being used for all factors evaluation as standard
- Assignment of factors to stakeholder as discussed earlier
- Evaluation of assigned factors using Motorola instrument; if any assigned factors
- Checking current status that includes all factors evaluation score and maturity level

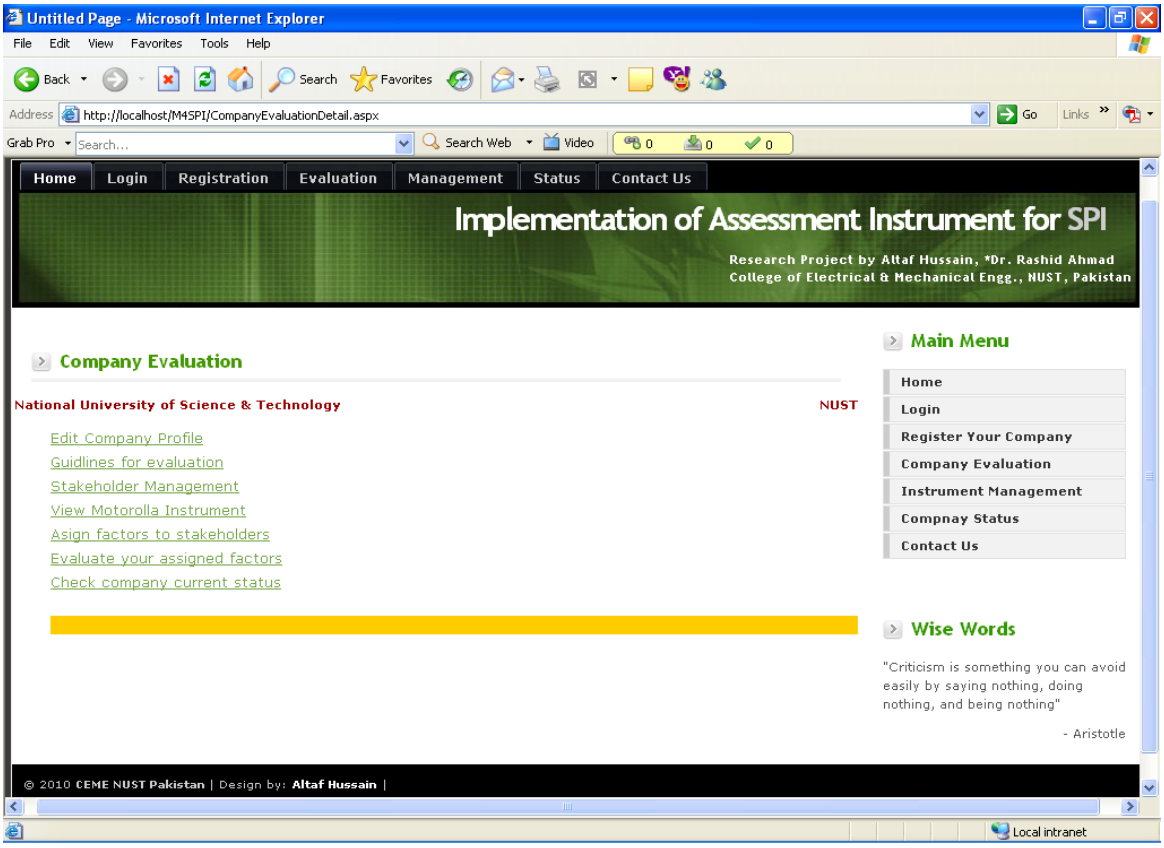

Figure 30: Company evaluation form

5.2.8 Practice Evaluation Page

This is the main interface of this instrument that will be used by all those stakeholders or project manager to whom some factors for evaluation are assigned. Login stakeholder will get all of his/ her assigned factors in the available combo-box and all the concerned practices will be made available in the practice combo-box for evaluation on selection. Stakeholder will have to evaluate all practices of each

assigned factor with three dimensions (Approach, Deployment, Results) using Motorola instrument.

