A METHOD TO DECREASE COMMON PROBLEMS IN EFFORT DATA
COLLECTION IN THE SOFTWARE INDUSTRY

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ABSTRACT

A METHOD TO DECREASE COMMON PROBLEMS IN EFFORT DATA
COLLECTION IN THE SOFTWARE INDUSTRY

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Efficient project planning and project management is crucial to complete the software projects in expected time and requirements. The most critical stage in project planning is estimation of the software size, time and budget. In this stage, effort data is used for benchmarking data sets, effort estimation, project monitoring and controlling. However, there are some problems related to effort data collection in the software industry. In this thesis, a pilot study and survey study are conducted to observe common practices and problems in effort data collection in the industry and results are analyzed. These problems are explained in terms of tool, process and people factors and solution suggestions are presented according to these problems. In accordance with the findings, a method and a tool which can facilitates to provide more accurate data are developed. A case study is performed in order to validate the method and applicability of the tool in the industry.

Keywords: Effort, Effort Data Collection, Estimation, Project Planning

ÖZ

YAZILIM SEKTÖRÜNDE EFOR VERİSİ TOPLAMA PROBLEMLERİNİ AZALTMAYA YÖNELİK BİR YAKLAŞIM

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Yazılım projelerinin zamanında ve istenen şekilde bitmesi, başarılı bir proje planı ve proje yönetimi için çok kritiktir. Proje planı yapılırken en önemli aşama ise yazılım büyüklüğü, zaman ve maliyet kestirimi yapılmasıdır. Tüm bu planlamanın temelinde, efor bilgileri önemli bir yer teşkil eder. Yazılım sektöründe toplanan efor verisi, yazılım veri kümelerinin oluşturulması, proje planı için gerekli efor tahminlerinin gerçekleştirilmesi, proje takip ve kontrolü için kullanılır. Ancak yazılım sektöründe, efor verisi toplamayla ilgili bazı problemler mevcuttur. Bu çalışma kapsamında, bu problemlerin sektördeki varlığını sorgulamak için bir pilot çalışma ve anket çalışması yapılmış ve efor verisi toplamadaki en önemli problemler ayrıntılarıyla incelenmiştir. Problemler araç, süreç ve insan olmak üzere üç başlık altında toplanmış ve her başlık için çözüm önerileri sunulmuştur. Bu çözüm önerileri doğrultusunda bir yaklaşım ve efor verisi girmeyi kolaylaştıracak ve insanları efor verisi girmeye teşvik edecek bir araç geliştirilmiştir. Yaklaşımı doğrulamak ve aracın uygulanabilirliğini, problemlere olan etkisini inceleyebilmek için bir durum çalışması yapılmıştır.

Anahtar Kelimeler: Efor, Efor Verisi Toplama, Tahmin, Proje Planlama

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This thesis is dedicated to my great family; my spouse, dad, mom, and brothers.

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CHAPTER 1

INTRODUCTION

Efficient project planning and project management is crucial for the success of software projects (Ozkaya, Ungan, & Demirors, 2011). Software projects without a well-prepared project plan are mostly bound to fail (Anton, 2003). According to the researches, 60% of software projects fail because of the erroneous initial estimations for project effort and schedule (Molokken & Jorgensen, 2003). Many projects are abandoned due to planning errors. All software organizations share the same goal: to meet functional needs of customers by a software application with acceptable quality, within budget and on schedule, but only 30%-35% of the projects are completed within estimated schedule and scope (The Standish Group, 2009).

Human resource is the main and the most critical resource since human is the base for software development and personnel cost stands as the most significant part in software projects. Therefore, human resource management is important for the success of a certain project. Unfortunately, software managers and developers suffer from overtime work due to insufficient human resource management (Johnson, Moore, Dane, & Brwer, 2000).

To improve human resource management, effort estimations are used. Effort estimations are made by using historical data of other software projects (Menzies, Port, Chen, & Hihn, 2005). Effort data collection subject is the key factor for historical data collection. Collected effort data are used for project management activities such as project monitoring and controlling activities. Also, it is one of the main inputs for project data sets, benchmarking studies, effort estimation models and project planning activities. Errors in the collection of this effort data result inaccurate data sets and consequently inaccurate effort estimations with models utilizing these data sets. These inaccurate estimations, ultimately, result in failures in software projects (Attarzadeh & Siew Hock Ow, 2008).

1.1 Problem Statement

Experimental studies show the inaccurate results of benchmarking studies and effort estimation models (Top, Ozkan, Nabi, & Demirors, 2011). In the study of Top, Ozkan, Nabi, and Demirors, effort estimation models are developed using different software benchmark repositories such as ISBSG, Albrecht, China, Desharnais, Finnish, Maxwell and Kemerer. When the results are evaluated according to the results of the estimation models, they find only 1 of the 7 selected projects have accurate results with the applied estimation model. In this regard, the key question is that: is the past effort data suitable for using benchmarking, effort estimation studies and project planning (Maxwell, 2001)? If the effort data which is the main factor of these studies have inaccurate values, all models that use the effort data give inaccurate results.

The quality of the effort data for the past projects is questionable because of missing data for the software projects (Cartwright, Shepperd, & Song, 2003). Strike, El Emam, and Madhavji analyzed several projects' historical data and found missing effort data more than 40%. These inaccuracies of the effort data affect the quality of historical data sets in the industry (Strike, El Emam, & Madhavji, 2001). Thus, project plans are prepared according to erroneous effort estimations and these erroneous results affect next projects which will use the effort data of previous project. Therefore, the process is like a vicious cycle.

In this study, we investigated the effort data collection practices in the industry and factors that lead to inaccurate effort data collection. A pilot study was carried out to observe problems in effort data collection and a survey was conducted to monitor the existence of these problems in the industry as well as causes of these problems. These problems were explained in different categories to find solutions which include people, process, and effort data collection tool factors. Main problems were found as organizational politics, employees' reluctance, and the tools that do not facilitate to record effort data. According to these problems, the solution approach was developed which was given in the following section.

1.2 Approach

The aim of this thesis is to raise awareness of effort data collection process in the software industry by showing the common practices and problems in effort data collection and find solutions to these common problems. To achieve the aim, firstly, we identified the problems step

by step and then suggested a solution approach. We analyzed the problems by various studies in order to suggest clear solutions.

To reach our solution approach, we analyzed our previous survey and pilot study results by root cause analysis, and fishbone diagrams methodologies and applied these techniques which provide us to clarify the problems in the industry deeply. We identified the problems into three categories;

•   The problems about Effort Data Collection Tool

•   The problems about Effort Data Collection Process

•   The problems about personnel which record the efforts

After clarifying problems, we identified the solution suggestions for the problems. These suggestions were found by the pilot study results, the survey study results and our researches. All suggestions were explained for our problem categories which were tool, process, and people factors. The main problems about process and people are related to the organizational politics and insufficient knowledge of people about effort data collection purposes. Thus, solutions suggestions depend on giving sufficient knowledge about the reasons why we need to collect effort data. The problems about tool are related to the usage difficulties of the tools and not encouraging people to record their efforts. So, the suggestion about the tools is implementing features that will facilitate to provide more accurate effort data.

Our Effort Data Collection Methodology is developed by analyzing all of these results. The Effort Data Collection Tool is also implemented according to these results. The Effort Data Collection Tool is a software application which includes the needs of the personnel in the industry and implemented according to requirements of the personnel that have different experiences in the industry from diverse domains.

1.3 Validation

After implementing the tool, we performed a case study to validate our results. Our objectives to conduct the case study were given below:

•   To find whether the effort data collection tool facilitates to provide more efficient data

•   To find the impacts of the new features in our tool by comparing the previous tools of the users

•   To find whether users provide more accurate data if necessary information and knowledge provided about the tool and about the reasons we need to use these tools.

In this regard, we applied our case study to three software organizations in the industry. After we had given the necessary information about the tool and explained the importance of the effort collection process, they used it. After this step, we analyzed the effort data of the organizations in our tool and compare the results with our first studies. We discussed the results of our methodology with these organizations to see the results and applicability of our Effort Data Collection Tool.

1.4 Organization of Thesis

The remainder of the thesis is structured into four chapters.

Chapter 2 presents the related research on benchmarking and effort estimations studies and well known issue and effort tracking systems in the industry.

In Chapter 3, the methodology to decrease common problems in effort data collection in the software industry is given. All studies that are conducted to develop the methodology are described in detail. Also, the effort data collection tool implemented in this thesis is introduced with all functionalities, use case diagrams and database design.

Chapter 4 explains the case study that is conducted to validate the methodology. The research questions, case study plan, approach and results are discussed in this chapter.

Finally, conclusions and future work are discussed in Chapter 5. Also, the contributions of our study are given in this chapter.

CHAPTER 2

RELATED RESEARCH

In this chapter, the related researches about benchmarking data sets, effort estimation models and issue and effort tracking systems are explained briefly.

2.1 Related Research on Benchmarking and Effort Estimation Studies

There are not many studies in the literature concerning effort data collection methods and related difficulties. Most of the studies and surveys focus on effort estimation models and problems of these models (Molokken & Jorgensen, 2003), (Ferens, 1999). In the literature, only a few studies have been conducted about the problems in the effort data. Most of the time effort data collection practices are discussed as a part of other studies. Chris Mann and Frank Maurer (Mann & Maurer, 2005) conducted a study that gathered effort data of a selected organization through a period of two years, and compared the results with time the employees supposed to work. Outcomes of the study were used to improve the processes of the company. The improved processes increased the productivity of the company. A similar study was conducted as a part of this study. In our pilot study, a similar method was used and errors in the effort data were identified (Ozkaya, Ungan, & Demirors, 2011).

According to the researches, 30% to 40% of the software projects have overrun efforts which show us the estimation error in the software projects is very high (Jorgensen & Molokken-Ostvold, 2004). It is obvious that achieving a software project in the specified time and budget with the given requirements is the critical feature of the software projects. Through this way, effort and cost estimations are the main concern in the software engineering research for a long time (Lamersdorf, Münch, Torre, Sánchez , & Rombach, 2010). Several estimation models were improved and a plenty of studies were performed in this area. Effort data is critical for this aspect.

Effort estimations are made by using previous project efforts in order to make close estimations to the real life. Software organizations can use their previous projects or find other organizations' previous projects by benchmarking repositories. In the industry, there are some repositories which are called benchmarking repositories that collect the software organizations' previous projects to help other organization with their software effort estimations.

In this context, software benchmarking is significant to make better effort estimations for the software projects. The main purpose of the benchmarking is to give valuable information to the software organizations for project management (Lokan, Wright, Hill, & Stringer, 2001). Benchmarking process starts by collecting data to the repositories from the software organizations. The most well known repository can be stated as the International Software Benchmarking Standards Group (ISBSG) Dataset, the Promise Dataset, and Laturi/Finnish Software Metrics Association (FISMA) Experience Database (Gencel, Buglione, & Abran, 2009). Software organizations supply effort data for their projects and necessary information about the project as organization sector, development area, development language, architecture etc.

As it is emphasized, effort estimation models and benchmarking repositories are used for a long time in the industry. Although the software organizations have several estimation models and data sets for the previous projects, there are still estimation errors in the industry which results overruns effort and budget in the projects.

Effort data is at the heart of these problems. This thesis aims to find the reasons of the inaccurate effort data collection and find a methodology to decrease these problems.

2.2 Related Research on Issue and Effort Tracking Systems

The idea of collecting effort data was used by the software development companies to develop new applications to achieve this goal. With the purpose of collecting effort data of the projects, several software applications were introduced to the industry.

These systems are used to control, manage and track the projects. Some of them are about the project life cycle and tracks the issues of the project. It is possible to create, manage the issues, and list all of the history, generate reports, get kind of charts by using these systems. Effort and Time tracking systems are different in some way. Their purposes are to track your time and

effort.

Furthermore, there are some systems that combine these two features which are tracking issues and tracking effort. In this document, we analyzed these titles by giving examples of the most popular systems in their areas. We choose three tools which are Jira, Bugzilla, and Dovico. The selection criteria were their popularity and their project types. Jira is proprietary software and free for the open source projects that are suitable for their criteria. Bugzilla is an open source tool, and Dovico is a commercial tool. In Chapter 3, the features of these programs are used to improve our new method for collecting effort data accurately.

2.2.1 Jira

In software Jira is a well known issue tracking system in the software industry. It is easy to track projects, issues, and the bugs in the projects. It is written in Java. It is a proprietary system which means it is not a free product. It is only free for open-source projects that meet their criteria. It is user-friendly system and has kind of reports and functionalities. Some of the functionalities of Jira are given below.

- Creating, editing issues, managing issues

- Defining issue types, issue priority, issue status

- Resolving, assigning, opening, closing issues

- Creating one or more projects

- Editing default work flow

- Downloading and uploading files to the issues

- Entering work logs to the issues (This part is related to time tracking)

- Sending e-mails to the related persons when an issue is created or started etc.

- Tracking all history of issues and project

- Getting kind of reports, charts

- Searching issues by kind of criteria

- Creating searching filters

Below, some screenshots of Jira are provided.
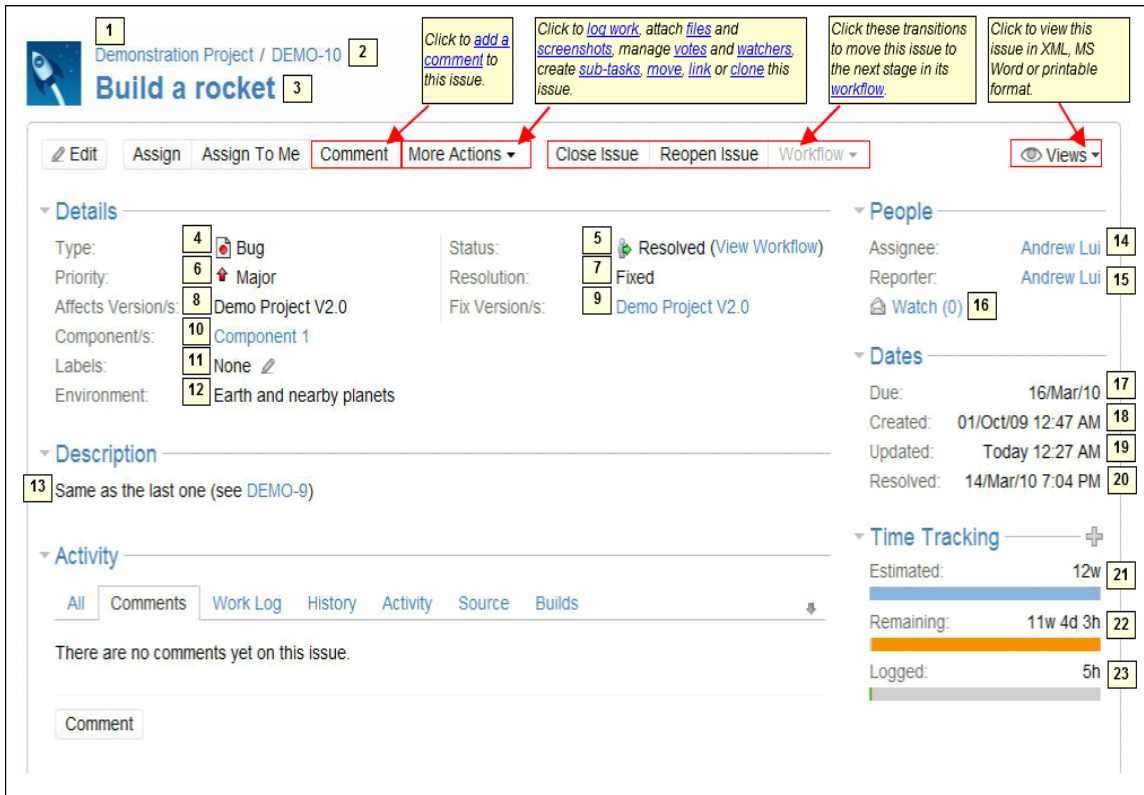
Figure 1 Screenshot of an issue

Figure 2 Searching issues

2.2.1.1 Integration with Other Programs

Jira has some plugins and integration tools with other systems. Integration of some revision control systems and other tools are discussed below. Jira can be used in Eclipse development platform by its Eclipse plugins. Also, it has integration with revision control systems. Some of them are given below.

