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EMPLOYEE PERFORMANCE ASSESSMENT IN QUALITY ASSURANCE using Analytical Hierarchy Process

A Project Report

Presented to

The Faculty of the Department of Computer Science

San Jose State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Computer Science

By

Rahul Jain

Dec 2008

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ABSTRACT

EMPLOYEE PERFORMANCE ASSESSMENT IN QUALITY ASSURANCE

By Rahul Jain

Employee performance often determines the progress of a company. Poor appraisals and improper assessment directly effects employee satisfaction and impair company results. Many managers rely primarily on behavioral impressions without appropriately including factual information of the actual work done. There is clear benefit from procedures that elicit and use both factual and subjective criteria for assessment. Analytical Hierarchy Process (AHP) is a methodology that can be applied to complex decisions with multiple criteria [29]. AHP has the capability to combine both subjective and objective evaluation factors, thereby minimizing bias in decision making [29]. The methodology also allows subjective measures from both managers and peers of a worker to be included.

This project proposes a unique application of AHP for the calculation of employee performance by a quality assurance department. My implementation of the methodology shows how subjective evaluation by both managers and peers and factual data can be combined to better optimize performance appraisal results. The results of an AHP application can be presented to the manager in graphical format to facilitate comprehension and interpretation. My application of AHP improves upon all the current products in the market for performance appraisal through the methodology to include both multi source subjective and factual data.

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1. INTRODUCTION

In this project I dealt with the mining and assessment of the data from different data pools. Data pool refers to data from three different sources such as subjective data by both managers and peers, and factual data that must be considered for the optimal performance appraisal results.

Employee performance plays a very crucial role in the progress of a project. There are many existing performance appraisal software that help managers to write job profiles, manage employee performance reviews, and make performance plans but none of them evaluate optimum employee performance.

The goal of this research project is to enhance the current performance appraisal process. The new technique mentioned in this paper not only takes care of the manager's review and peer reviews of the employee but also takes care of the factual data.

The project uses a framework called VB.NET to implement the idea. The database contains a predefined table that will track the number of modules validated by the tester, number of bugs logged, and stores the data in an SQL database. This data is called factual data and is unbiased. In addition, the database also has a table devoted to store information of testers such as quality, discipline, result orientation and customer orientation which is entered by the managers. This data is called subjective data and is often biased. The word biased justifies the fact that the nature of inter personal interaction can effect the outcome of a review. The third type of data comes from 360 degree reviews, also called peer to peer reviews that will provide a valuable piece of information. This data can be biased but plays an important role to evaluate an employee as coworkers are the best persons to review an employee. I am assuming the case where every employee rates the other employee without any professional

competition. Data mining of the information is done for employee performance evaluation using AHP.

Section 2 and Section 3 provides an overview of the AHP and definition of employee performance. Section 5 and Section 6 gives an overview of the related literature studied and related commercial software available. Section 7 puts forward the project details such as how the idea came to mind, system requirements and software used. Section 8 explains the details of the project implementation such as the front-end design, back-end design and data flow diagrams. Section 9 shows the AHP calculations that go behind the implementation. Section 10 explains about the results and Section 11 presents conclusion. Section 12 provides the possible future scope.

2. EMPLOYEE PERFORMANCE

2.1 What is the need for optimal assessment?

Employee performance holds a very integral part in a company's success. Calculation of Employee performance tells employees what they need to improve to perform their jobs successfully. Absence of such system can lead to employees being unclear about the organization's expectations, which can eventually result in arguments, dissatisfaction, stress and low output [11]. Managers are often responsible for making performance plans. While job duties tells an employee what tasks he must do, performance plans informs an employee what an organization expects from him. Before a performance plan can be made, it becomes necessary for a manager to be fully aware of the performance assessment results. An optimum performance assessment system will not only help to formulate better performance plans but also provides an organization with incredible competitive edge.

2.2 Performance management methodology

There are five basic components for Performance management.

1. **Planning**

An efficient organization plans work well in advance [12]. Planning not only helps employee to concentrate their energy towards a particular goal but also helps an organization to efficiently utilize their resources. It also helps to better adopt change and reduce resistance. Employee performance plans made by the manager should be adaptable to changing needs and work requirements.

2. **Monitoring**

Periodic monitoring of projects and employee performance are characteristics of an efficient organization. Periodic performance measuring and feedback not only helps organization to increase productivity but also helps employees to reach their objective. By

periodic monitoring, managers can identify unacceptable performance at an early stage rather than noticing it at the end of the appraisal period [12].