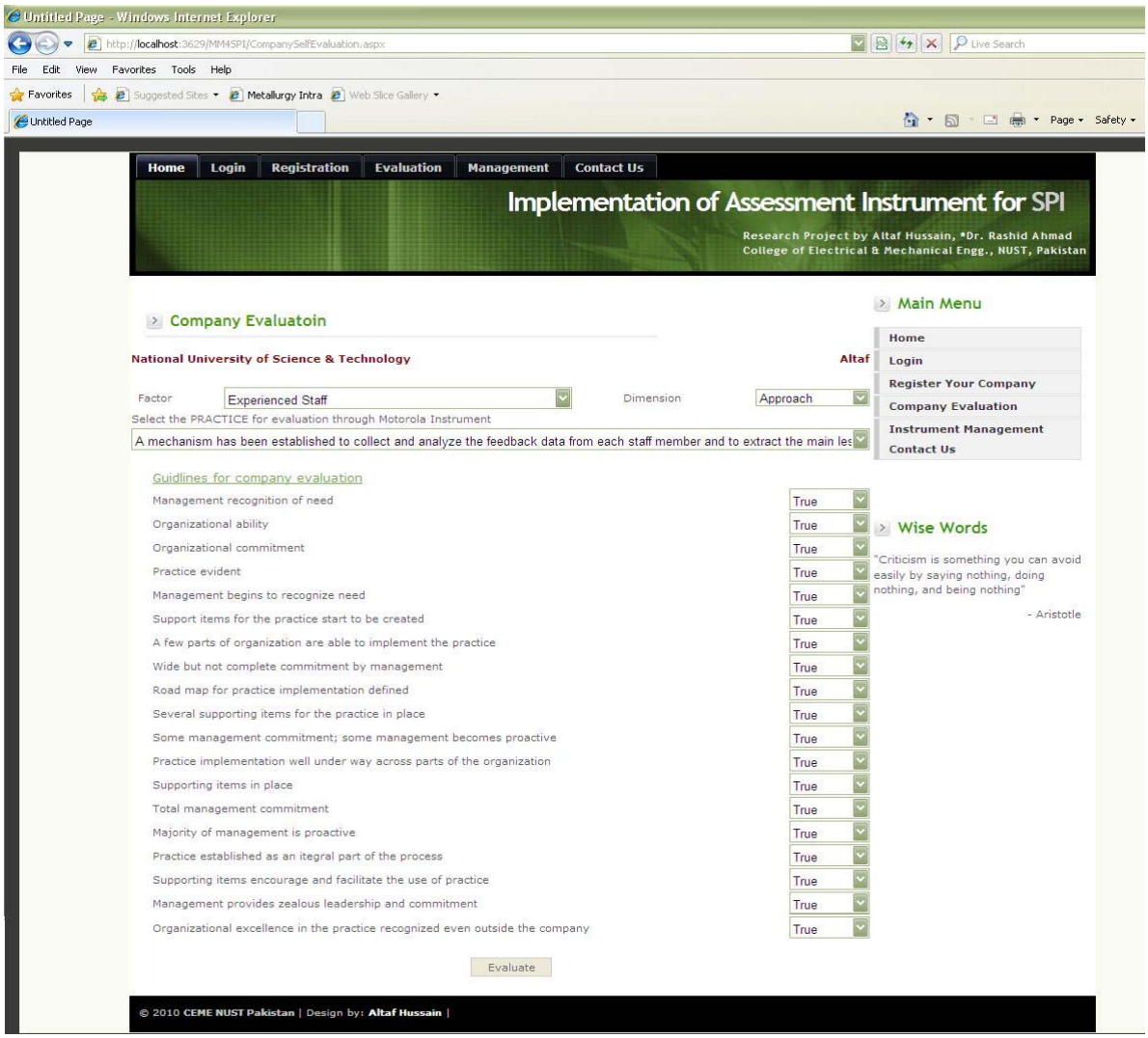

Figure 31: Factor & Practices Evaluation Page

5.2.9 Evaluation Guidelines Page

This interface simply shows the guidelines to know about how to evaluate your company using this instrument.