Perforce SCM: Perforce SCM (Software Configuration Management) system. You can integrate it with Jira to control history.

Subversion: Subversion is another revision control system which is open source.

CVS: CVS is another revision control system.

FishEye: JIRA's FishEye integration allows you to browse your source-control repository from inside JIRA.

ClearCase: ClearCase has integration with JIRA including real-time notifications of code

changes.

2.2.1.2 Time Tracking Mechanism for Effort Collection

Jira has a basic timer mechanism. It is possible to enter your start and finish time of your issues. Also, you can enter work logs to enter your time partially. It can be taken kind of reports according to your effort.

When plugins are used, it is possible to have timers in Jira. Eclipse has a Jira plugin which has this timer. When you start to write codes and start the timer, timer automatically calculates the time you have worked. By this way, Jira can have better timer mechanism in order to track coding effort data.

2.2.2 Bugzilla

Bugzilla is another popular issue tracking system. It is an open-source product and written in Perl programming language. People generally find Bugzilla user interface a little complicated at first sight, because it is one screen that you can find lots of the functionalities. Later on, it is easy to use. Bugzilla was created by tracking bugs. Jira calls tasks as issues; Bugzilla calls the tasks as bugs. Similar to Jira, some of the functionalities of Bugzilla are given below.

- Creating, editing bugs, managing bugs

- Defining bug types, bug priority, bug status

- Resolving, assigning, opening, closing bugs

- Creating one or more projects by using "Classification trees"

- Downloading and uploading attachments to the bugs

- Entering work logs to the bugs (This part is related to time tracking)

- Sending e-mails to the related persons when a bug is created or started etc.

- Tracking all history of bugs and project

- Getting kind of reports, charts

- Searching bugs by kind of criteria

- Basic time tracking

- Vote system which users can vote the bugs

Below, some screenshots of Bugzilla are provided.

Figure 3 Bugzilla Main Page
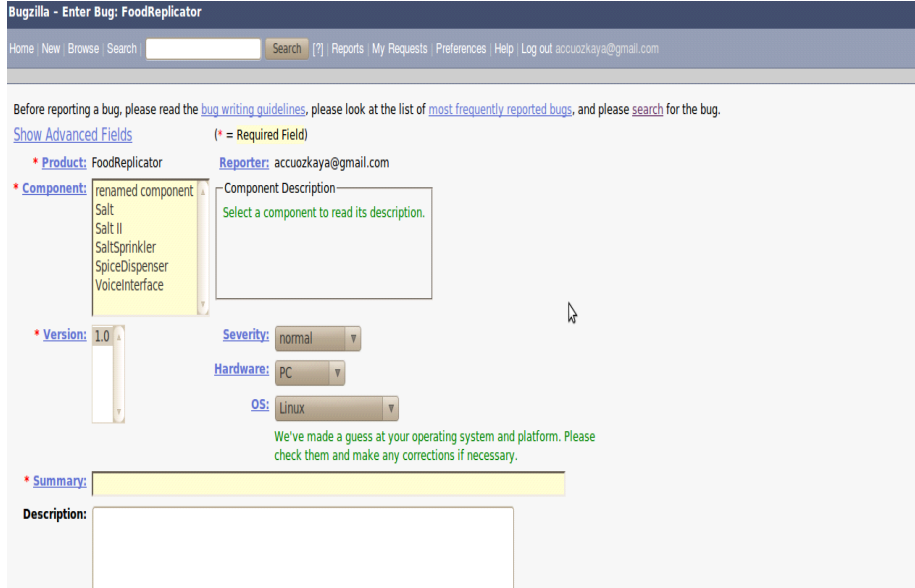
Figure 4 Creating new bugs

2.2.2.1 Integration with Other Programs

There are some programs that can be integrated to Bugzilla, but we discuss the third party tools that Bugzilla will be integrated in this part.

Bonsai: Bonsai is a concurrent version system. You can integrate Bugzilla with Bonsai to track all history of your bugs.

Perforce SCM: Perforce SCM (Software Configuration Management) system. You can integrate it with Bugzilla to control history.

Subversion: Subversion is another revision control system which is open source.

CVS: CVS is another revision control system

2.2.2.2 Time Tracking Mechanism for Effort Collection

Bugzilla has a very basic timer mechanism. You can enter the time you fix the bugs, and your estimations. It is possible to see how much time spent on the issues, estimated time about the issues, and deadlines. There is a "Time Summary" button, and you can take reports of your time.

2.2.3 Dovico

Dovico is another issue and time tracking system. It is commercial software. It includes project planning, issue tracking, and time tracking concepts. Basic functionalities are given below.

•   Creating, editing, and managing issues

•   Listing personnel calendar according to time they entered

•   Getting kind of reports

•   Getting e-mail notifications when an issue started, assigned etc. and when the specified budget or time reached

•   Tracking all history of the project, and issues

•   Creating one or more projects

•   Searching by filters

•   Defining approval mechanisms

•   Good time tracking mechanism

Some screenshots are given below.
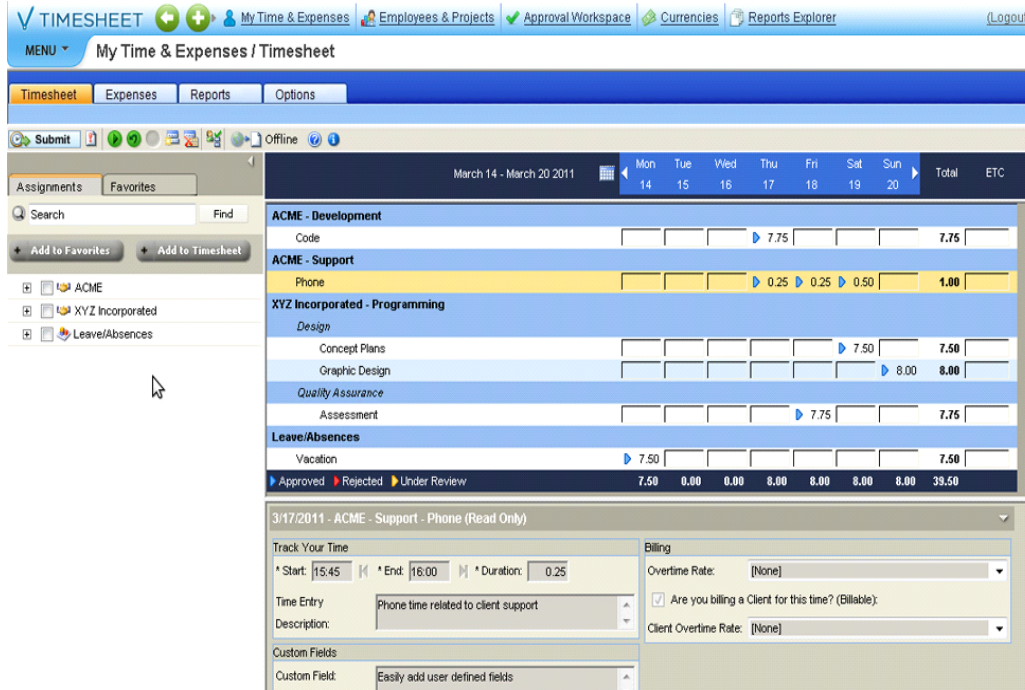
Figure 5 Timesheet of Dovico
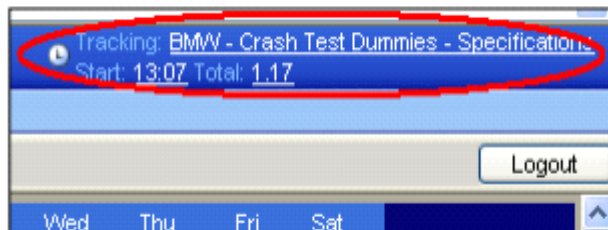
Figure 6 Timer for a task

2.2.3.1 Integration with Other Programs

Dovico can be integrated with the programs Microsoft Project/Project Server, QuickBooks, and Active Directory. Also, there is an export/import tool for other applications in various formats (text, comma separated, html, xml, etc.)

Microsoft Project/Project Server: Microsoft Project/Project Server is a project management

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program that managers develops plan, tracks projects, and analyze the tasks. It is commonly used in software development companies for planning projects. Dovico has an integration with this tool that can import and export information between these two tools.

After creating your projects in Microsoft Project, you can send it to Dovico TimeSheet. Using these tasks, employees can record their effort in these tasks like an ordinary task in Dovico. After completing the records, you can export these data into Microsoft Project to see your project status.

QuickBooks: QuickBooks is a software about accounting. You can use with Dovico to track your employee's time and calculate your expenses. You can send the information that you collect in Dovico to QuickBooks to achieve your accounting processes.

Active Directory: Active Directory is a directory system to store employee's information. Dovico has integration with Active Directory that synchronizes all users between these programs.

Import/Export Tool: You can import and export your records to/from Dovico in lots of formats (text, comma separated, html, xml, etc) as projects, tasks, employees, time records etc.

2.2.3.2 Time Tracking Mechanism for Effort Collection

Dovico has a good time tracking mechanism. It is possible to track your time by recording your efforts by manual or just clicking the timer by start and stop buttons.

First, you add your tasks, and when you want to start the task, you can click start button and the timer starts. When you want to finish the task, you can click the stop button. The timer calculates the time you have worked. The figure shows the assignment and timer screenshot of Dovico.
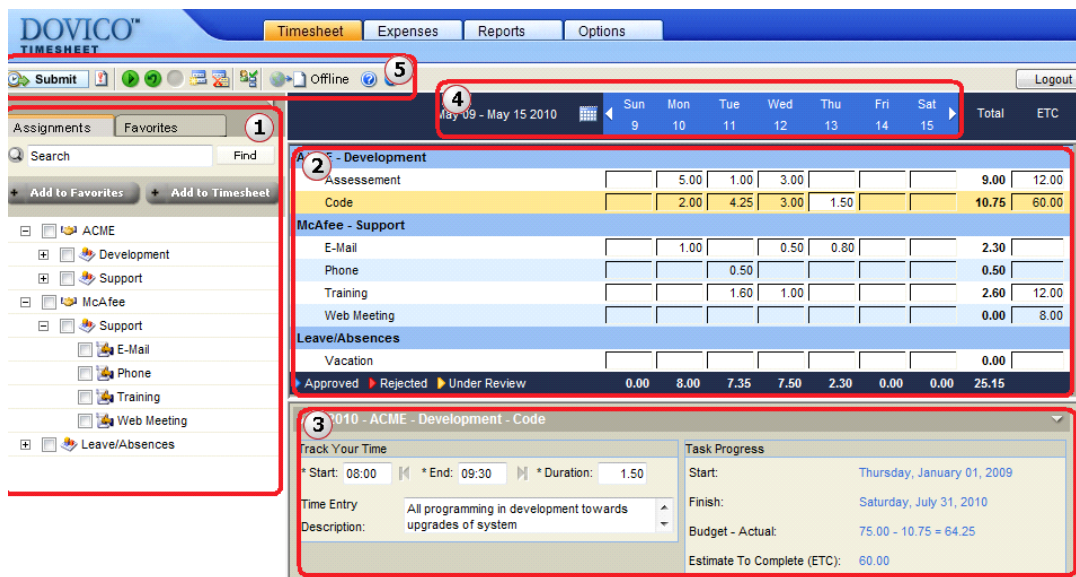
Figure 7 Time Tracking of Dovico

2.3.4 Comparison of Jira, Bugzilla, and Dovico

As it is explained, Jira, Bugzilla and Dovico have lots of functionalities in common, but also there are some differences between these issue tracking systems. We prepared a set of criteria to see the differences and similarities between Jira, Bugzilla and Dovico. We used a pointing system that is used in ISO/IEC 15504 (ISO/IEC, 2004).

• N: Not achieved (0 - 15%)

• P: Partially achieved (>15% - 50%)

• L: Largely achieved (>50% - 85%)

• F: Fully achieved (>85% - 100%)

Table 1 Comparison of Jira, Bugzilla and Dovico

Functionalities	Jira	Bugzilla	Dovico
User Interface	L	P	F
Gadgets	P	N	L
Email Notifications	F	F	F
Personal Time Calendar	F	F	F
Timer	P	P	F
Integration with Other Programs	L	P	P
Overtime Control Mechanism	N	N	N
Project Plan Integration to the Tool	P	P	F
Comparing Project Plan Roles and Issue Roles	N	N	N
Telephone, Meeting and E-mail Notifications for Daily Records	N	N	P
Dynamic Daily Effort Tracking	L	L	L

User Interface: When we analyze the tools according to the UI, Bugzilla has a very simple interface, but not effective. Jira has a better interface which is more user-friendly and have dashboards that can be changed. Dovico's user interface is better than others because it is very easy to use.

Gadgets: Bugzilla has no gadgets. Jira has gadgets that can be used in the dashboard. Dovico is better, because it has a desktop gadget that can be used in Windows.

E-mail Notifications: All of the tools have e-mail notifications. Administrators can determine the mailing list according to the issue status.

Personal Time Calendar: All of the tools have calendars, but Jira and Bugzilla have calendars by using plugins. Dovico has a built-in calendar.

Timer: All of the tools have timer mechanisms, but Jira and Bugzilla have basic timers. In Bugzilla, you can enter your issue start and stop dates. In Jira, when you use plugins (Ex: Eclipse Plugin), you can click start and stop buttons while you are coding. When you finish the work, it automatically calculates your effort according to your tasks. Dovico has a timer as Jira plugin.

Integration with Other Programs: Jira has integrations with some applications. Dovico and Bugzilla are worse than Jira in this area. Jira has a lot of plugins for programs. Bugzilla and Jira can be developed as open source, so they have integration with other programs. Also, they are more common in use, so other applications try to be integrated with Jira and Bugzilla.

Overtime Control Mechanism: All of them are poor for overtime mechanism.

Project Plan Integration to the Tool: Dovico is better. You can import your project plan to Dovico, and then export the effort record from Dovico to Microsoft Project. Bugzilla and Jira provide this functionality by file formats as text, csv, xls etc.

Comparing Project Plan Roles and Issue-Time Tracking Tools' Roles: There is no comparing mechanism for this area.

Telephone, Meeting and E-mail Notifications for Daily Records: Jira and Bugzilla have no mechanisms for this feature, but there is a basic mechanism in Dovico to record efforts according to this data.

Dynamic Daily Effort Tracking: All of them have kind of reports, but none of them have dynamic gadgets to see the daily efforts.