3. Developing

In order to get optimum results from its employees, a manager needs to make sure that the performance capacity of the employee increases i.e. developing a capacity to perform more. To achieve this employees must be given training, introduced to new skills and should be tested with more responsibility thereby widening their capacity to perform [12].

4. Rating

It is very important for an organization to know their star performers [12]. Each employee should be rated on how well he performs. In addition to comparing the performance over the period of time, performance across a set of employees should also be done.

5. Rewarding

After all is said and done, it is important for an organization to reward the top performers. This not only keeps the spirits alive but also boost's up the confidence of an employee. Good managers should not wait for their organization to award the employee. Words of mouth such as "good job", "thank you" are actions that reward good performance.

Figure 1: Performance Management key components [12]

3. AHP

3.1 History

AHP was formulated by the American mathematician Dr Thomas L Saaty in the early 1980's. Dr. Saaty's motivation came while working for the Wharton School. He came across the difficulty of differences between a scientist and lawyer for a systematic approach for decision making. Dr. Saaty was motivated to develop a simple way that can help people with complex decisions. This led to the development of AHP [2]. The power and simplicity of AHP has led to its worldwide acceptance. AHP is used in fields such as research, education, healthcare and government in a wide variety of a decision making situations. Implementation of AHP can be seen in applications like during formulation of drug policy [2], selecting a project manager [2], choosing marketing strategy [2], and personnel management.

Dr. Saaty founded a company called Expert Choice which makes Expert Choice software based on AHP. The software provides a structured approach and process for prioritization and decision making. The software has been in the market for 23 years and used in universities worldwide. Dr. Saaty also formulated the next –generation version of the software called Decision Lens. The Company quotes the software as:

"Decision Lens provides a family of desktop and web-based software solutions designed to support group decision-making for planning, financial, IT and performance-related decisions" [10]. Dr. Saaty currently works at the University of Pittsburgh, teaching in the Joseph M. Katz Graduate School of Business.

3.2 What is AHP?

AHP stands for Analytical Hierarchical process. AHP involves breaking the problem down into sub problems and later combining the solutions of the sub problems into a conclusion [2]. By doing so, it takes into consideration all the factors such as judgment,

perception and impression that can affect decision making capability. AHP is used when a complex decision needs to be made.

A common misconception that occurs is that people misunderstand AHP as an analysis tool due to the use of the word "Analytical" in its name. AHP is more than a methodology that helps in multiple choice decisions. It can be broken down into three steps:

1. **Decomposition**

In decomposition, a problem is broken down into smaller manageable subproblems. To do so, iteration is done starting from top (general level) to bottom (specific level) thereby breaking the problem into submodules that becomes sub-hierarchies. Navigating through the hierarchy from top to bottom, the AHP structure comprises of goal, criterion and sub criterion.

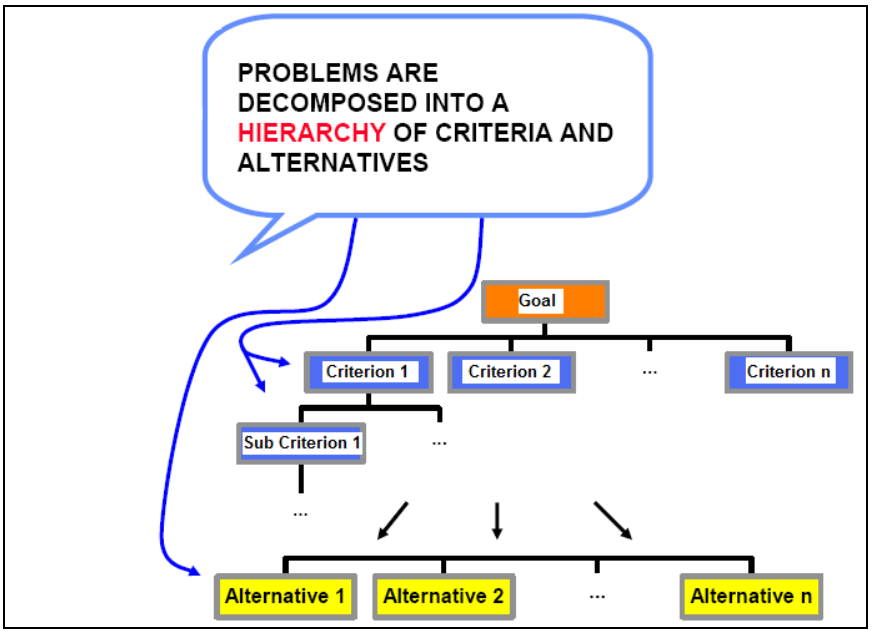

Figure 2: A simple AHP hierarchy [1]

2. **Weighting**

After the hierarchy has been made, the relative weights are assigned to comparison attributes. A pairwise comparison is then done to determine the importance of one criterion over the other.