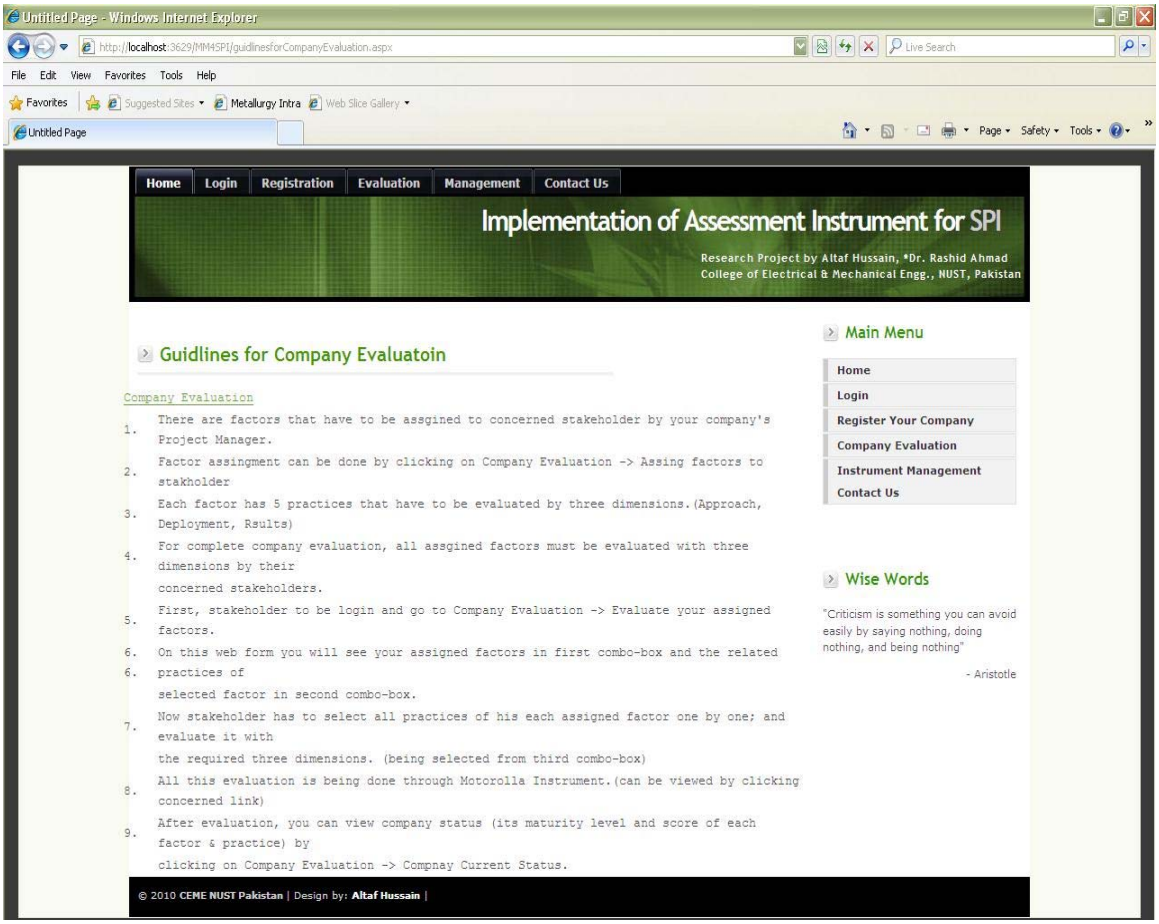

Figure 32: Evaluation Guidelines Page

5.2.10 Company Status Page

This interface is designed for viewing the status of company with different aspects of this model. It enables the project manager/ stakeholder to view:

1. Maturity level of company
2. Factor score along with concerned practices score
3. Weak factors that need to be improved for moving to higher maturity level

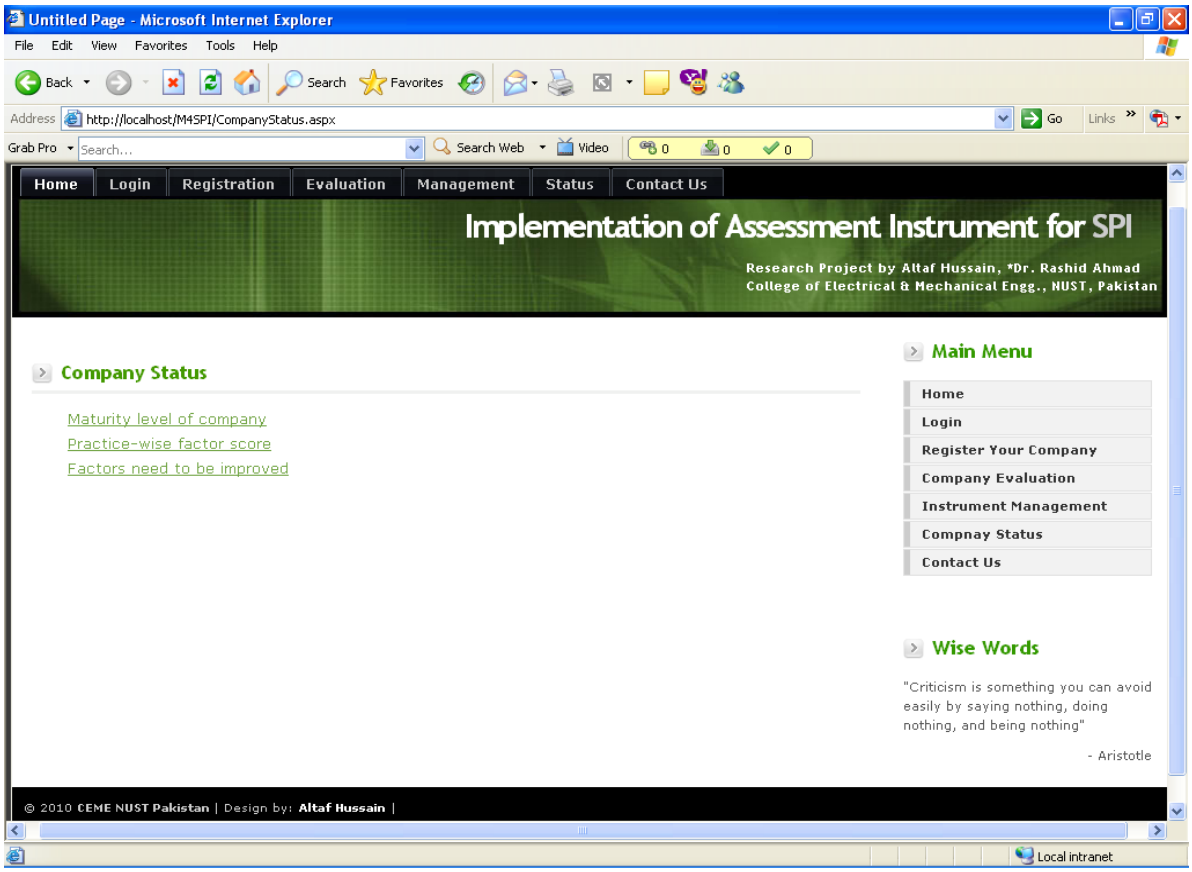

Figure 33: Company Status Page

5.2.11 Company Maturity Level

This interface is designed for viewing the maturity level of the company along with score of each factor and concerned practices. It is the final report that will show the score of each practice and related factor evaluated by the stakeholders.