We discussed the three well known issue-time tracking systems. They have very similar functionalities. We analyzed these functionalities according to the criteria that were given by people in the software industry. These tools implement some of the criteria, but some of them were not met. In Chapter 3, we meet some important features such as integration, gadget, user roles, and keeping meeting effort records that have not included in these tools.

CHAPTER 3

APPROACH: A METHODOLOGY TO DECREASE COMMON PROBLEMS IN EFFORT DATA COLLECTION IN THE SOFTWARE INDUSTRY

This chapter describes a pilot study and a survey study to find the problems of the effort data collection in the software industry and the solution approach to solve these problems. A pilot study has been conducted in order to observe the problems about effort data collected in the industry. After analyzing the results of the pilot study, a survey has been conducted regarding the problems observed in the pilot study with the purpose of investigating their prevalence in the industry.

After discussion the results of the survey, we aimed to find the requirements of a good effort collection methodology that will facilitate to provide effort records accurately. In order to find the methodology, we analyzed the results of the pilot study and the survey study. In addition, we put our suggestions regarding to our previous researches about effort data collection tools.

In section 3.1, pilot study and its results are discussed. In section 3.2, we give the survey study and its results. The requirements of effort data collection tool are given in section 3.3. The tool design is given in section 3.4 and the functionalities of the tool are discussed in the last section.

3.1 Pilot Study

3.1.1 Overview

The A pilot study was conducted in order to observe the problems about effort data collection in the software industry. It was planned to be carried out in a medium-scaled software company in Ankara, Turkey. Within this study, past effort data of the chosen organization was gathered and

analyzed. The effort data was compared to the time that employees spent in the organization. Following the comparison process, the deviations found were considered the possible problems in effort data collection process.

3.1.2 Study Plan

The plan was to find a software organization which supplied the necessary effort data for the study. The study was planned to be conducted under privacy conditions. In order to analyze the effort data, a project that had previous effort data and a software team whose team members had different roles and responsibilities were selected. Following the selection, we gathered the effort data for each team member in the project and found the deviations between the effort time provided and real time that team members spent in the project.

3.1.3 Implementation

As the study plan, a pilot study was achieved with the aim of asserting more clearly the presence of problems about the collection of effort data in the industry. We planned to specify the results of this study to be the inputs for the survey study. In the pilot study, we analyzed the effort data for the past 3 years in a medium-scaled software company which has ISO-9001 quality certificate. To analyze the effort data, the effort data collection tool of the company was used. During the analysis of data, software engineers working on the chosen software modules and the amount of time these developers spent on these modules were considered in order to find the deviations in the effort records.

Users were chosen for different experience categories in order to compare whether the experience of the users affects the quality of the effort data collected. 5 users were selected for the pilot study. The team included seniors and juniors.

After selecting appropriated modules, we analyzed the collected data. We considered 3 important criteria:

• The time spent by each user to the modules

• The time that the users have to spend from the start of the module until selected date

- Users' off days and official holidays during the implementation of modules

First, the number of work days expected to be spent by the employees were calculated. Following the calculation, their working days in the organization and the total hour of daily work were multiplied in order to find total work hours in the organization. The difference between this effort data and the effort data they supplied to the effort data collection tool, we found the errors in effort data. It is a reality that it is impossible to work all day without a break; therefore 25% missing data is considered acceptable for the accuracy of effort data per day according to our discussions with project manager.

For our case, we choose a period of six months from January 2011 to June 2011. This period includes 180 days. When we excluded 1 day as official holiday and 51 days as weekends from total time period, we came by 128 work days. The daily work hours are 8 hours for the organization and none of the users had off days during this time period, so expected effort for the module is calculated 1024 hours by multiplication of work days and daily work hours.

The related information about the selected users was given in Table 2.

Table 2 Pilot Study Results

User #	Role	Experience in the software industry (years)	Experience in the organization (years)	Expected effort for the module (hours)	Reported effort data for the module (hours)	Missing Effort Data (%)
User # 1	Project Level Manager	12	5	1024	768	25
User # 2	Project Personnel	7	3	1024	532	48
User # 3	Project Personnel	5	3	1024	471	54
User # 4	Project Personnel	2	1	1024	491	52
User # 5	Project Personnel	1	1	1024	450	56

As the effort data was given in the Table 2, expected effort for the module and reported effort data for the module were different. According to our acceptation criterion for data loss, only project manager provided accurate results. The results for the selected project and team members are given below.

- Role of the team member affects the quality of the collected effort data. It shows

necessary knowledge about the effort data collection process supplies more accurate results.

• Experience in the software industry and software organization can affect the quality of the collected effort data, but there is no direct relation between them.

As it is explained, there is a considerable error deviation between expected effort for the module and reported effort data for the module. If this data used in effort estimation models, the model would not give accurate results for the future project estimations.

Upon determining the difference between reported effort data and the expected effort spent, reasons of this problem were discussed. We consulted the project manager and the employees with the purpose of finding the possible reasons of deficient or erroneous efforts stated by them. The results were discussed in the following section.

3.1.4 Results

Following the pilot study, problems in collected effort data were determined. The most significant problems pointed by the team members and our findings according to our analysis are given below.

1. Discrepancies in the abstraction levels of task definitions
2. No effort data is provided for overtime work
3. No effort data is provided for unplanned tasks
4. No effort data is provided for immediate/urgent tasks
5. No effort data is provided for tasks such as calls, meetings, and e-mail traffic
6. Employees are not compelled to provide effort data in specific periods
7. Employees provide effort data about tasks expected from them, as well as ones they already perform
8. Both organization's and employees' lack of awareness about the topic
9. Social causes such as the employees' reluctance about providing effort data or their ignorance on the matter

These findings were considered as inputs to our next study in order to observe the existence of these problems in the industry as well as causes of these problems.

3.1.5 Threats to Validity

The pilot study was applied to one software organization. Although the organization has ISO-9001 quality certificate, there may be some mistakes in the effort data collection process of the company. In this regard, the error deviations may be unrealistic.

In the pilot study, the daily total work hours were assumed as 8 hours, but it is obvious that it is hard to work all day long for a software developer. This may have caused some errors while analyzing expected effort for the module.

3.2 Survey Study

3.2.1 Overview

A survey study was designed to determine the presence and prevalence of the problems obtained in the pilot study in the industry. This survey was applied to a total of 42 people from different organizations. There were 22 different organizations named by the participants and 11 participants' organizations were left unspecified. The results of the survey study were planned to be inputs for improvement of the effort data collection methodology.

3.2.2 Study Plan

The survey was planned as face-to-face interviews with the participants in the software organizations in Ankara, Turkey. The questions of the survey were prepared to include classical questions about the participants' organization, experience etc, agree/disagree questions about the effort data collection tool of the participants' organization, and open-ended questions to identify the participants' opinions and suggestions to improve a good methodology.

The results of the survey were planned to be evaluated by the authors. Within the scope of evaluation, problems obtained in the pilot study would be compared to the survey results, and new problems would be added to the results if found.

3.2.3 Implementation

In accordance with this plan, first, 20 questionnaires were applied to the students of Software Engineering from the Middle East Technical University, Informatics Institute. The other half of the survey, however, was conducted online due to factors such as time limitation and participants' refraining from face-to-face answering. Participants providing no organization name and/or completing the survey on the Internet were observed to express the problems regarding their organizations more clearly.

In the first part of the questionnaire, questions were asked about organizations' name, domain of activity, certifications for quality and/or maturity level; participants' duty in the organization and the number of years the participant has worked in that organization. With this information, the number of organizations and the diversity of domains of activity for these organizations were determined.

It was ensured that participants from all positions including project staff, project support staff, project level managers and administrative managers participated in the survey. Participants also had varying years of experience, mitigating any possible effects of personal experience over the results.

In the second part of the questionnaire, questions were asked about the effort data collection tools used in the organizations, effort collection frequencies and the purpose of effort collection within the organization.

In the third and fourth parts of the questionnaire, questions were asked about the issues in effort data collection and errors in effort data.

Final part of the questionnaire consisted of open ended questions in which participants' were asked to provide their experiences, comments and suggestions on the matter. The survey is given in Appendix A.

3.2.4 Results

For the findings obtained in the pilot study were addressed in the survey, and through the survey, all issues mentioned above were proven to be present in industry. It was observed that above mentioned problems are prevalent in the entire software industry regardless of domain.

The data obtained from the first part of the questionnaire is given on Table 3, Figure 8, and Figure 9. Participants' organizations posed a diverse sample set. There were both organizations possessing the highest level of quality certificates and ones without any quality certificate at all. The answers given indicate a higher level of reliability in collected effort data as the maturity and quality level increases in an organization. However, certain problems were still observed regardless of the level of organization.

Table 3 Organizations' Domains of Activity Based on Number of Participants

Organization's Domain of Activity	Number of Participants
Banking / Finance	5
Defense Industry	15
Telecommunication	4
MIS	12
Consumer Electronics	1
Public	1
Insurance	1
Environment - Energy	1
R&D	1
Other	1
Total	42
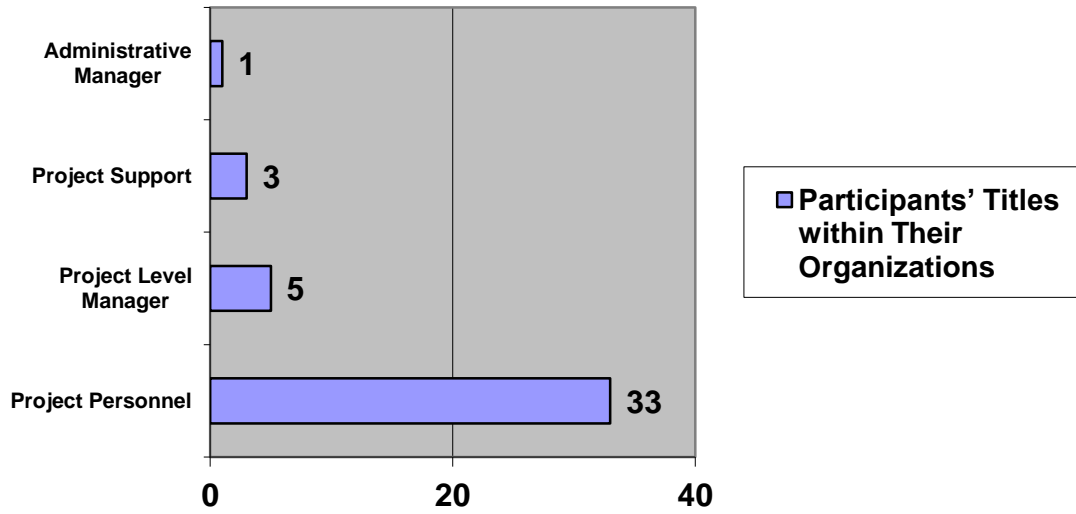
Figure 8 Participants' Titles within Their Organizations
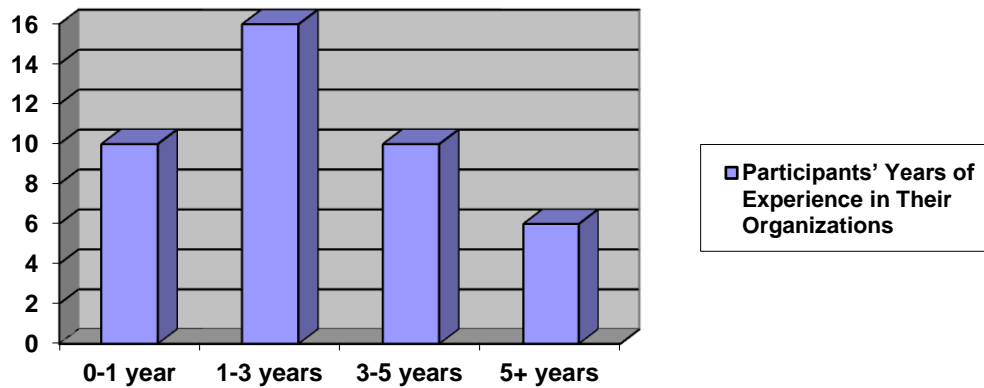

Figure 9 Participants' Years of Experience in Their Organizations

It was observed that same effort collection tools could be used with different configurations and different frequencies. Data obtained from this part is given in Figure 10, Figure 11.
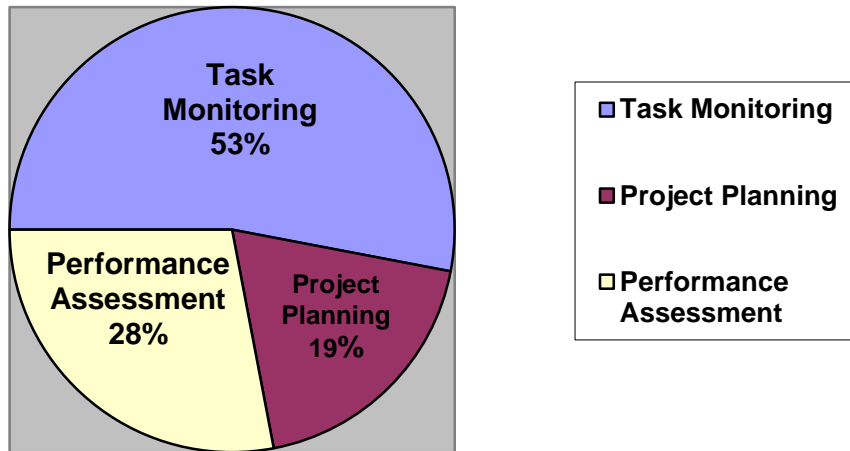
Figure 10 Purpose of Effort Data Collection in the Organization
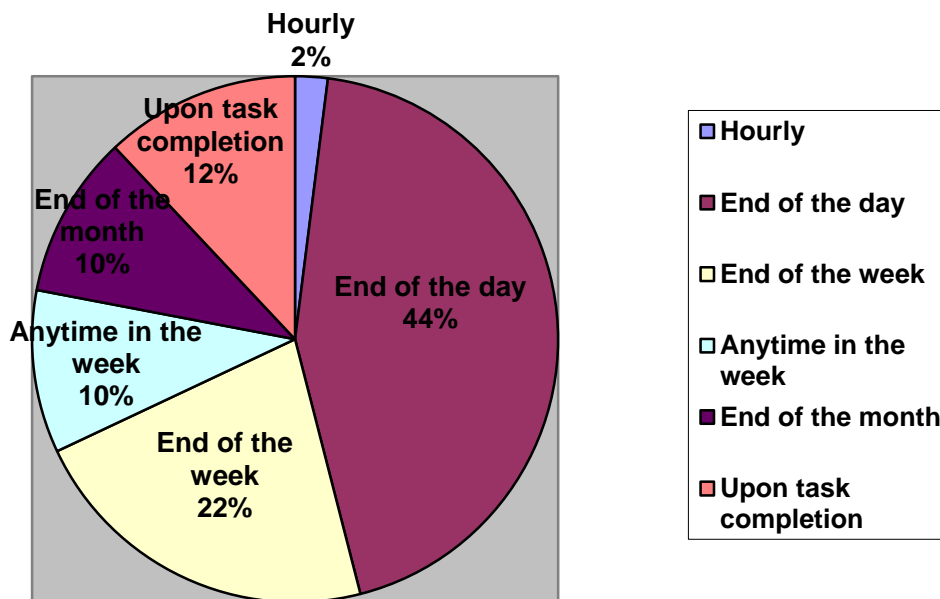
Figure 11 Effort Data Reporting Frequency

60% of the participants stated that their tasks were identified in different levels of abstraction. This difference causes problems during the input of effort data and renders the collected data useless for many purposes. For instance, both an 8-week-long task and a 1-hour-long task are represented with the same level of abstraction, which interrupts a regular effort data input.