1 equal 3 moderate 5 strong 7 very strong 9 extreme

	STYLE	RELIABILITY	FUEL ECONOMY
STYLE	1/1	1/2	3/1
RELIABILITY	2/1	1/1	4/1
FUEL ECONOMY	1/3	1/4	1/1

Figure 3: Weighting in AHP [1]

3. Evaluating

After a relative score for each alternative is assigned within the hierarchy all the way up to the top, an overall score is computed [2].

4. HOW IT IS DONE TODAY

Today's Employee Performance Review is manual where a manager reviews an employee based on different criteria such as Honesty and Integrity and Goal Orientation. A sample employee review is shown below. A manager reviews an employee on a grade of 1 to4 and an average is calculated at the end which represents employee score. The appraisal is based on this final value calculated when is the average of the review values.

[redacted]

Print Form | Reset Form

Employee Performance Review

Date of Review: 08/07/2008

Employee

Last Name: J | First Name: R

Job Level: Consultant | Job Title: T A

EDS Employee ID: | Review Year: 2007-2008

Saber Alias: XXXX | Saber E-Mail: XXXX

Manager

Last Name: G | First Name: V

Saber Alias: XXXX | Saber E-Mail: XXXXX

Instructions

This employee performance review will communicate and clearly summarize your performance since your last appraisal. This evaluation measures performance in our three key areas: **Competencies, Work Ethic,** and **Attitude.**

Required fields: Select "Highlight Fields" button to view required fields.
Definitions: Each competency is specific to the job level. Click on the competency text for a definition.

Evaluation Measurements

4 Exceeds Performance Expectations
3 Meets Performance Expectations
2 Below Performance Expectations; Improvements Required
1 Requires Immediate, Substantial and Sustained Improvement
NA Not applicable

General Core Competencies

	4	3	2	1
1. Honesty and Integrity	○	●	○	○
Comments:				
2. Goal Orientation	○	●	○	○
Comments:				

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Figure4: Page 1 of Employee Performance Review form

[redacted]

Print Form | Reset Form

Employee Performance Review

Attitude

	4	3	2	1
5. Wears appropriate business attire; maintains appropriate grooming and personal hygiene standards	○	○	○	○

Comments:

Career Development

	4	3	2	1
1. Acquires and masters the required skills and knowledge of the job	○	○	○	○

Comments:

Total Average: 3.06

Manager Comments

What I Like:

Good communication with the team members.

What Can Improve:

Analytical and Technical skills.

Employee Comments

Rev. 07-2008 Page 5 of 6 © [redacted]

Figure5: Page 5 of Employee Performance Review form

5. RELATED LITERATURE

There is an extensive interest in AHP all over the world among computer scientists. This section describes some of the excerpts from the numerous articles that were closely studied. These articles discuss AHP or employee performance in general:

5.1 Literature studied

1. **Title: A review of employee evaluation procedures and a description of "high Potential" executives and professionals [9]**

The article examines employee evaluation procedures by focusing on assessment center, psychological tests and personnel interview [9]. These procedures are used by companies to select "high potential" executives [9]. Over the time, increased competition has led the companies to identify and hire employees with appropriate skills to get maximum output. Today, many resource executives realize the importance of human resource planning and its incorporation as vital factor that helps the organization to get a competitive edge.

To achieve human resource goals three commonly used methods are the personal interview, assessment centers, and standardized psychological tests [9]. The article reviews a most recently available procedure called the System for Testing and the Evaluation of Potential [9]. The first application of STEP program uses the estimates from the Potential for Successful Performance (PSPs) for personnel decision making [9]. The second application of STEP program is for the identification of the strength and weakness of personnel.

2. **Title: How to Make a Decision: The Analytic Hierarchy Process [2]**

The paper explains the importance of AHP when it comes to making complex decisions. People express their judgment in terms of importance, preference and likelihood [2]. We develop standards of excellence and poorness based on past knowledge and use them to rate the alternatives. However, the above way is useful in repetitive situations such as salary raises and admissions which should meet the established norms [2]. In the absence of norms

one often compares alternatives instead of rating norms [2]. The goal is to formulate efficient hierarchical structure that includes criteria to determine the best choice [2].

3. **Title: A Multicriteria Decision Model Application for Managing Group Decisions [20]**

The paper explains the use of AHP by multicriteria decision model to resolve the problem occurring due to of lack of consensus for choosing selection criteria [20]. MCDM was applied to a publishing house responsible for the selection procedures, providing a list of agency criteria that greatly influenced the agency selection [20]. It was discovered that dominant criteria is not always crucial in affecting group rankings. Combined group judgments were used by the selection making group to reduce the dominance but yet maintaining the balance of power [22]. Computer simulations were used to study how power and assessment of criteria were related.