The score of any practice or factor shown below than 7 will be considered as the weakly implemented and others will be strongly implemented. Considering this evaluation the maturity level along with its description will be displayed on the top of the report. In case of any one of the practice or factor is left unevaluated, and then the company will be considered as at Initial Level.

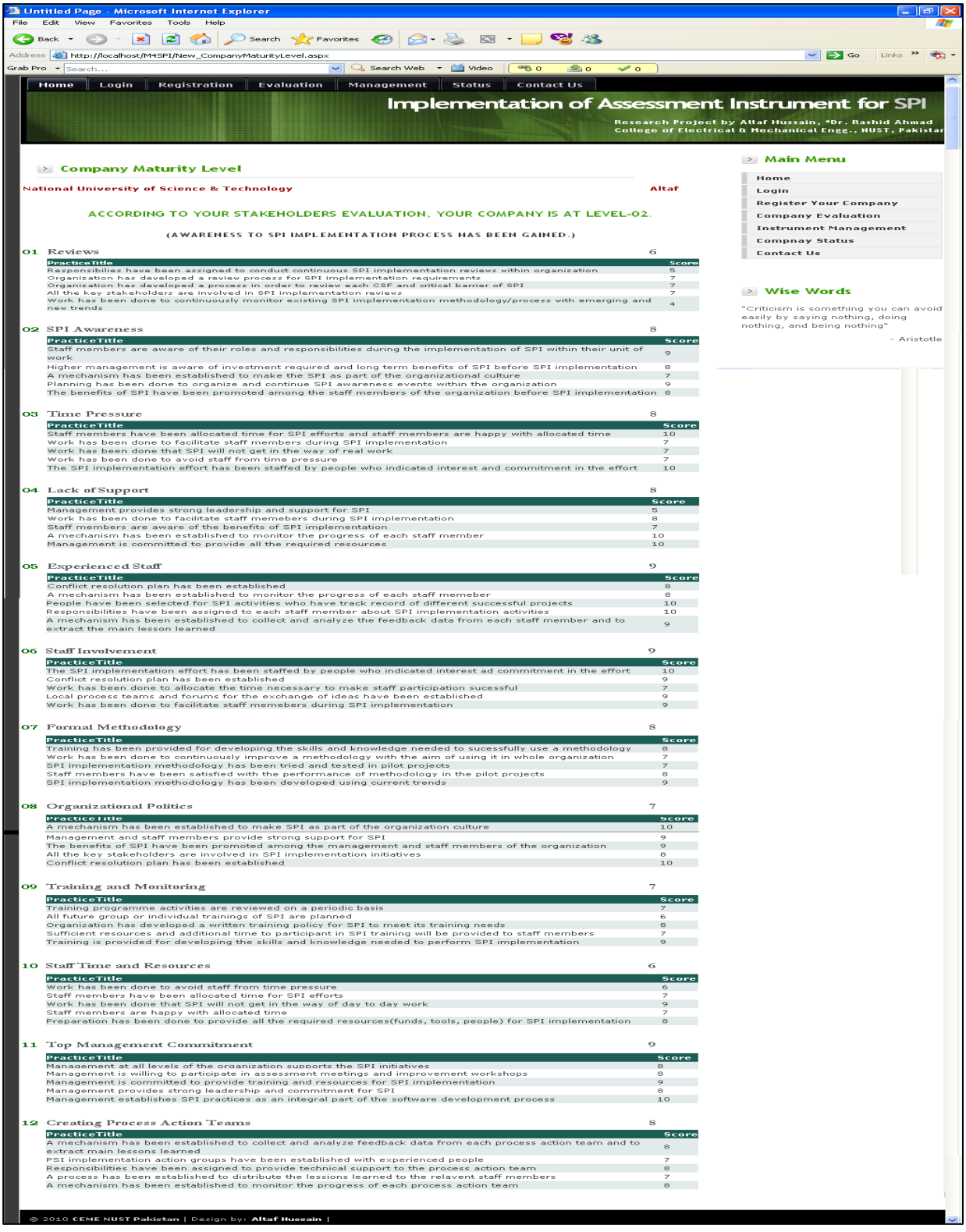

Figure 34: Organizational Maturity Level Report

5.2.12 Practice-wise Factor Score

This web form will provide the interface to project manager and stakeholders to view the practice-wise score of each factor.