53% of the participants stated that they don't record any effort data for overtime work, 40% for unplanned tasks, and 50% for immediate tasks. When overtime work, unplanned tasks, and immediate tasks in software industry are considered (Ferens, 1999), the amount of lost effort data here is substantial.

66% of the participants were determined to record no effort data for tasks such as phone calls, meetings, and email traffic. The loss of effort data regarding these tasks is also estimated to be of significant amount.

By the end of the survey, information about 20 different effort collection tools which were mentioned by the participants was gathered. There are organizations that utilize existing commercial tools for collecting effort data and there are those that develop and use their own effort data collecting tools. We have also observed that different configurations and data input intervals are used for same tools. Same tools can be used with different intervals such as; end of the week, end of the day, on the hour, end of the month, and on task completion.

Of the participants, 62% stated a tendency to make changes in the effort data they provide due to factors such as performance assessment, project deadlines and audits. 83% stated they happen to charge their effort for several tasks to a single task item, regardless of its correspondence to the actual tasks they worked for. 71% stated that they are not able to provide accurate effort data because of performing multiple tasks. These findings indicate the fact that effort data collection in the industry is prone to be considerably unreliable. Questions that belong to the mentioned part of the survey and the answers of participants are given below.
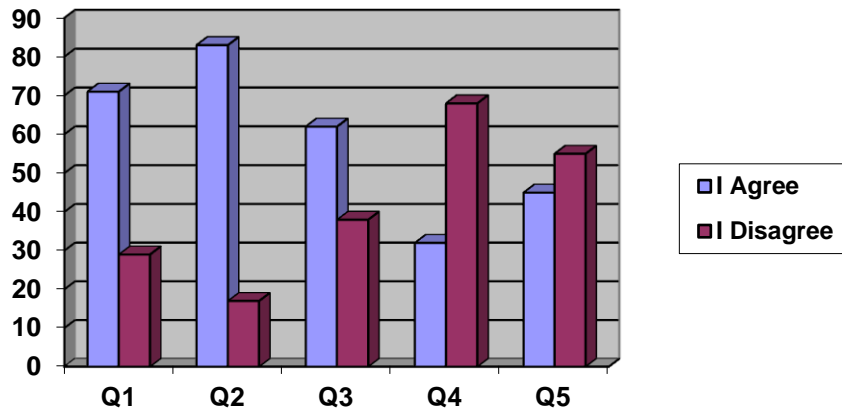
Figure 12 Common Errors in Effort Collection

Questions for Figure 12:

1. I may be unable to record my effort data accurately as I work for multiple tasks at a time.

2. When I work on many small tasks, I may record them as a single task, even if the task descriptions do not match.

3. If the actual effort spent on a task is much more or much less than the estimated, I might be required to change the data and record a value closer to the estimate.

4. I think that the collected effort data is also used for evaluating my performance. Therefore, I might alter the values while I am recording my effort data.

5. In certain specific situations such as project deadline, project milestone, progress billing, auditing, etc. I might be expected to alter my effort data or record the effort spent on a task under another one.

%69 of participants stated that they have been informed and trained on their effort data gathering tool by their organizations. However, while answering open ended questions, they also stressed that these trainings were aimed to instruct them on the usage of tools; but not intended to raise awareness among employees on the importance of effort data and its purpose. It is concluded that both organizations and employees do not have the required level of awareness about the

importance of collecting the actual effort data.

We asked participants about their opinions and suggestions in open ended questions. We asked about the difficulties they experience in gathering effort data; their suggestions for more accurate effort data collection methods; and their suggestions on any additional information that should be gathered about their work while gathering effort data.

Participants mentioned general problems of project management in software industry, and they added that these problems are affecting both the expected effort they need to spent and the accuracy of the effort data they report. Participants list difficulties in effort data collection and reasons for inaccurate effort data as:

•   Recording effort data also requires quite a lot of effort.

•   Software developers consider recording their effort data as a tedious and unnecessary task.

•   Effort estimations are made without taking the skill and development speed of individuals into account.

•   It is not possible for a developer to work the whole time during the working hours.

•   Deviations from project plan due to the scope creep through the project lifecycle.

•   Lack of organizational awareness about effort data collection.

•   Inaccurate effort estimations due to management's lack of up to date software and technology knowledge.

•   False effort data is recorded so that records meet the initial estimations.

•   Especially in R&D projects, the amount of effort required by each task may vary greatly. This makes effort data collection difficult.

•   Lack of support and/or pressure of higher management.

•   Lack of automated tools to collect effort data, effort data is recorded manually.

After the participants mentioned the problems in effort data collection, in another open ended

question, we asked their suggestions for these problems. Participants' suggestions can be summarized as:

• Benefits of effort data collection should be demonstrated to the managers. Employees should be trained and awareness development activities should be performed.

• Team leaders should review the recorded effort data in periodic meetings.

• Tasks should be broken down to smaller units instead of abstract definitions.

• Non-project activities such as meetings, reports, research etc. should be included as tasks so that effort for those activities can also be recorded.

• Effort data collection tools should be automated and integrated to the working environment.

• Effort data collection tools should give periodic warnings and send reminders to ensure the data is recorded regularly.

• Employees should be informed that effort data is utilized in many activities such as, effort estimation, training planning, personal career planning etc.

• Persons that provide their effort data properly should be awarded.

• Effort data collection tools should be easy to use and flexible.

After the participants mentioned the problems and their suggestions, in another open ended question, we asked what kind of information they think should be provided along with the effort data. Participants' suggestions can be summarized:

• In the effort data collection tools, there should be detailed pre-defined selections for tasks and attributes, instead of free text fields which require more time to fill.

• The employee should be able to further break down the task to manage his/her own effort and record effort data separately for those sub tasks.

• Information about the complexity of the task should be entered.

• Information about the employees experience about the task should be entered. (The task is a routine or is it being done for the first time, the responsible person(s) had the required experience to complete the task or not etc.)

We separate the factors leading to inaccurate effort data into two categories; conscious and unconscious errors.

Unconscious errors may be defined as difficulties related to the nature of capturing effort data in software engineering and errors done during data input. While creating effort data, it is not easy to determine how much of the work in a certain time period can be defined as expected project effort. In a work breakdown structure, it may not always be trivial to precisely separate and decouple tasks/work packages. Moreover, it may not always be possible to implement those tasks in separate time periods. Some tasks might have to occur simultaneously and utilize the same resources. Such difficulties complicate capturing real effort data and cause errors in datum.

Furthermore, impractical nature of effort data collection tools and their lack of ability to integrate with other software engineering tools also cause problems in effort data collection.

Questions in sections two and three of the questionnaire conducted during the study address this type of errors. Factors defined as conscious errors, on the other hand, may be explained as problems related to the attitude and understanding of persons and problems in organization culture concerning effort data collection. These problems can be summarized as the lack of awareness about the relationship between the effort data and project management activities. It is observed that effort data is either, being used out of its purpose, misused or not used at all. Several practices were noted to cause problems in effort data.

It was observed that some organizations use effort data to assess employee's performance and use this performance information for decisions like bonuses, promotions etc. This, practice causes employees to alter their effort data due to social and economic concerns. They tend to report their effort closer to what was estimated or asked by their superiors, which results in inaccurate data.

Similarly, organizations are known to include effort data in their contracts. Some contracts are based solely on the amount of effort spent and some require certain amount of effort to accumulate for progress payments. These practices directly influence the effort data as; effort

becomes an economic asset for the company rather than an objective metric. Companies use their effort data to get payments or pass audits. This results in the effort data to be altered directly by management's demand and incentive.

Questions in section four of the questionnaire conducted during the study address to this type of errors.

In the study, it was also observed that the majority of the employees try to match the effort data that they report with the amount of effort estimated for the tasks assigned to them. In this case, erroneous effort estimation causes erroneous effort data. Most effort estimation methods include verification of their estimation results through comparison with actual effort data. Based on these comparisons, the methods are adjusted to improve their further estimations. However, as with the abovementioned case, this adjustment is reversed. This creates a reinforcing cycle in which inaccurate estimations result in inaccurate effort data and inaccurate effort data results in inaccurate estimations in return.

Similarly, collecting erroneous effort data leads to the creation of erroneous data sets for internal and/or external benchmarking studies. Most project management activities utilize such data sets. Employees provide data matching as per the expectations of these management activities, altering the real data due to several concerns. Thus, a vicious cycle forms, which negatively affects the success of project management activities in organizations (Ozkaya, Ungan, & Demirors, 2011).

3.2.5 Threats to Validity

Participants of the study were chosen from the same country, city and had similar educational backgrounds. This may have introduced a regression effect into the sample set regarding participants' perception of the matters. However, participants' organizations were very diverse with respect to, domain, size and maturity levels, mitigating this regression effect.

In the questionnaire, name of the participants' organization was also asked, with intention of grouping the answers. Although answering this question was left optional, it is likely that participants did not wish to provide unfavorable information about their organizations. In this regard, certain errors may have not been observed in the study.

Participants, having insufficient awareness about the matter, may have perceived certain issues regarding the tool and method for collecting effort data as natural or unavoidable. This may have caused some issues to be overlooked in the survey (Ozkaya, Ungan, & Demirors, 2011).

3.3 Effort Data Collection Tool Requirements

In this section, root cause analysis is discussed in order to find the main reasons of the errors in the collected effort data. Following the identification of the reasons, the solution suggestions are explained in terms of tool, process, and people factors in the software industry. The necessary requirements are given according to our methodology to decrease common practices and problems in effort data collection in the software industry.