4. **Title: Personnel evaluation with AHP [21]**

Personnel evaluation problem is a serious problem when it comes to hiring a right person for any academic, business or government operation needs. Any mistake made, the company has to bear with the consequences till the person retires. The main problem with personnel evaluation is identification, weighting and evaluation [21]. Upon the identification of attributes, weights are assigned and each candidate evaluated for a desirable criteria. Pairwise comparisons are made between employment characteristics and overall desirability [21]. The AHP provides an effective and simple method for personnel evaluation. Fear is that it might prove to be complex or inconvenient for non-technical people [21].

5. **Title: The Analytic Hierarchy Process: An Exposition [22]**

The paper examines history and development of AHP [22]. Functions such as structuring complexity, measurement and synthesis are responsible for AHP's vast usage [22]. Paper addresses academic debates and defends why AHP is more superior in solving issues

involving transitivity [22]. Simplicity, flexibility and accuracy are the advantages of AHP to MAUT [22]. This fact can be proven by the world wide usage of AHP, in applications such as health care, strategic planning, benchmarking and quality management [22].

Although there are numerous organizations that have benefited from AHP but there are organizations that are still unaware of it. The exposition hopes to educate these organizations about the possible use of AHP to solve complex decisions [22].

6. **Title: Employee performance evaluation using analytic hierarchy process [23]**

Managers struggle when it comes to giving performance reviews. Every appraisal cycle, they look for a best way for allocating salary raise [23]. The AHP methodology is used to deal with the performance evaluations for a local company in Indiana. Employees will be evaluated based on criteria such as adaptability, initiative, quality of work, job knowledge and work relationships [23]. AHP implementation showed better results than method previously being used. Results were convincing enough for the company to use this method for future performance evaluations [24].

7. **Title: Using analytic hierarchy process (AHP) to improve human performance: An application of multiple criteria decision making problem [24]**

The paper examines the use of AHP methodology to solve human performance improvement problem [24]. The paper presents a model that structures relation between human performance improvement and the style of management [24]. In using AHP methodology for the human performance problem, a hierarchical structure and a pair wise comparison is made. The result concludes that among different management styles such as company culture, human capability and attitudes, best one is management by value [24].

8. **Title: Using the Analytical Hierarchy Process as Tool for Assessing Service Quality [25]**

Continuous quality improvement is a must for both manufacturing and service sectors [25]. While manufacturing has made efforts to improve quality, the service sector has lagged behind because of inherent difficulties such as poor customer satisfaction. The other measures for service quality are reliability, responsiveness, assurance and empathy [25]. The paper determines if a unified measure of service quality can be formulated [25]. AHP methodology is used to present a model that helps to derive a single quality index.

9. **Title: Employee performance evaluation by AHP: A case study [17]**

Employee performance evaluation is done to get an insight about the employee's contribution to the organization [17]. The main objective of performance evaluation is to identify and reward an employee who fulfills the organizational objective, concurrently to analyze whether the objective is met. The paper uses AHP to calculate employee performance based on subjective criteria such as planning, discipline, thinking,communication, commitment and teamwork [17]. Each criterion is divided into sub criteria and pairwise comparisons are done. The overall ranking of the employees are obtained based on the results calculated from AHP.

10. **Title: Application of Fuzzy Analytical Hierarchy Process in Selecting a Project Manager [26]**

A capable project manager has the decisive influence on the outcome of a project [26]. Qualitative measures are still used while selecting a project manager. The paper explains the importance and selection of a good project manager. The paper establishes a mathematical model of comprehensive evaluation by application of fuzzy AHP based on triangular fuzzy

numbers that can evaluate the project manager's quality and ability [26]. The goal of finding the project manager's abilities is divided in criteria and sub criteria as shown below.

Pairwise comparison is done and weights are determined scientifically and objectively rather that at will [26]. The paper calculates a comprehensive evaluation index and evaluates project manager's ability, then later used to select the best candidate.