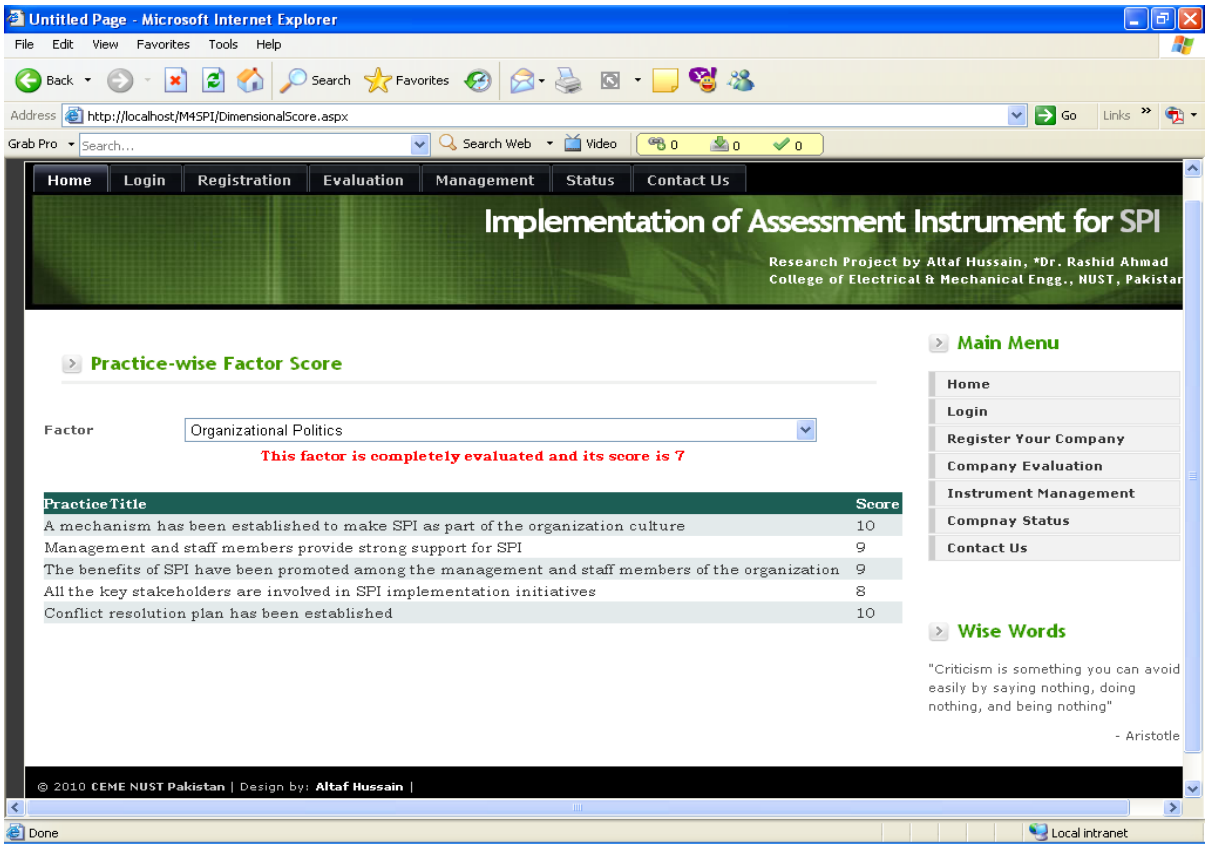

Figure 35: Organization Factor's Score

5.2.13 Factors Need To Be Improved

This web form will provide the interface to project manager and stakeholders to view all those practice and factors weakly implemented in the practice of their company. All the weak factors will be filled up in the shown combo box and the related practices will be shown below along with their score. Therefore, top management can find out reason of weakness in SPI implementation.