3.3.1 Root Cause Analysis

As Rooney and Heuvel emphasized root cause analysis is a process of investigating the root causes of events (Rooney & Heuvel, 2004). To prevent the recurrence of the problems, the main reasons of the problems are identified and the solutions are discussed. In this context, we applied root cause analysis method to main problems we found in previous studies in order to understand the root factors that lead to inaccurate effort data collection. The fishbone diagrams were shown below in order to show the root cause analysis results.
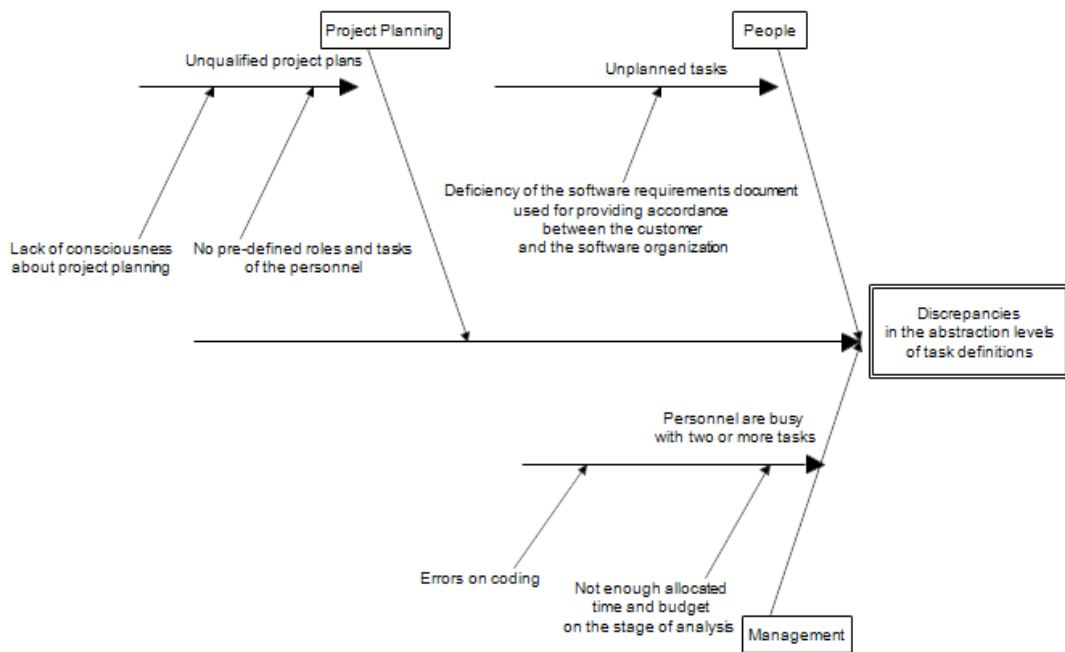
Figure 13 Reasons for Discrepancies in the Abstraction Levels of Task Definitions
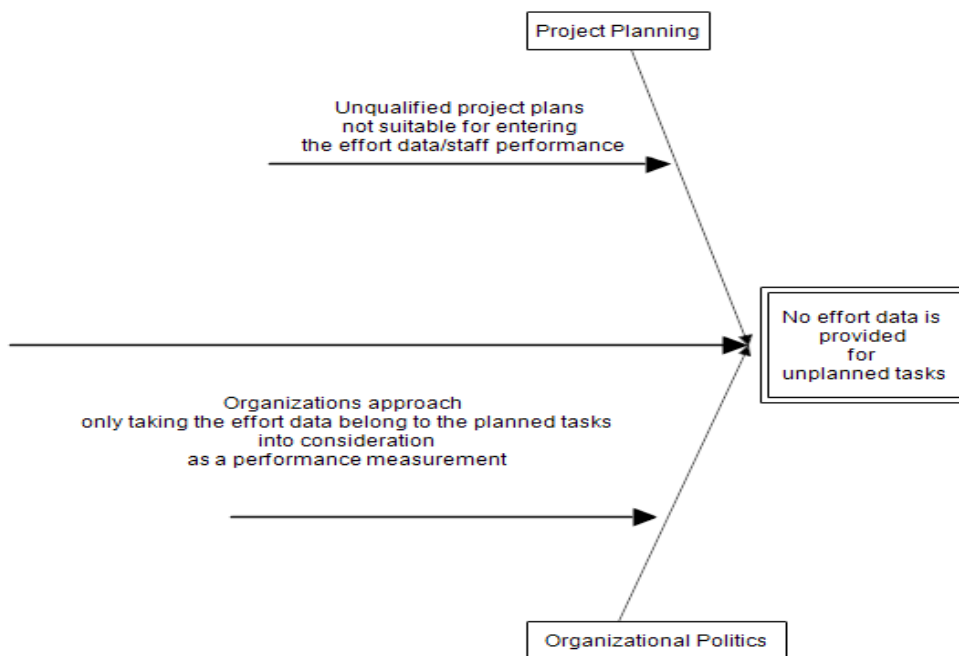
Figure 14 Reasons for Unplanned Tasks
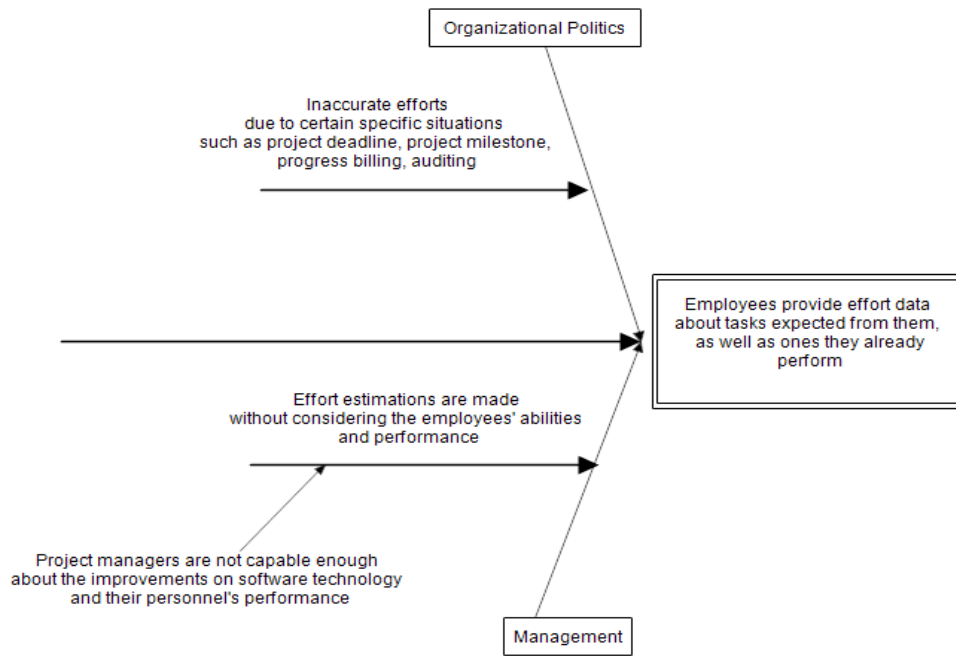
Figure 15 Reasons for Employees Provide Effort Data about Tasks Expected from them, as well as ones they already perform
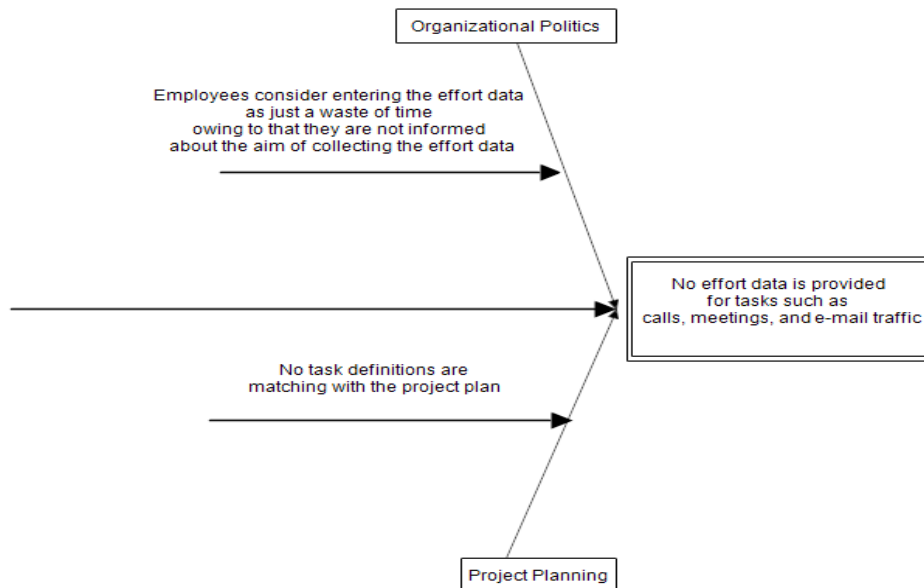
Figure 16 Reasons for not providing effort data for tasks such as calls, meetings, and e-mail traffic
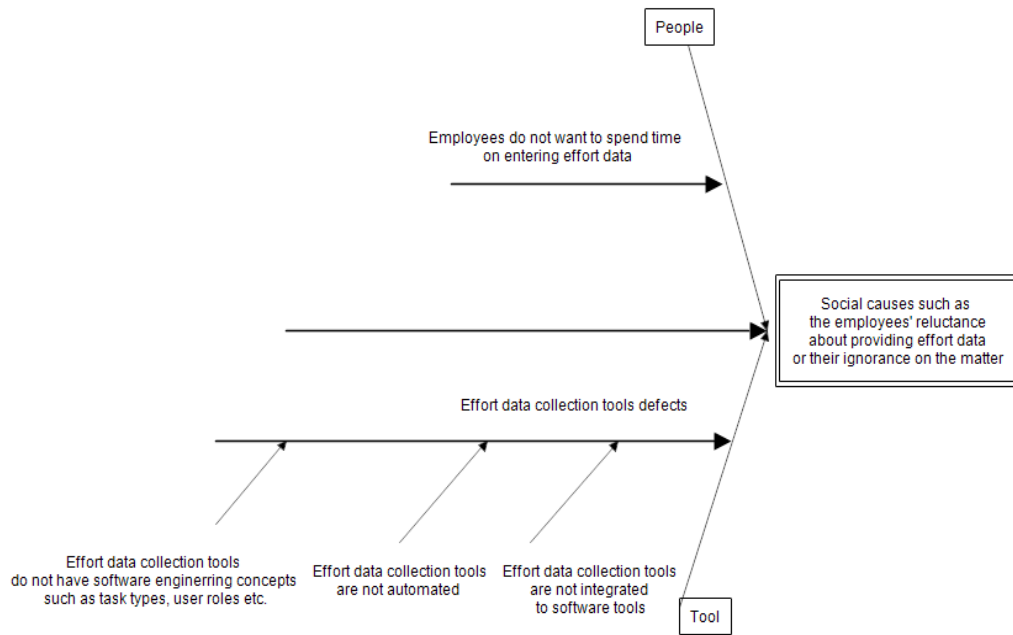
Figure 17 Reasons for Social Causes
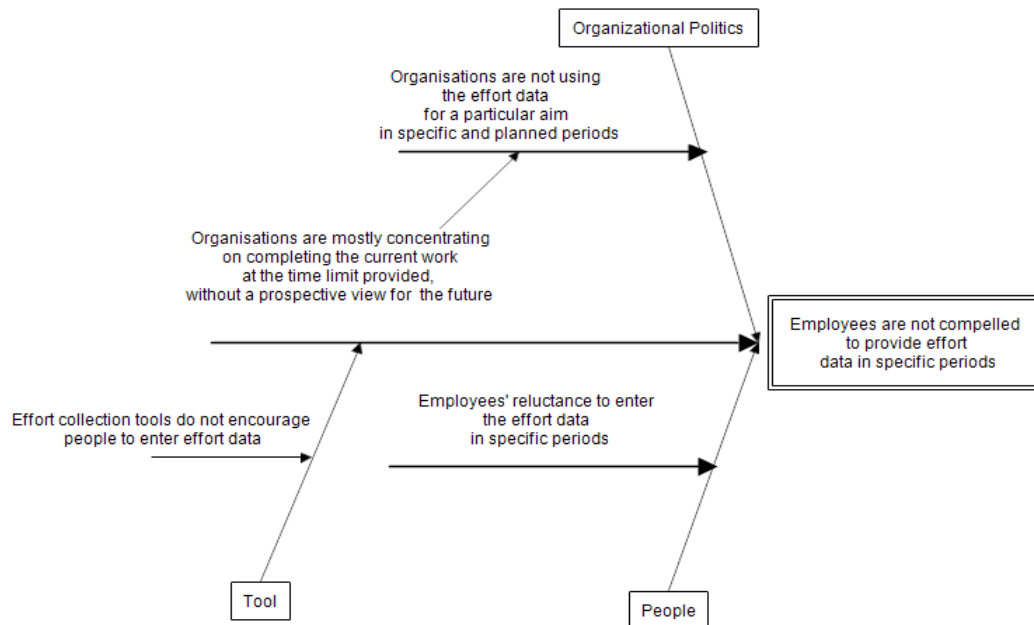
Figure 18 Reasons for not providing effort data in specific periods
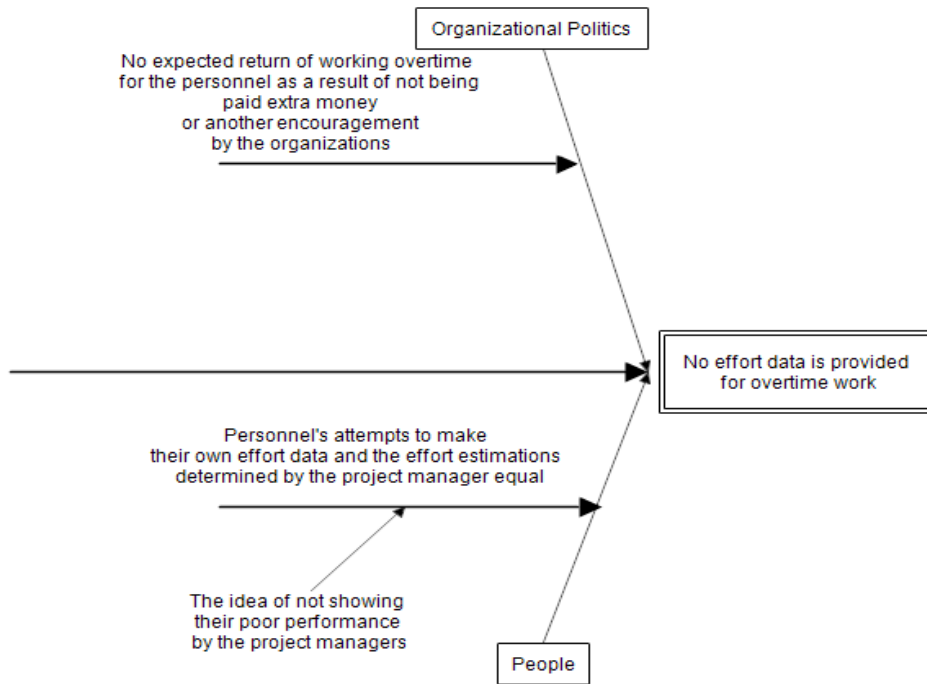
Figure 19 Reasons for not providing effort data for overtime work
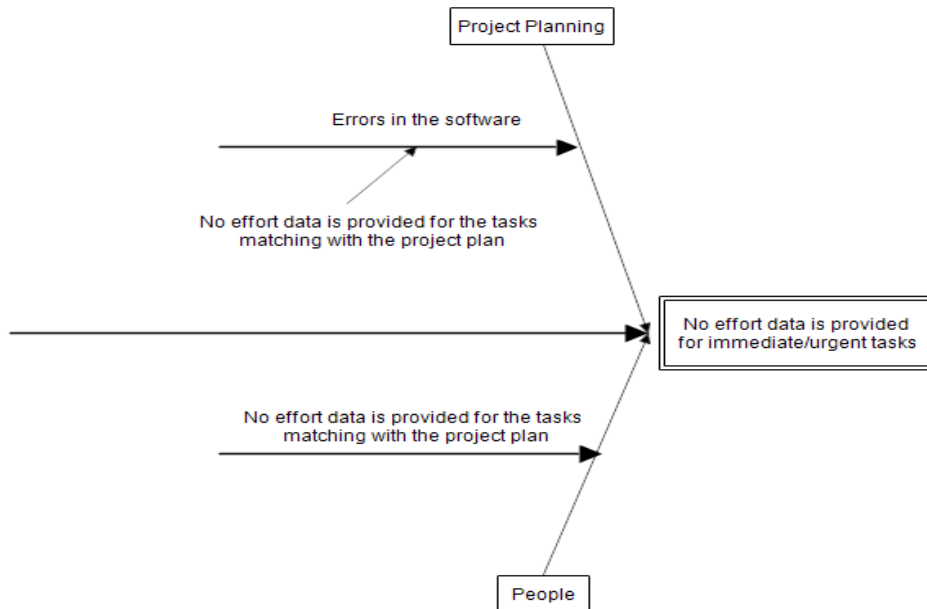
Figure 20 Reasons for not providing effort data for immediate tasks

As it is shown in the diagrams, the main reasons of the problems are addressed in this section. We found some solution suggestions by analyzing these main results. The solution suggestions are provided in the following section.

3.3.2 Solution Suggestions

As it is emphasized, following the analyzing the reasons of the problems in effort data collection, we improved a methodology. It consists of three parts which are tool, process, and people factors. The suggestions about tools are used in implementing our Effort Data Collection Tool and other suggestions are used for education and providing information to the users of effort data collection tools. All suggestion solutions are provided below.

Tool

1. Graphical user interface must be easy to use. Also there must be tools in the form of gadgets, serving the purpose of gathering the effort data.
2. There must be a number of systems working integrated with other programs. Users shouldn't enter the same data in two different tools.
3. Reports and warnings must be gathered by the tool and through this way, users must be forced to enter the effort data needed, in a specific order.
4. Overtime work information must be entered to the tool in detail. Besides, the tool must include a variety of parts related to overtime work.
5. It is feasible and functional to establish a connection between work breakdown structure and the tool by preparing the work breakdown structure in the project plan in a specific formation. Then, work breakdown structure can be imported to the tool. Through this, work packages will have adapted/transferred to the tool successfully.
6. Roles of work packages in work breakdown structure and in the tool must be compared with each other. By the help of this comparison, it must be examined whether the users strive for only completing the work required or they carry out some other pieces of work not required by the manager.
7. Tool must give users notice of recording the effort data for phone calls made, e-mails sent and the meetings participated related to the work.

8.   Users must define meetings for selected users. By this way, there is no need for all participants to record meeting effort data. This feature provides recording effort data accurately related to meetings.

9.   Users must be able to observe their daily performance dynamically.

Process

1.   Reasons of working overtime must be examined accurately. If the reason of working overtime is the inefficiency of project plan, then there is an obvious problem with the work packages. Briefly, work packages have been made inaccurately. Additional money can be paid for the personnel because of the problems based mainly on the organization and the project management.

2.   In the project plan, there must precisely be the definitions for each work, for the purpose of matching the unplanned work packages with each other. Coding errors, additional requests and complaints made by the customers can be considered a few examples for the unplanned work pieces.

3.   Type of works that seems possible to come out all of a sudden should be handled in the risk management process. By this way, those kinds of works will be considered in the project plan and schedule.

4.   Work breakdown structure must be prepared in great detail at the stage of project planning.

5.   The content of roles and which roles are responsible for particular tasks must be well-defined in the project plan. Through this way, it will not be expected from the users to complete the tasks apart from their roles given at first and personnel will not waste their time on that kind of tasks. It must be significantly considered and examined if the personnel are assigned to work apart from their main tasks.

6.   Detailed task definitions must be made for the meetings, phone calls, e-mails etc. in the project plan.

7.   The essential importance must be given to the analyze stage by the project managers, the potential difference must be minimized between the draft plan made at the analyze stage and the outcomes at the end of the work. Sufficient amount of money from the budget and sufficient time must be allocated to the analyze stage.

People

1. The purpose of gathering the effort data and the knowledge of how those data can be used in their career must be impressed upon users. Those kinds of effort data assessment tools must be used in the companies to a large extent by creating awareness on users.

2. Managerial sanctions must be imposed on users in an effort for them to take the act of recording the effort data more serious and significant. While striving for this aim, analyzing methods of performance may be improved to a certain extent. Probable outcomes of the tool can be used as performance criteria on performance measurement. And consequently we can succeed in preventing users from seeing the performance tools inessential.

3. It must be considered significantly that users shouldn't be able to try to make their own effort data similar to the effort estimations belong to each specific user.

3.4 Effort Data Collection Tool Design

As discussed in the previous chapters, our Effort Data Collection Tool is a tool that all requirements are collected from the people in the industry. In accordance with the findings in the previous chapters, the Effort Data Collection Tool is designed and developed by the technologies that will be discussed in this section.