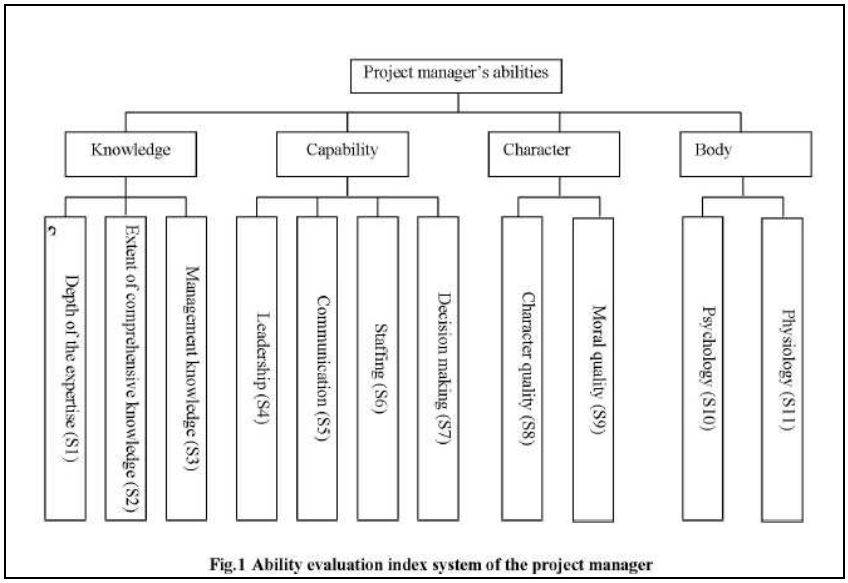

Figure6: Criteria for Selection of Project Manager [26]

11. Title: Improving Employee Satisfaction on Performance Appraisal: A Case Study on Thai Companies [27]

A performance appraisal is important to improve the quality of work in a company [27]. A fair appraisal not only appreciates an employee's work but also leads to increase in motivation, there by increasing productivity. The paper analyzes the importance of improving employee satisfaction on the appraisal system. A survey on performance measurement is conducted and 300 questionnaires are sent out to some government agencies and private companies [27]. The goal of the survey is to obtain input about the current appraisal system in Thailand and the criteria being used in current appraisal system. Data collected from the survey

is analyzed and used to find the best suited appraisal system for Thai companies. The comparison between government and private companies reveals that private employees are better satisfied than the government.

5.2 Related literature evaluation conclusion

AHP and employee performance has been the center of discussion in numerous articles published over the decade. Companies today understand the importance of assessing employee performance and its function for a successful organization. The articles studied above reveals that, inspite of AHP's vital role in making complex decisions, not much has been researched or explored in terms of AHP's application to evaluate employee performance. The application of AHP studied above varies only from a mere selection of a project manager to calculation of a service quality index to improve human performance.

Also, the articles fail to address how the factual and subjective peer review could play a role in an optimum employee performance review. The article "Employee performance evaluation by AHP: A case study" [17], explains the subjective criteria for employee performance. The paper does not discuss the importance of peer reviews and factual criteria for performance appraisal. Another article "Employee performance evaluation using the analytic hierarchy process" [23] discusses only the subjective managerial criteria selected by a company's directors to grade their employees.

The need still exists to better utilize AHP methodology in the area of employee performance and to combine factors such as subjective managerial criteria, factual criteria and subjective peer review criteria to optimize performance evaluation.

6. RELATED COMMERCIAL SOFTWARE

This section describes some of the existing performance appraisal software available commercially.

6.1 List of software

1. **Software:** Managers Assistant 3.0**; Company:** Manager assistant

Managers Assistant provides a quick and easy way to track, control and evaluate the behavior, activities and performance of the employees [3]. The key features and benefits include customizable ratings, weighted averages, self calculating rating score, email reminders, and report generation [3]. The software lays emphasis on employee management but fails to consider 360 degree data and factual data for review.

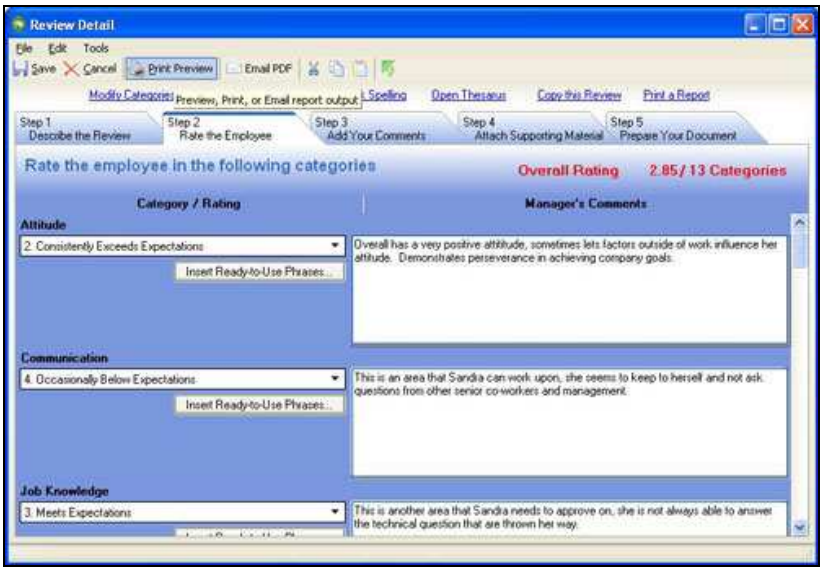

Figure 7: Screen displaying the employee review page [3]