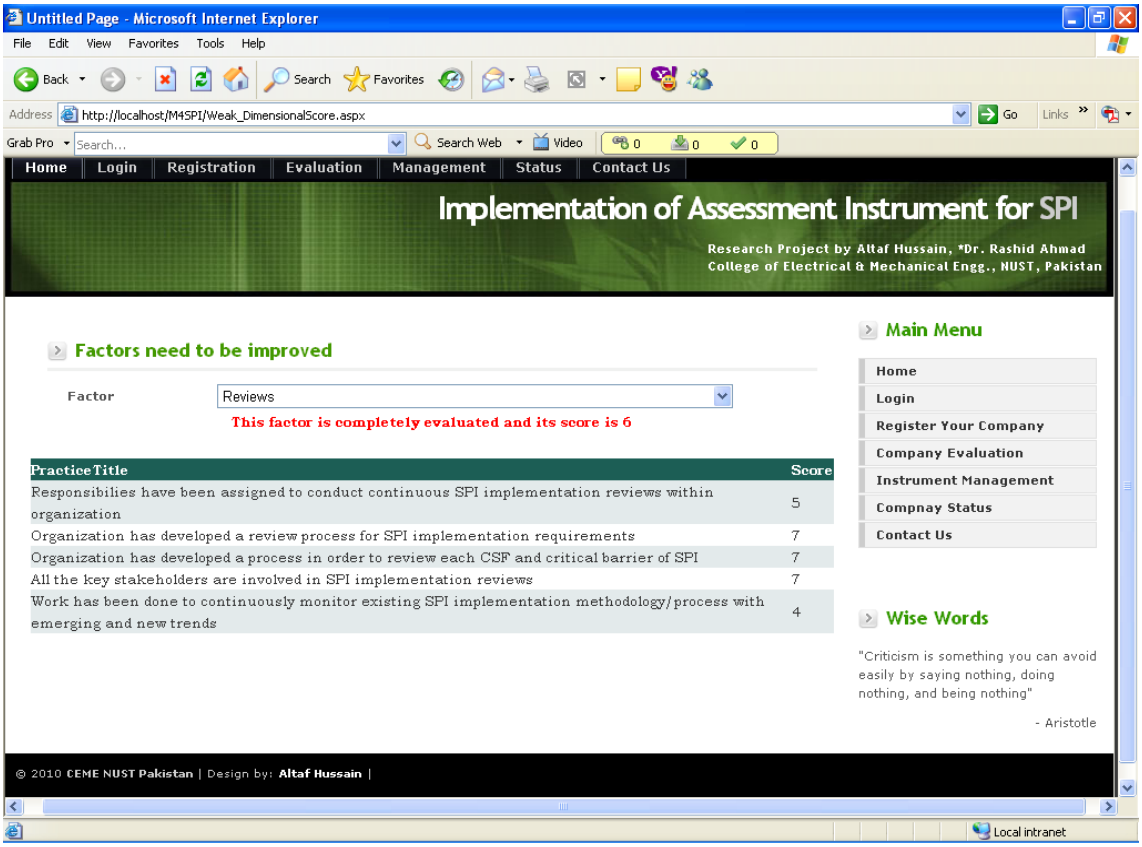

Figure 36: Organization Weakly implemented Factors

5.3 Strengths of Assessment Instrument

The worth mentioning features of this assement instrument.

- Instrument is web based; therefore it can be made available publically on web to all software companies to use it for evaluating their own SPI activities.
- Project manager has the full rights for his own company. He can assign factors to the concerned stakeholder keeping in view their field of work. In addition he can revoke an already assigned factor from a stakeholder as well.
- This instrument guides the project manager and stakeholders about the weakness of their company practices that need to be improved for moving to the upper maturity level.

5.4 Limitations of Assessment Instrument

Following are a few limitation of this assement instrument.

- This instrument is designed initially to automate the current maturity model and any future amendments to the maturity model will require a bit modification.
- In first version of this instrument, one time evaluation of a company is possible but that evaluation can be re-evaluated later on. Therefore It needs modification for multiple evaluation of a company by its stakeholders.

CHAPTER 6

CONCLUSION AND FUTURE WORK

In this chapter, we will provide the description of CASE tool validation and the overall summary of our work. We will also highlight some future work that can help to further enhance the maturity assessment instrument.

6.1 CASE Tool Validation

This CASE tool was tested by IT department of a well reputed technical organization; the name of organization is kept confidential as per our commitment with their top management. This department has 40 employees comprising of 05 senior programmers, 20 junior programmers, 04 system analysts, 04 software leads, 02 database administrators, and 04 system developers (Quality Assurance). The department is led by a Project Manager, who opted to use this assessment instrument for self assessment and evaluation. His report is as under, which consists of mainly two parts

1. Manager's Experience
2. Manager's Feedback for Instrument Enhancement

6.1.1 Manager's Experience

I came to know about this assessment instrument for SPI from some reliable source and implemented it with the consultation of my top management on experimental basis. Fortunately I found very encouraging results within my department. It really helped me to improve my workforce satisfaction and maturity of software development processes. I personally found it an efficient tool to be used as a proper

way of improving organizational capabilities and helping them to use its full potential to compete in the market.

Parameters outlined in this technique cover a wide range of factors affecting software companies. The most important thing in projects is handling the time pressure and meeting the timelines of the project without overstressing the employees, because overstressing results in worker dissatisfaction, and reduced output. This technique gave us a good idea of handling the time pressure we are facing in different projects. In addition support of top management and workforce involved in different software developments activities are as well required for successful execution of any project. This model provides worth mentioning guidelines for this factor achievement and improvement.

The involvement of staff and their training is also required for implementation of SPI. After carrying out surveys in the organization we were able to involve the staff in SPI and also found out the training requirements of different staff members which resulted in their skill development and making them versatile and enabling them to work under different working circumstances and environments. After all these activities, we applied this technique in our projects and got incredible results, although it requires some improvements regarding techniques of handling the time pressure and conflict management, but still it proved to be very useful for our organization.

6.1.2 Manager's Feedback for Instrument Enhancement

It's a very handy technique for the evaluation of a software industry, as we can implement this assessment instrument without consultation of any certified and skilled officials, unlike CMMI technique which requires their concerned certified personals for evaluation. The most striking feature that I liked about this instrument is that the evaluation is done by the people who are related to the factors directly, and they are in a very good position to identify the correct feedback to be given against each practice.

But there is always room for improvement so I would like to offer some suggestions for the enhancement of this instrument. Multi-time evaluation process may be

introduced, which is necessary for having a complete analysis of the improvements made against the deficiencies highlighted during the tenure between two evaluations. This tenure in my opinion may be one quarter (3 months), as in projects environment most of the progress reports are made on quarterly basis, and this is ample time required for having a feedback on the practices implemented to overcome earlier deficiencies.