The Effort Data Collection Tool was developed in three stages. At first stage, we developed a web-based program using Google Web Toolkit and java programming language. This program includes most of the features that corresponds to our previous findings. At the second stage, we developed an IGoogle gadget that is connected to our program. This gadget shows the tasks defined in the program and it is possible to view tasks and record effort data to these tasks. This gadget was designed as simple as possible to facilitate to record effort data accurately. At the third stage, we developed an auto run application that starts automatically when a user's computer starts. This application was also designed to facilitate to record effort data accurately with same features as the gadget. It is always in the desktop of a user to remind to record daily effort data accurately. All applications run as a single application with the same database.

For the web-based application, IBATIS was used for object relational mapping and PostgreSql

was used as database. The database diagram is shown below.
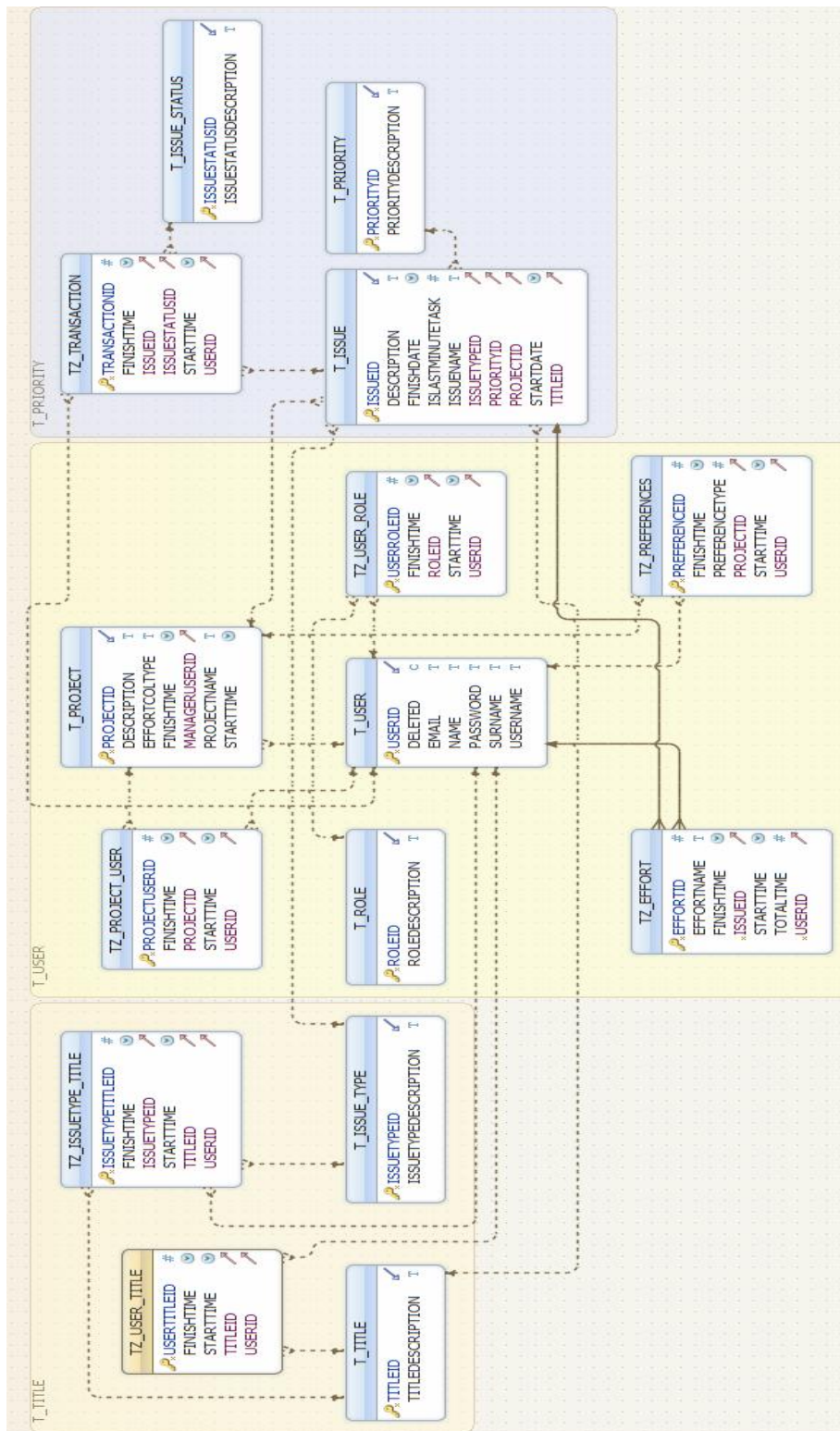
Figure 21 Database Design of the Effort Data Collection Tool

For the Igoogle gadget, java servlets are used. It was implemented using ajax, xml, and html files.

For the auto run application, java programming language and IBATIS object relational mapping technique were used.

3.5 Effort Data Collection Tool Functionalities

The Effort Data Collection Tool is designed and implemented according to requirements that were found in the previous pilot, survey and root cause analysis studies. In this context, the Effort Data Collection Tool includes both main features of a standard issue and effort data collection system as defining projects, defining users, defining tasks, defining effort records etc. All of the functionalities are given in the use case diagram in Figure 22 and Figure 23 below.
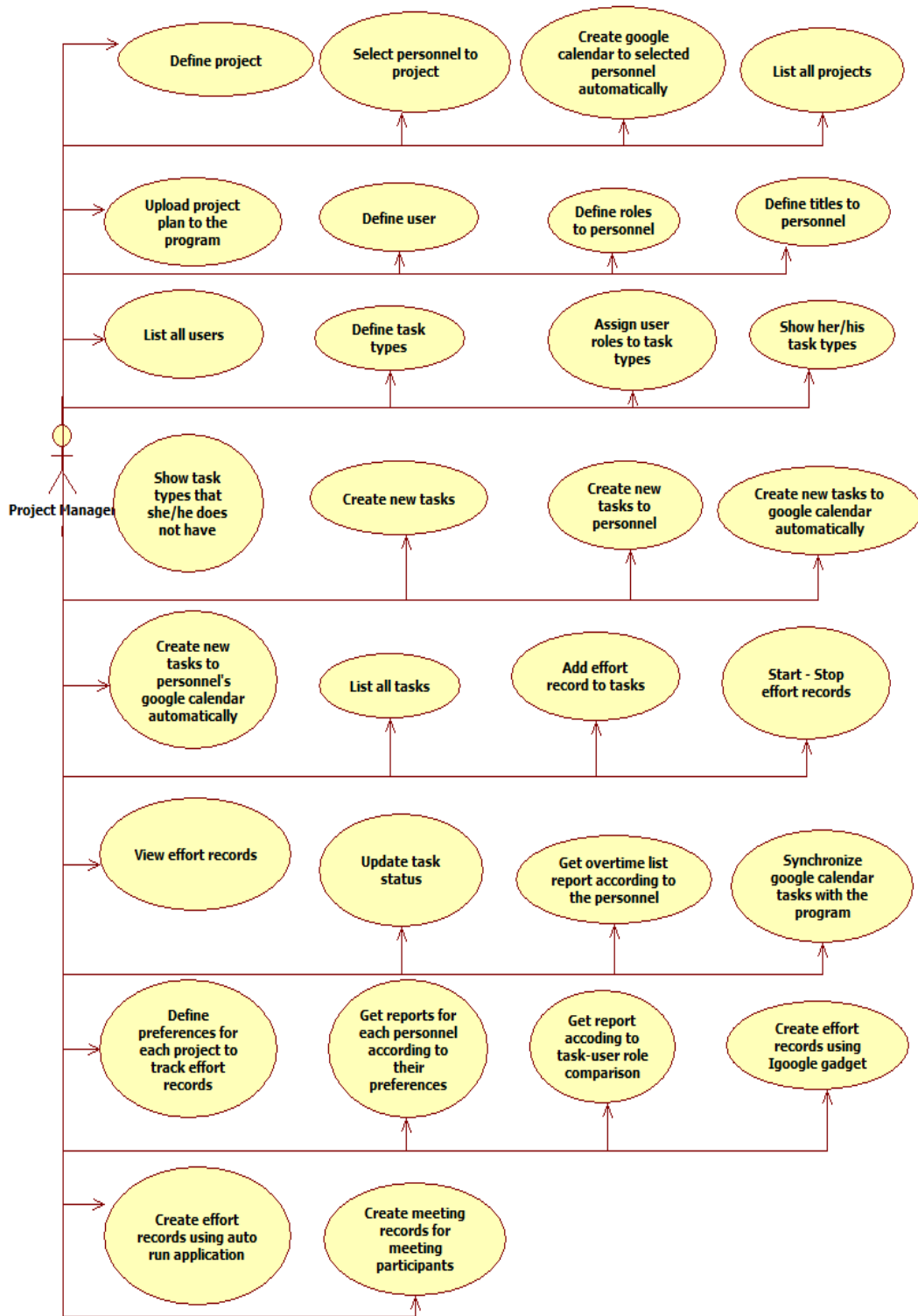
Figure 22 Use Case Diagram of the Effort Data Collection Tool for Project Manager
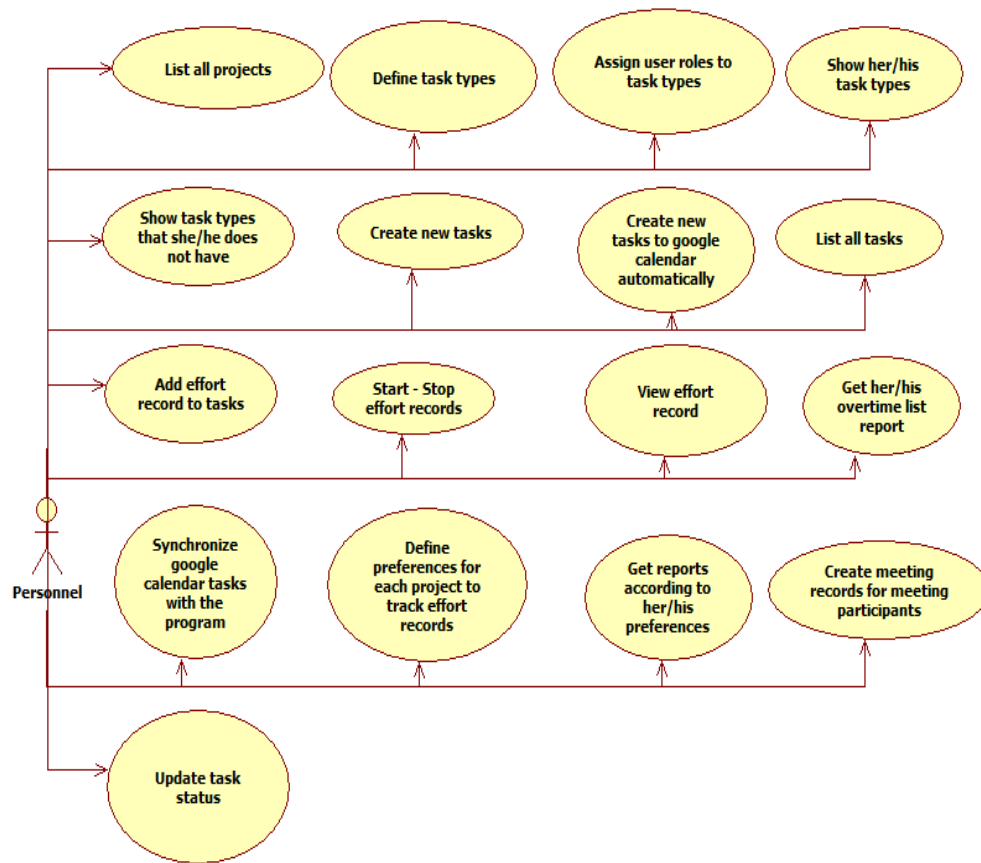
Figure 23 Use Case Diagram of the Effort Data Collection Tool for Personnel

Except for standard features of the effort data collection tools, some new features are discussed and some features are combined for developing our Effort Data Collection Tool. Some screenshots of the standard features are given in Appendix B.

It is found from our previous studies, the integration with other programs is a significant problem for the effort data collection tools. Users do not want to enter two effort records for different programs they use. To solve this problem uploading project plan and Google Calendar integration were added to our system. When project manager defines a new project and selects personnel for the project, new calendars are created in the users' Google account with the specified project name. If project manager uploads a project plan after creating the project, the tasks defined for each user are defined both in the program and their calendars in Google. If users define new tasks in the tool, these tasks are also defined in the Google calendar

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automatically. Thus, users can see their daily tasks in their calendars. The synchronization is also provided between the Effort Data Collection Tool and Google Calendar. For example for a task, if dates are updated or task is deleted, the update or delete processes are also achieved in the user's calendar and in the program. Some screenshots are given below and Appendix B.
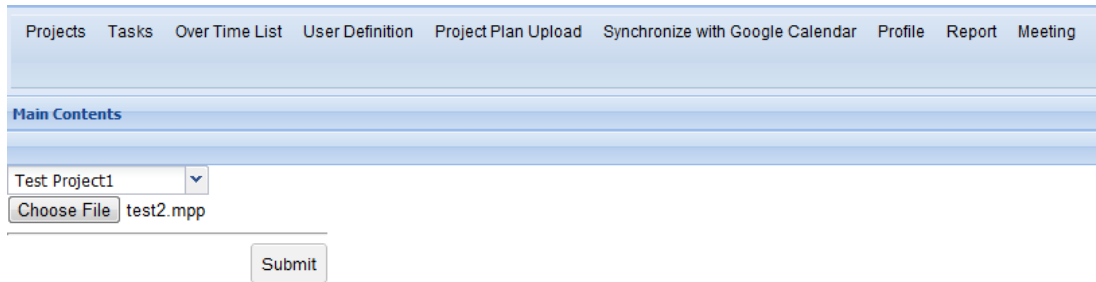
Figure 24 Uploading Project Plan to the Effort Data Collection Tool
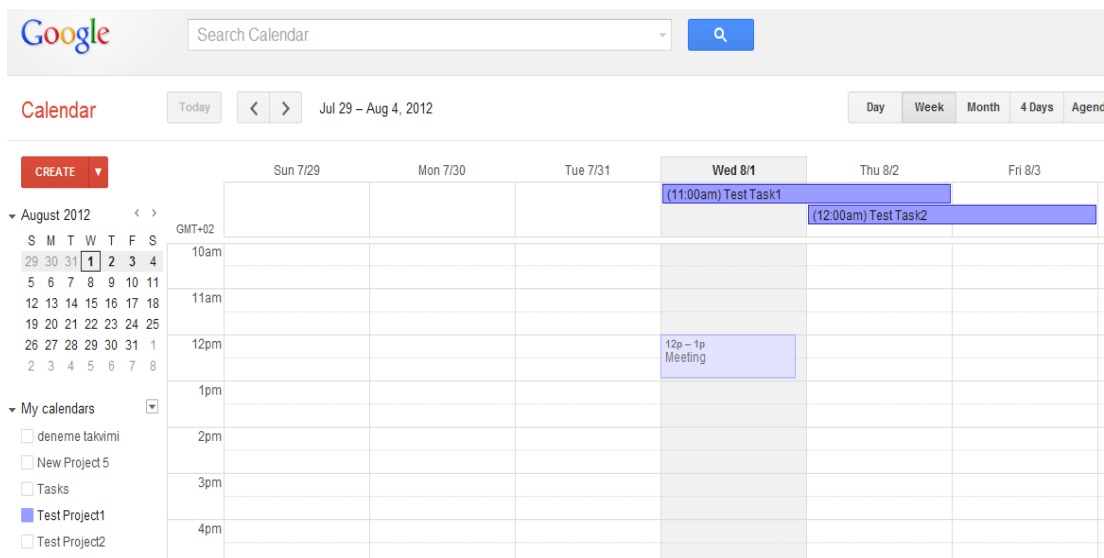
Figure 25 Google Calendar View after Defining Task to the Effort Data Collection Tool

Another finding from the previous studies is that users want tools that will facilitate to record effort data as gadgets or desktop applications. IGoogle gadget and auto run desktop application are implemented in order to solve this problem.