2. **Software:** Success factor Professional Edition; **Company:** Success Factor

Success factor is a web-based solution with goal management, performance reviews, dashboards and analytics, and employee profile as the four main modules [4]. The key features include 360 degree feedback, appraisal history, email notification and report generation. The software lays emphasis on 360 degree review but fails to consider factual data for review [4].

Also, it does not combine subjective manager data and 360 review data for a comprehensive review.

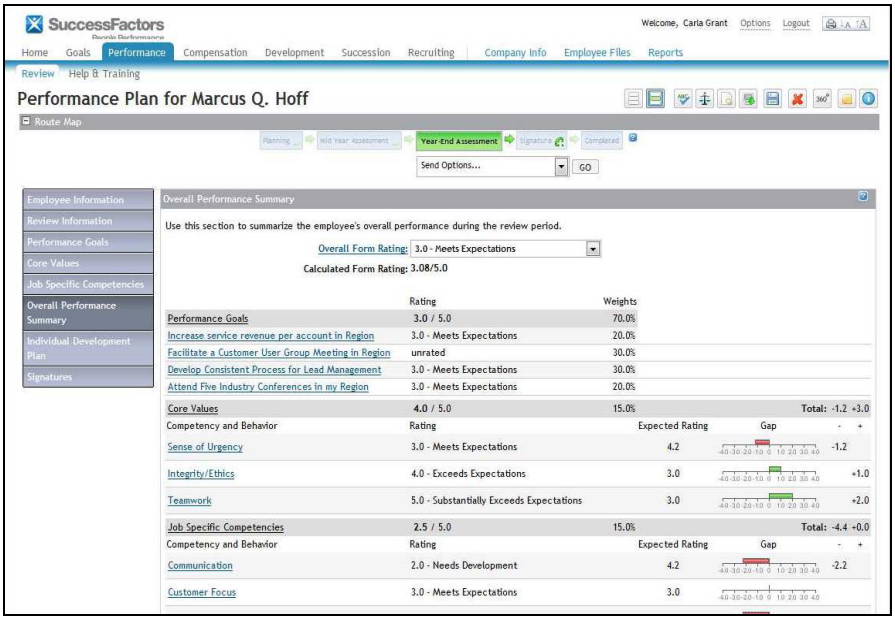

Figure 8: Screen displaying the employee review page [4]

3. **Software:** TrakStar; **Company:** Promantek

A web based performance appraisal system that can be customized to fit an organization needs. The key features of software include Import and export data, email reminder, performance appraisals, performance plans and report generation [5]. The software does not consider 360 degree reviews and factual data to grade an employee.

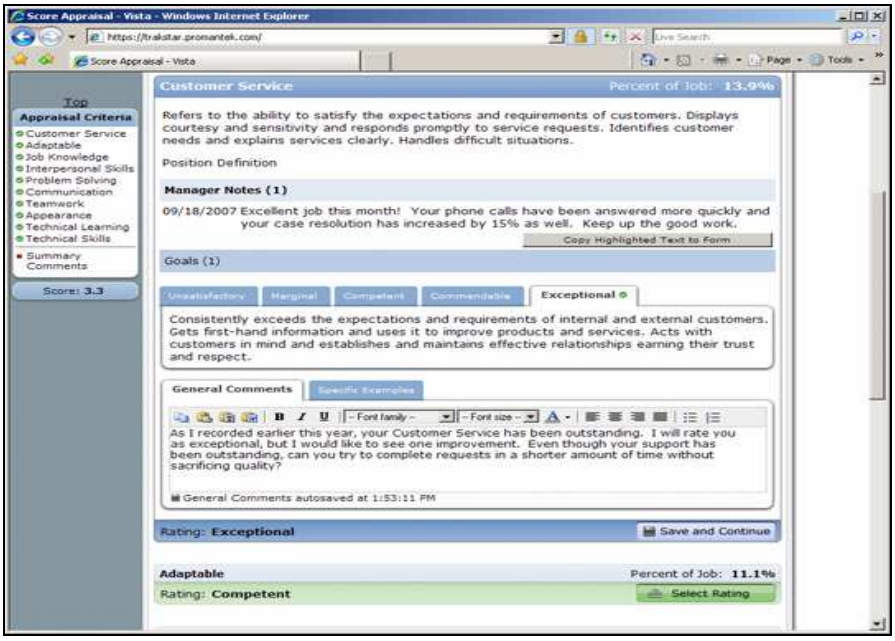

Figure 9: Screen displaying Appraisal Criteria [5]

4. **Software:** Talent Platform**; Company:** iCIMS

Talent platform fulfills the pre-hire and post-hire needs by serving as ONE platform for application tracking, on boarding, performance management and succession planning [8]. The key features include 360 degree feedback, compensation management, custom evaluation forms, email notifications, import and export data and report generation [8]. Apart from diversified group of features, the software fails to consider factual data for review.