6.2 Overall Summary of the Thesis

As discussed in chapter 1, our work is greatly influenced by the research of Niazi et al [9]. In fact we have practically implemented their Maturity Model after critically analyzing it. We started our work with literature survey which gave us a thorough and exhaustive knowledge about SPI. By reviewing existing literature in this area and analyzing the nature of software development process we were able to identify the weaknesses & flaws in the current approaches and efforts taken for SPI. In fact answer to the following question was explored: “What de-motivates practitioners in order to implement SPI initiatives?”

From the analysis of the literature we found that large enterprises using processes based on SPI models and standards can produce higher quality software, reduce development cost and time, and increase development productivity. Identification of only ‘‘what’’ activities to implement is not sufficient and that knowledge of ‘‘how’’ to implement is also required for successful implementation of SPI programs. We found that there was a great need to develop some mechanism that could assist SPI practitioners in the design and implementation of effective SPI initiatives. We found that one such mechanism has been proposed by Niazi et al [9] in the form of a maturity model for SPI implementation in order to guide organizations in assessing and improving their SPI implementation processes. However, this mechanism still needed some enhancement and physical implementation so that it can be made available to the organization in the form of a CASE tool.

As discussed in chapter 3, maturity model for SPI proposed by Niazi et al [9] has three dimensions; Stage Dimension, Critical Success Factor (CSF) Dimension, and Assessment Dimension. Stage dimension comprises of four maturity levels; initial, aware, defined and optimizing, and set of CSFs and critical barriers for all these levels has been defined in CSF dimension. In assessment dimension each of the CSF and critical barrier is measured in order to assess how well the factor has been implemented in practice of the assessor's organization. In order to resolve the conflict of different stakeholder's evaluation standards of same factor, an already tested instrument i.e. the Motorola instrument has been used in this dimension.

Assessment instrument is a web based implementation using .NET (dot net) framework and SQL Server 2005 is being used for data management. It enables the project manager of the assessing company to first register his company and define about four stakeholders keeping in view the factors being mentioned in maturity model for the assessment of their organization processes. Then, project manager has to assign the concerned factors to these stakeholders and they have to evaluate all practices of their assigned factors using Motorola Instrument. After evaluating all factors, CASE tool provides the stakeholders with current SPI status of their organization and suggests them improvements in the form of mentioning factors faintly implemented in practice of their organization. This tool provides the final evaluation report to stakeholder showing the maturity level of their organization and status of all factors along with their defined practices. As exactly five practices are suggested in this model [9] for achieving a specific CSF, so the score of each of these practices evaluated by stakeholders shows that how well that practice is implemented and either need any improvement or not. Therefore, considering our tool evaluation report, the practitioners involved in the faintly implemented processes in the organization, highlighted by assessment instrument, can be guided accordingly by the project manager.

6.3 Future Work

In the design of the maturity model for SPI authors [9] have extended the concept of critical success factors (CSFs) and critical barriers (CSFs). However, the set of practices suggested by Niazi et al, to satisfy each of these CSFs or CBs in the maturity model, are at a very abstract level. Further research is needed to elaborate the model and practices with some fine grain details.

Secondly, in case more than one practice has been suggested to achieve one CSF, no mechanism has been detailed how to prioritize these practices. For example, there are five practices suggested to achieve one CSF. Out of these five, two practices are of critical importance and rest three less important. Suppose a company implements the three simple and less important practices but avoids the critical practices, it still gets sufficient marks to alleviate its maturity level disproportionately. An empirical study is required to be carried out in the Software Industry seek their opinion in prioritizing these practices.

Although the authors [9] have extended the concept of CMMI to develop their maturity model for SPI but their model only has the staged representation. We recommend that this model should also have continuous representation like CMMI. Further research work is needed to suggest how continuous representation can be added to this model. This will allow the companies to measure their SPI maturity level in any specific process area.

This future work can be implemented in the next version of this assessment instrument and the Software Industry can be provided with an effective CASE tool.

APPENDIX – A

List of practices for CSFs and critical barriers defined with in maturity model

Factor	Practices
SPI Awareness	1. The benefits of SPI have been promoted among the staff members of the organization before software process improvement implementation 2. Higher management is aware of investment required and long term benefits of software process improvement before software process improvement implementation 3. Staff members are aware of their roles and responsibilities during the implementation of SPI within their unit of work 4. Planning has been done to organize and continue SPI awareness events within the organization 5. A mechanism has been established to make the SPI as part of the organization's culture
Staff involvement	1. The SPI implementation effort has been staffed by people who indicated interest and commitment in the effort 2. Work has been done to facilitate staff members during SPI implementation 3. Work has been done to allocate the time necessary to make staff participation successfully 4. Local process teams and forums for exchange of ideas have been established 5. Conflict resolution plan has been established
Training and monitoring	1. Training is provided for developing the skills and knowledge needed to perform SPI implementation 2. Sufficient resources and additional time to participate in SPI training will be provided to staff members 3. Training program activities are reviewed on a periodic basis