IGoogle is a Google personalized webpage. Gadgets are applications that can be added to IGoogle webpage and used as a program within IGoogle. We developed an IGoogle gadget that users can list their tasks defined in Effort Data Collection Tool. After adding our gadget to their IGoogle webpage using our gadget address, they can login using their username and password in the Effort Data Collection Tool. Following the login process, they can list their tasks, and effort records that are related to these tasks. It is possible to start and stop effort records for the selected tasks. This feature provides that the effort data collection tool always remains in one's mind. Thus, users can record their daily effort with a start and stop buttons. Some screenshots of the gadget are provided below and Appendix B.
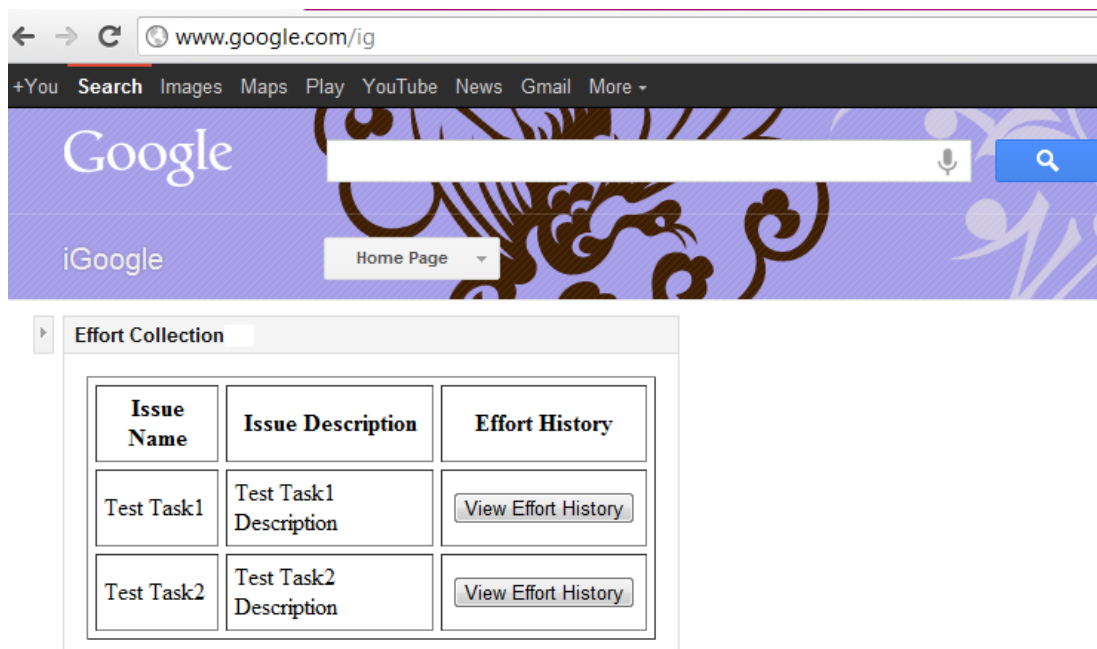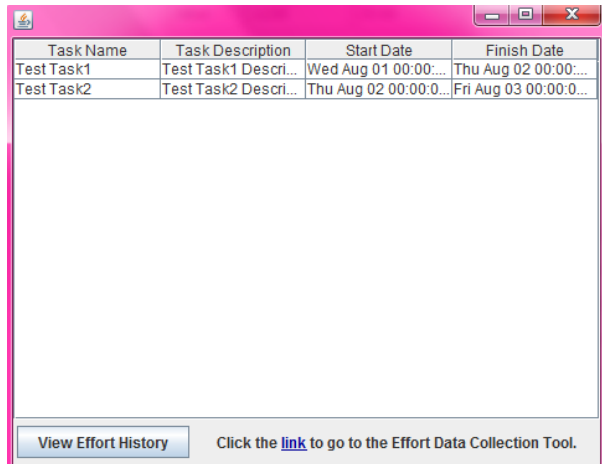
Figure 26 Listing Tasks in IGoogle Gadget

Desktop application is another solution for the specified problem. This application automatically starts when you start your computer. It needs a basic setup. Following setup process, users can list their tasks in a small window in their desktop. Functionalities are same with the IGoogle

gadget. It is possible to start and stop effort records with clicking the buttons. Also, there is a link to go to web application in the program. Some screenshots for desktop application are given below.

Figure 27 Listing Tasks in Desktop Application

The Effort Data Collection Tool also suggests a solution to the problem of effort records that are related to telephone, e-mail, and meeting. There are warnings for telephone and email effort records. For meetings, the person that arranges meeting can select the meeting participants and enter the meeting time interval. Then, for the selected time interval, effort records are automatically recorded for the selected participants. So, there is no need to record meeting effort data for the participants. It prevents the inaccuracies of the meeting effort records.

Figure 28 Recording Meeting Effort Data

According to our previous studies, users have hesitations to record their effort data accurately because of the performance assessments. For benchmarking studies, we have a solution that users can choose their preferences that they specify in the program. They can decide which type of information will be shown to the managers. The tool has three options.

•   Only show my total effort in this project (without considering tasks)

•   Show both my total effort and the effort spent in each task in this project

•   Show my total effort, effort in each task and detailed effort record in each task in this project

Defining preferences for the personnel, they can feel comfortable for recording effort data and it can facilitate to provide more accurate data for benchmarking studies.

Figure 29 Defining Preferences

Another major problem is overtime effort records. Personnel work overtime because of the inaccurate project plans in the industry. We also pointed this problem is a social problem, but the tool can have some features in order to show the overtime records in the organization. Thus, an overtime mechanism and report was added to the Effort Data Collection Tool. When start – stop functions are used for recording effort data, it automatically keeps that time. So, if a user start or stop a task except the daily working hours, we can get a report of his/her overtime effort. You can get overtime report by entering daily working time interval and selecting a user in the report page, and overtime effort records will be listed for the related personnel.

Figure 30 Listing Overtime Work

CHAPTER 4

APPLICATION OF THE EFFORT DATA COLLECTION METHODOLOGY

This chapter describes a case study to analyze the applicability of our methodology in the software industry. We aimed to analyze results of the application of our methodology. In section 4.1, we give the research questions, in section 4.2 we explain our case study plan and design. The implementation of the case study is given in section 4.3. In section 4.4, the results are discussed and the validity threats are explained in section 4.5.

4.1 Research Questions

Considering our methodology and new features of the Effort Data Collection Tool, the following research questions were determined.

1. Does the Effort Data Collection Tool facilitate to provide more accurate data?

We aim to analyze whether the users record their effort data more efficiently by using our tool. We plan to analyze this data and compare to our previous findings to find whether the missing effort data decrease.

2. Does the Effort Data Collection Tool decrease the time spent on recording effort data to the tool?

We aim to get users' ideas about this time to the time spent on the previous tool of the organization.

3. Do the users provide effort data records more efficiently if necessary information provided about the tool and about the reasons to use these tools?

We aim to find whether the given information facilitates to record effort data more carefully. We plan to tell them in which areas the collected data is used. With these results, the social aspects of collection effort data process are discussed.

4. Are the new features of the Effort Data Collection Tool easier to use than the organizations' previous effort data collection tool?

We aim to find whether our solution suggestions for the tool facilitate to record effort data in an efficient way when we compare with the other tools.

4.2 Case Study Plan and Design

The case study was planned to validate the applicability of our methodology in the software industry with real project plans and effort records. The main criterion to select the team members for the case study is that they have answered our survey study and pointed the problems about the effort data collection processes and the tools before. In this concept, we prepared a case study plan as follows:

1. Selecting two different software organizations
2. Selecting a software project team from each software organization
3. Meeting with the software teams and give information about the tool, and the importance of using effort data collection process for the success of the software projects by benchmarking and estimation methods
4. Installation of the program to our server and install necessary components to the computers of the users
5. Providing technical support during two weeks while software teams using the tool
6. Analyzing the collected effort data by the users at the end of two weeks
7. Meeting with the users in order to have their comments about our methodology
8. Analyzing whether the noise in the collected effort data is decreased
9. Comparing the results of the collected effort data to our previous effort data collections

4.3 Implementation

In order to answer our research questions, we found two software organizations. Organization 1 is a large-scaled software company which works in lots of areas like telecommunication and geographical information systems. We choose a software team which includes one project manager, one software analyst and two software developers. Organization 2 is a small-scaled software company which works about software quality process activities. We planned to apply our case study to a project team in Organization 2, but only one software developer used the Effort Data Collection Tool because of a seminar that was given to other team members in the selected week for the case study. Therefore, providing the validity of our application with more users, we choose one more software developer from another software organization. Because of the time limitation, Effort Data Collection Tool was used for one week by all users. The common point of all users was that they have answered our previous survey, so their suggestions were used in the implementation of our tool.

To conduct the case study, the author of the thesis met with the software organizations to supply necessary information about our methodology and setup the Effort Data Collection Tool. Firstly, the necessary information was given about the importance of effort data collection for software organizations. Which activities involve effort data and why we need to effort data for project planning were told users. Our previous studies were explained and the problems of the effort data collection were discussed. After raising awareness of effort data collection, the Effort Data Collection Tool setup was completed. A demo was supplied about how to use the tool and new features that came with our tool are explained in detailed.

Secondly, the necessary information about the users and their effort data collection tools were gathered in order to compare the results after usage of the Effort Data Collection Tool with our previous studies. The related information about the organizations is given below.

Organization # 1

The project in Organization # 1 is about geographical information systems. The team members work for large-scaled projects, therefore their project plans are generally high-level. The team leader prepares the work breakdown structure monthly.

We analyzed the roles, responsibilities, and years of experience of the team members to compare with our previous survey results.

Team Leader:

•   Project manager and team leader, also works for software design and implementation

•   Total experience in software industry is more than 10 years,

•   Experience in this company is 2 years,

Senior Software Developer:

•   Responsible for software design and implementation,

•   Total experience in software industry is approximately 8 years,

•   Experience in this company is 1 year,

Junior Software Developer:

•   Responsible for software design and implementation,

•   Total experience in software industry is approximately 2 years,

•   Experience in this company is 1 year,

Software Analyst:

•   Responsible for software analysis,

•   Total experience in software industry is approximately 5 years,

•   Experience in this company is 1 year,

A simple effort collection tool was implemented by the organizations' software developers. This tool has simple functionalities. It is web-based. It is designed to keep track of the tasks and the effort of the team members spent for each work packages. The team members use this tool at the end of the day or at the end of their tasks. There is not any integration with other programs. They record their effort data manually. According to the team members, positive and negative properties of their tool are given Table 4 below. We used the methodology that was used in

Section 2 when comparing issue and effort tracking systems.

Organization # 2

The project in Organization 2 is about software quality processes. They implement a quality measurement tool. The role, responsibility, and years of experience of the team member are given below.

Software Developer:

•   Responsible for software design and implementation,

•   Total experience in software industry is approximately 1 year,

•   Experience in this company is 1 year,

•   Part-time personnel

A simple effort collection tool is used by software developers. It is very easy to use and does not contain lots of functionalities. It is web-based. The main functionality is to keep track of the tasks. According to the team members, positive and negative properties of their tool are given Table 4 below.

Organization # 3

The project in Organization 3 is about social platform. The role, responsibility, and years of experience of the team member are given below.

Software Developer:

•   Responsible for software design and implementation,

•   Total experience in software industry is approximately 3 years,

•   Experience in this company is 1 year,

The organization does not use an effort data collection tool. The effort records are entered to an Excel sheet. The personnel send their effort record at the end of the week. It is not easy to use.

According to the team member, positive and negative properties of recording effort data in an Excel sheet are given in Table 4 below.

Table 4 Comments of the Organizations about the Effort Data Collection Tools used in the Organizations

Functionalities	Organization # 1 Effort Data Collection Tool	Organization # 2 Effort Data Collection Tool	Organization # 3 Effort Data Collection Tool
User Interface	L	L	P
Gadgets	N	N	N
Email Notifications	L	L	N
Personal Time Calendar	P	N	N
Timer	N	N	N
Integration with other programs	N	N	N
Overtime Control Mechanism	N	N	N
Project Plan Integration to the tool	N	N	N
Comparing project plan roles and issue roles	N	N	N

Table 4 (Cont.)

Telephone, meeting and e-mail notifications for daily records	N	N	N
Dynamic Daily Effort Tracking	N	N	N

After the usage of the Effort Data Collection Tool, the collected effort data was analyzed. The method we used for the pilot study that was given in Chapter 3 was used to evaluate the data. We calculated total work hours and reported effort data of the users. Our assumption was the same. 25% missing data is considered acceptable for the accuracy of effort data. The results for Organization # 1, Organization # 2, and Organization # 3 are given below.

Table 5 Results of Collected Effort Data Analysis for Organization # 1

User #	Role	Experience in the software industry	Experience in the organization (years)	Expected effort for the module (hours)	Reported effort data for the module (hours)	Missing Effort Data (%)
User # 1	Project Level Manager	10	2	40	35	12.5
User # 2	Project Personnel	8	1	40	45	0
User # 3	Project Personnel	2	1	40	30	25
User # 4	Project Personnel	5	1	40	30	25

* User # 2 recorded five hours more than expected effort, thus it can be seen that overtime work was also provided by user # 2.

Table 6 Results of Collected Effort Data Analysis for Organization # 2

User #	Role	Experience in the software industry	Experience in the organization (years)	Expected effort for the module (hours)	Reported effort data for the module (hours)	Missing Effort Data (%)
User # 1	Project Personnel	1	1	20	14	30

Table 7 Results of Collected Effort Data Analysis for Organization # 3

User #	Role	Experience in the software industry	Experience in the organization (years)	Expected effort for the module (hours)	Reported effort data for the module (hours)	Missing Effort Data (%)
User # 1	Project Personnel	3	1	40	35	12.5

In the Organization # 1, provided effort data by all users are convenient for our acceptation criterion. Also, it is seen that one of the users provided overtime work to the tool. In the Organization # 2, missing effort data is 30% which can be pointed as problematic. In the Organization # 3, the missing effort data is 12.5% which is also convenient for our acceptation criterion. There is missing effort data for all users except one user that has provided overtime work. It can be related to our claim that it is not possible to work all day.

4.4 Results

We aimed to answer our research questions by this study. We listed missing effort data for each user and all users recorded effort data convenient for our acceptation criterion. Only User # 1 in the Organization # 2 has missing data 30% because of his lack of experience. When we compare the results with the pilot study results, it can be seen the missing effort data percentage decreased from 25% to 12.5% for project managers, 56% to 25% for junior software developers. For senior software developers, the missing effort data percentage decreased from 54% to 0% for due to the provided effort data about the overtime work. It supports the claim that the information about the importance of recording effort data for the overtime work we provided to users and the overtime work reports that can be taken from the Effort Data Collection Tool affects the accuracy of collected effort data.