5. **Software:** Halogen eAppraisal; **Company:** Halogen Software

Halogen eAppraisal is web based performance appraisal software [6]. It is a quick and easy way to create performance appraisal for employees. The key features include appraisal history, organizational goal management, competency management, 360 degree review, report generation, employee evaluation forms and email notifications [6]. Apart from neglecting factual data, the software fails to combine subjective manager data and 360 review data for a comprehensive review.

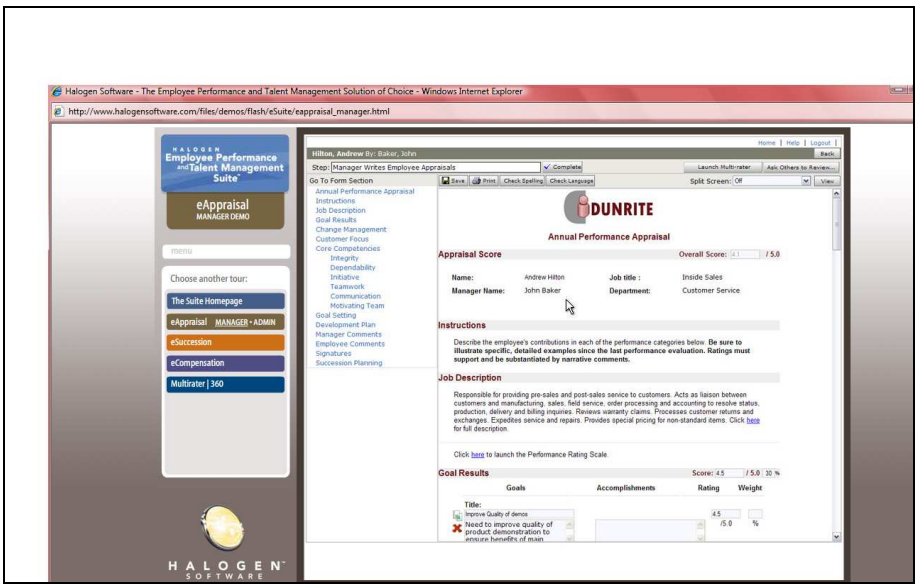

Figure 10: eApparaisal module screen shot [6]

6. **Software:** Review SNAP**; Company:** Applied Training Systems

Review SNAP is a web based performance review management system. The key features include 360 degree review, customizable ratings, weighted averages, data import and export and report generation [7]. The software does not consider factual data for review.

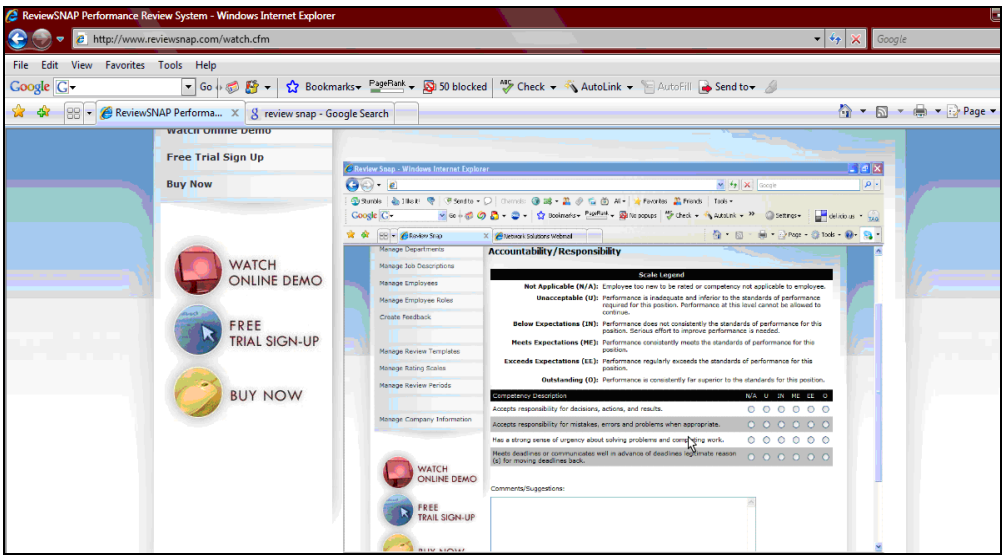

Figure 11: Review SNAP module screen shot [7]