	4. Organization has developed a written training policy for SPI to meet its training needs
	5. All future group or individual trainings of SPI are planned
Senior management commitment	1. Management provides strong leadership and commitment for SPI
	2. Management establishes SPI practices as an integral part of the software development process
	3. Management at all levels of the organization supports the SPI initiative
	4. Management is willing to participate in assessment meetings and improvement workshop
	5. Management is committed to provide training and resources for SPI implementation
Time pressure	1. Staff members have been allocated time for SPI efforts and staff members are happy with allocated time
	2. Work has been done to avoid staff from time pressure
	3. Work has been done that SPI will not get in the way of real work
	4. The SPI implementation effort has been staffed by people who indicated interest and commitment in the effort
	5. Work has been done to facilitate staff members during SPI implementation
Experienced staff	1. People have been selected for SPI activities who have track record of different successful projects
	2. Conflict resolution plan has been established
	3. Responsibilities have been assigned to each staff member about SPI implementation activities
	4. A mechanism has been established to monitor the progress of each staff member
	5. A mechanism has been established to collect and analyze the

	feedback data from each staff member and to extract the main lessons learned
Formal methodology	1. SPI implementation methodology has been developed using current trends 2. SPI implementation methodology has been tried and tested in pilot projects 3. Staff members have been satisfied with the performance of methodology in the pilot projects 4. Training has been provided for developing the skills and knowledge needed to successfully use a methodology 5. Work has been done to continuously improve a methodology with the aim of using it in whole organization
Organizational politics	1. Management and staff members provided strong support for SPI 2. A mechanism has been established to make SPI as part of the organization's culture 3. The benefits of SPI have been promoted among the management and staff members of the organization 4. All the key stakeholders are involved in SPI implementation initiatives 5. Conflicts resolution plan has been established
Staff time and resources	1. Preparation has been done to provide all the required resources (funds, tools, people) for SPI implementation 2. Staff members have been allocated time for SPI efforts 3. Staff members are happy with allocated time 4. Work has been done to avoid staff from time pressure 5. Work has been done that SPI will not get in the way of day to day work

Creating process action team	1. SPI implementation action groups have been established with experienced people 2. Responsibilities have been assigned to provide technical support to the process action team 3. A mechanism has been established to monitor the progress of each process action team 4. A mechanism has been established to collect and analyze the feedback data from each process action team and to extract the main lessons learned 5. A process has been established to distribute the lessons learned to the relevant staff members
Review	1. Organization has developed a review process for SPI implementation requirements 2. Work has been done to continuously monitor existing SPI implementation methodology/ process with emerging and new trends 3. Organization has developed a process in order to review each CSF and critical barriers of SPI 4. Responsibilities have been assigned to conduct continuous SPI implementation reviews within organization 5. All the key stakeholders are involved in SPI implementation reviews
Lack of Support	1. Management provides strong leadership and support for SPI 2. Management is committed to provide all the required resources 3. Work has been done to facilitate staff members during SPI implementation 4. Staff members are aware of the benefits of SPI implementation 5. A mechanism has been established to monitor the progress of each member

APPENDIX – B

Motorola Instrument (source [32])

Score	Key Activity evaluation dimensions		
	Approach	Deployment	Results
Poor (0)	▪ No management recognition of need ▪ No organizational ability ▪ No organizational commitment ▪ Practice not evident	▪ No part of the organization uses the practice ▪ No part of the organization shows interest	▪ Ineffective
Weak (2)	▪ Management begins to recognize need ▪ Support items for the practice start to be created ▪ A few parts of organization are able to implement the practice	▪ Fragmented use ▪ Inconsistent use ▪ Deployed in some parts of the organization ▪ Limited to monitoring/verification of use	▪ Spotty results ▪ Inconsistent results ▪ Some evidence of effectiveness for some parts of the organization
Fair (4)	▪ Wide but not complete commitment by management ▪ Road map for practice implementation defined ▪ Several supporting items for the practice in place	▪ Less fragmented use ▪ Some consistency in use ▪ Deployed in some major parts of the organization ▪ Monitoring/verification of use for several parts of the organization	▪ Consistent and positive results for several parts of the organization ▪ Inconsistent results for other parts of the organization
Marginally qualified (6)	▪ Some management commitment; some management becomes proactive ▪ Practice implementation well under way across parts of the organization ▪ Supporting items in place	▪ Deployed in some parts of the organization ▪ Mostly consistent use across many parts of the organization ▪ Monitoring/verification of use for many parts of the organization	▪ Positive measurable results in most parts of the organization ▪ Consistently positive results over time across many parts of the organization
Qualified (8)	▪ Total management commitment ▪ Majority of management is proactive ▪ Practice established as an integral part of the process ▪ Supporting items encourage and facilitate the use of practice	▪ Deployed in almost all parts of the organization ▪ Consistent use across almost all parts of the organization ▪ Monitoring/verification of use for almost all parts of the organization	▪ Positive measurable results in almost all parts of the organization ▪ Consistently positive results over time across almost all parts of the organization
Outstanding (10)	▪ Management provides zealous leadership and commitment ▪ Organizational excellence in the practice recognized even outside the company	▪ Pervasive and consistent deployed across all parts of the organization ▪ Consistent use over time across all parts of the organization ▪ Monitoring/verification for all parts of the organization	▪ Requirements exceeded ▪ Consistently world-class results ▪ Counsel sought by others

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