As it was given in pilot study, role of the team members affected the supplied effort data. The most accurate effort data was recorded by the project manager as we pointed in the pilot study. The experience in the software organization can also affect the collected effort data, but as pilot study, there is no direct relation between them.

To understand which solution suggestions are useful for the Effort Data Collection Tool, we met with the users after they had used it. The negative and positive features of the Effort Data Collection Tool are listed below in a strategy that we have used to compare the issue and effort tracking systems in Chapter 2.

Table 8 Comments of the users about the Effort Data Collection Tool

Functionalities	Organization#1 Comments on Effort Data Collection Tool	Organization#2 Comments on Effort Data Collection Tool	Organization#3 Comments on Effort Data Collection Tool
User Interface	P	P	F
Gadgets	F	F	F
Email Notifications	N	N	N
Personal Time Calendar	L	L	L
Timer	L	L	L
Integration with Other Programs	P	L	L
Overtime Control Mechanism	L	L	L
Project Plan Integration to the Tool	F	F	F
Comparing project plan roles and issue roles	L	L	L
Telephone, Meeting and E-mail Notifications for Daily Records	L	L	L

Table 8 (Cont.)

Dynamic Daily Effort Tracking	N	N	N

According to users' comments, most of the features found in the survey study were achieved by the Effort Data Collection Tool. When we compare their comments on their effort data collection tool to their comments on the Effort Data Collection Tool, the results show that the Effort Data Collection Tool has higher points than others.

One of the most important results that we obtained from the study is that the users said that they were not used to give importance to effort data collection process. The information that was given about benchmarking and effort estimation methods raised the awareness of effort data collection process.

The quantitative and qualitative findings of this study show that our methodology is applicable to the software industry.

4.5 Threats to Validity

The main threat of this study is that we conducted the pilot study and the case study in different organizations. For the comparison of the percentage of the missing effort data, we compared the results according to the same roles of the organizations to minimize the threat.

Secondly, the Effort Data Collection Tool was used for one week because of time constraints. In this regard, the collected effort data may have been inadequate to analyze the decrease of the inaccuracies of the effort data.

Another threat is the number of users of the Effort Data Collection Tool. It was used by 6 users. If the study was conducted with more users and more organizations, the results may be different.

Also, we explained users that we will use the results in the concept of this thesis. Therefore, they were aware of we would analyze the results and they might have recorded effort data more carefully for just one week.

Moreover, the study was not applied to overall organizations; therefore the study did not change organizational politics. Organizational politics should change to observe more accurate effort data because of the social problems.

Finally, the organizations were not selected to obtain accurate effort results. The only selection criterion was that they had filled our survey before.

CHAPTER 5

CONCLUSION AND THE FUTURE STUDY

This chapter describes the results and the future work of our study in two sections. Conclusions are given in the first section and future work is given in the second section.

5.1 Conclusions

In this thesis, we researched the common problems of effort data collection in the software industry. Project management and project plans are the key factors for project success and effort data is at the heart of project planning. Effort data shows the total effort that is spent for the project and provided by the personnel of the software organizations to show how much time they spend for the projects. It is used as an input for the future projects of the software organizations in software planning activities such as software benchmarking and effort estimation methods. For this reason, if there are errors in the effort data provided by the personnel, these inaccuracies of the effort data result effort estimation errors, inefficient project plans and failures in software projects.

In this respect, we aimed to show the common problems of effort data collection in the software industry and find the possible solutions. In order to observe the problems in the industry, first we conducted a pilot study in a middle scaled organization. We analyzed the past effort data and found inaccuracies in the collected data. We clarified the possible reasons of this problem and planned a survey study in order to investigate the presence of the problems observed in the pilot study.

The survey study was implemented by 42 participants from the software organizations in Ankara, Turkey. Some of the surveys were conducted face-to-face with the participants and other parts were applied online due to the factors such as time limitation and refraining of

participants from face-to-face answering.

Following the completion of applying survey, we analyzed the results. As a result of our studies, we have determined significant problems concerning the collection of effort data in software industry, and we have reached the conclusion that effort data may not be reliable all the time. All of the problems determined in the pilot study and those foreseen by us were observed throughout the industry.

To find a solution methodology to these problems, we decided to analyze the main causes carefully. Thus, we studied root cause analysis method and observed the root of the problems.

After using the root causes of the problems, we found solution suggestions to improve the quality of the effort data. We analyzed the solution suggestions in three parts which are tool, process, and people factors. Our solution methodology includes education about process and people factors, and developing a tool that facilitate to provide more accurate effort data.

To find solution approaches to effort data collection tool problems, we completed a related research according to the well known effort data collection tools in the industry. We selected Jira, Bugzilla, and Dovico. After analyzing the features of these tools, we compared them to each other in order to compare with our tool suggestions. We identified some significant features of these tools and some significant features that the tools do not have but we found essential in our pilot and survey study. In the implementation phase of our thesis, we used these features to implement our tool.

In accordance with our suggestion solutions for effort data collection tool, we implemented an easy to use tool which has integration with Google calendar. Tool has an IGoogle gadget and also desktop auto run application to remind users of recording effort data. Also, project plans can be uploaded to the tool. ISO 12207 tasks were used as program task types in order to follow project plan tasks in software quality standards. Furthermore, some features were implemented according to the effort data inaccuracies about meetings and problems about users' tasks that do not overlap with their roles. In addition, overtime information can be tracked by our tool.

After completing the implementation of the tool, a case study was conducted to validate applicability of our methodology in the industry. Three software organizations were selected. First, we gave information about effort data collection process and people factors that lead

inaccurate effort data. We introduced our solution methodology and gave information about our tool. As a result of this study, the effort data was collected from the tool and analyzed them by using the method that we followed in our previous pilot study. It is found out that more reliable data is observed by our methodology since the users have more information about why they should record effort data and our effort data collection tool has important features to facilitate to record effort data more efficiently. Below, comparison of Jira, Bugzilla, Dovico and our tool is shown according to our criteria.

Table 9 Comparison of Jira, Bugzilla, Dovico, and our Tool

Functionalities	Jira	Bugzilla	Dovico	Effort Data Collection Tool
User Interface	L	P	F	P
Gadgets	P	N	L	F
Email Notifications	F	F	F	N
Personal Time Calendar	F	F	F	L
Timer	P	P	F	L
Integration with Other Programs	L	P	P	L
Overtime Control Mechanism	N	N	N	L
Project Plan Integration to the Tool	P	P	F	F

Table 9 (cont.)

Comparing Project Plan Roles and Issue Roles	N	N	N	L
Telephone, Meeting and E-mail Notifications for Daily Records	N	N	P	L
Dynamic Daily Effort Tracking	L	L	L	N

The Effort Data Collection Tool has been implemented as a prototype. So, this study has some constraints. Some features such as email notifications, synchronizing the project plan with the tasks in the program, and some standard features of the issue tracking systems have not been implemented.

The contributions of our tool include some new features about the effort data collection tools such as Google Calendar integration, ISO 12207 task types, overtime control mechanism, and gadget features.

As a result, this thesis has contributions about effort data collection in the industry since it shows effort data may not be reliable all the time. Therefore benchmarking activities, effort estimation models, and project planning activities which use effort data can have inaccurate results in the software industry. Thus, this thesis raises awareness of effort data collection process. To prevent the problems observed, a methodology was developed and the Effort Data Collection Tool was implemented. By the case study results, it is seen that the new methodology and the Effort Data Collection Tool decreases the problems of the collected effort data.

5.2 Future Work

The Effort Data Collection Tool was used in three organizations in the case study. It can be

applied in more software organizations for professional use in order to validate the Effort Data Collection Tool applicability around the industry with more data. In addition, more features can be added to the Effort Data Collection Tool and it can be integrated to more programs by users' suggestions. The Effort Data Collection Tool can be developed with a more professional software developer team for professional use.

In this thesis, the solutions to social problems were also analyzed. However, all solution suggestions could not be applied to the overall organizations because of organizational politics. The solution suggestions can be applied to organizations to improve effort data collection process. Through this way, awareness about the relationship between the effort data and project management activities can be raised in the software industry.

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APPENDICES

Appendix A: The Survey for Common Practices and Problems in Effort Data Collection in the Software Industry

COMMON PRACTICES AND PROBLEMS IN EFFORT DATA COLLECTION IN THE SOFTWARE INDUSTRY

Dear Respondent,

This survey is prepared to determine the common practices and problems in effort data collection in the software industry. In this survey, personal information won't be gathered and used anywhere. The correctness of your answers will significantly enable this survey to maintain a qualified scientific research. Thank you for your great contribution to our scientific research.

A. GENERAL INFORMATION

In this part, general information about yourself, your organization and the effort collection tools that are currently being used in your organization will be asked to you. The only aim for gathering this information is categorizing and classifying the necessary information. We assure you that the name of your organization will never be used in our study.

Table 10 Questions for the First Part of the Survey

The name of your organization/company	
Which sectors is your organization mainly working on? (Banking / finance, defense industry, telecommunication, corporate software, consumer electronics etc.)	
Indicate here if your organization has a certificate of quality / competency. (CMMI, ISO 9001, AQAP, COBIT, ITIL etc.)	
How many years have you been working in your organization?	
What's your current position in your organization? Project personnel (design engineer, software developer etc.) Project support personnel (quality manager, configuration director etc.) Project level manager (project manager, leader etc.) Managerial director (Chief, managing director etc.)	

B. EFFORT DATA COLLECTION PERIOD

Table 11 Questions for the Second Part of the Survey

How often are you expected to record the effort data in your organization? (At the end of the day, week or month)	
Do you use any tool for recording the effort data? If so, please indicate the name of your job-tracking/effort data collection tool, or if not, indicate the method you use to track the effort you put.	
For what purpose are these effort data used in your organization?	

C. DIFFICULTIES IN EFFORT DATA COLLECTION

In this part, we aim for defining the problems in organizations while gathering effort data. "I certainly agree", means that you consider there aren't any problems to talk about in the sector you are working; "I certainly disagree" means that you have been undergoing the same problem.

Table 12 Questions for the Third Part of the Survey

Research Questions	I certainly agree	I agree	I disagree	I certainly disagree	No idea
The effort data gathering tool/method in my organization is user-friendly and it doesn't require so much effort to record the necessary data.					
I am informed about the purpose and necessity of recording effort data by the organization.					
The essential training to be able to use the effort data tool has been implemented to us by the organization.					
In the process of time, I record my effort data regularly and I make use of the effort data tool more often.					
I only enter the tasks that I have truly put in effort and completed.					
I record the effort data for my overtime work.					
I record the effort data for urgent tasks.					
I record the effort data for tasks such as calls, meetings and e-mail traffic.					
I record the effort data for unplanned tasks.					

Table 12 (cont.)

Tasks items for which I record the effort data are identified in the same levels of abstraction and the size of tasks does not vary so much.					
I suppose that effort data are used for the purpose of evaluating my performance.					
Tasks definitions for which I record the effort data are well and truly identified. While recording the effort data for a specific task item, I can easily find out true task definition. I don't need to record effort data into different or high level task definitions.					

D. COMMON ERRORS IN EFFORT DATA COLLECTION

Table 13 Questions for the Fourth Part of the Survey

Research Questions	I agree	I disagree
I may be unable to record my effort data accurately as I work for multiple tasks at a time.		
When I work on many small tasks, I may record them as a single task, even if the task descriptions do not match.		

Table 13 (cont.)

If the actual effort spent on a task is much more or much less than the estimated, I might be required to change the data and record a value closer to the estimate.		
I think that the collected effort data is also used for evaluating my performance. Therefore, I might alter the values while I am recording my effort data.		
In certain specific situations such as project deadline, project milestone, progress billing, auditing, etc. I might be expected to alter my effort data or record the effort spent on a task under another one.		

E. OPINIONS / SUGGESTIONS

In this part, your additional problems and if any, your suggestions will be considered in detail.

1. According to you, what are the most significant difficulties in collecting the effort data in the software industry?

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2. What do you suggest for collecting the effort data more effectively and accurately in the software industry?

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3. In order to collect the effort data more effectively, what kind of data may be entered into the effort data collection tool about the task you are working on?

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………………………………………………………………………………………………
………………………………………………………………………………………………

Appendix B: The Effort Data Collection Tool Screenshots

Figure 31 Defining New Task

Figure 32 Recording Effort Data

Figure 33 Listing Tasks

Figure 34 Synchronizing Google Calendar with the Effort Data Collection Tool
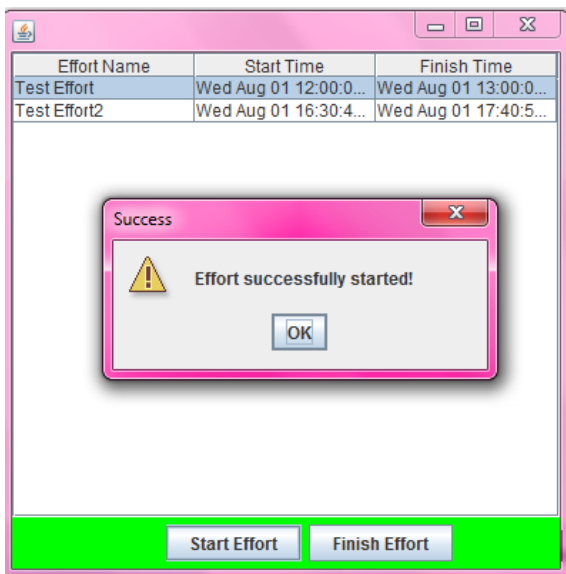
Figure 35 Recording Effort Data by IGoogle Gadget

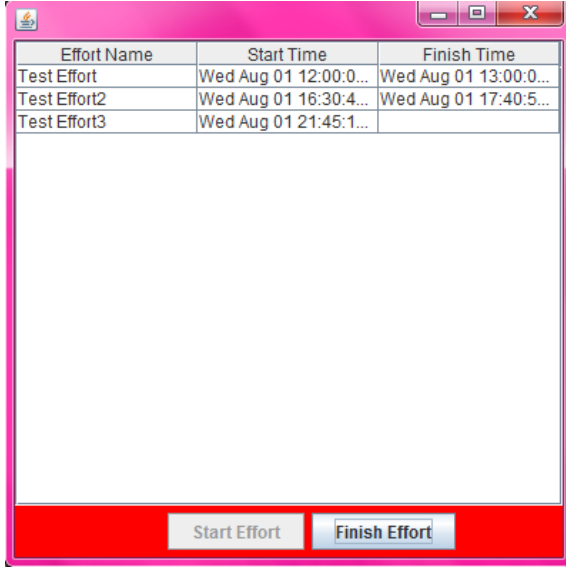**Figure 36 Starting Effort Data in Desktop Application**

Figure 37 Finishing Effort in Desktop Application

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Soyadı   : ÖZKAYA EREN
Adı   : AYŞEGÜL
Bölümü : BİLİŞİM SİSTEMLERİ

<u>**TEZİN ADI**</u> (İngilizce) : A METHOD TO DECREASE COMMON PROBLEMS IN EFFORT DATA COLLECTION IN THE SOFTWARE INDUSTRY

<u>**TEZİN TÜRÜ**</u> : Yüksek Lisans [X]   Doktora ☐

1. Tezimin tamamı dünya çapında erişime açılsın ve   kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın. ☐

2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullancılarının erişimine açılsın. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐

3. Tezim bir (1) yıl süreyle erişime kapalı olsun. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) [X]

Yazarın imzası ....   Tarih ....