7. **Software:** Blue**; Company:** eXplorance

Blue is web based, enterprise class software with applications such as surveys, 360 degree reviews, performance appraisals and training needs assessments [9]. The key features include 360 degree feedback, import and export data, performance appraisals and custom evaluation forms [9]. The software does not combine subjective manager data and 360 review data for a comprehensive review.

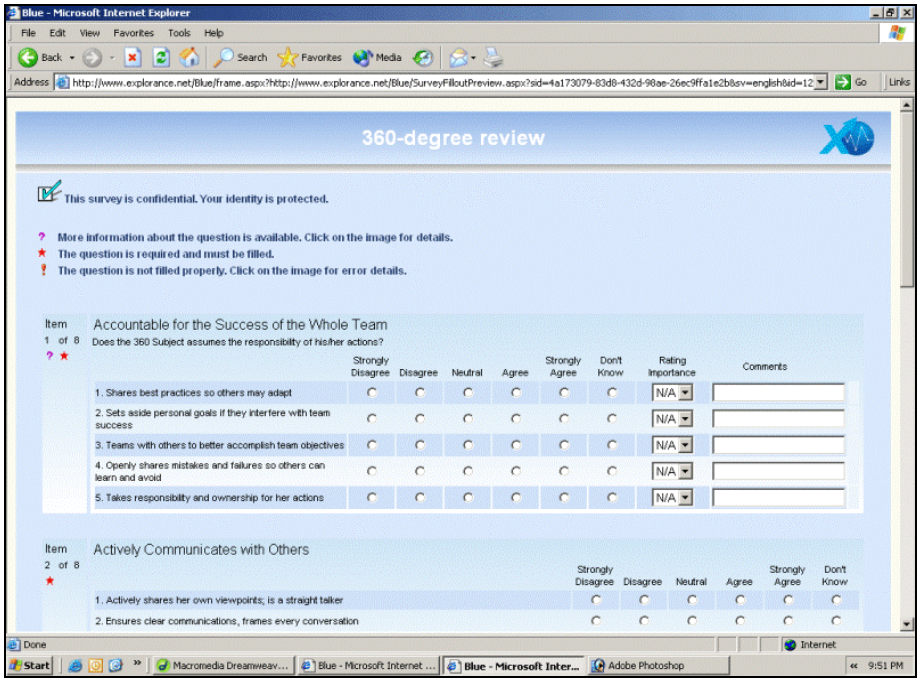

Figure 12: Blue 360-degree review screen shot [9]

6.2 Software evaluation conclusion

Most of the software being used by organization or developed are performance appraisal management software. They provide an interface to write job profiles, review employees, store reviews and generate report. They review employee based on criteria such as Integrity, Dependability, Teamwork, Customer satisfaction and Communication. Software like Blue, eAppraisal takes care of the 360 reviews and the subjective managerial reviews done by manager but fails to combine the results to formulate a ranking system.

Another problem that was not taken into consideration was none of the software was ever designed to compute factual data. As an employee works for long time in a company the review results tends to self influencing i.e. if a employee does well, he will continue to do well and visa versa [30]. Factual data helps to overcome self influence by reflecting the work an employee does. For example, for a quality assurance engineer factual data will reflect criteria such as the number of bugs, priority of bugs and type.

In addition to the above problem none of the software was ever designed to handle complex decision making. Almost all the software's were designed for graphical representation of data in form of charts, 3-D surfaces, scatter plots and flash animation.

The need still exists for software that combines the subjective data by both managers and peers, and the factual data to rate employees and pick the star performer in an organization.

7. PROJECT DETAILS

7.1 Overview

As a result of the extensive research done which spans research papers, consulting top line company managers and analyzing performance appraisal software, I understood how employee performance is measured in most companies. From the research papers, it became quite evident that work needs to be done to optimize current employee performance evaluation system.

The current methodology can be enhanced if all the factors such as subjective managerial data, factual data and subjective peer review data are taken into consideration. Also, I realized that the most neglected part was the factual criteria which hold the capability to further enhance the evaluation system. The idea to enhance the current methodology for employee performance evaluation was further supported while I was interning for a company called Risk Management Solutions.

During the performance reviews at RMS, I realized that my manager used subjective criteria such as teamwork, communication, and discipline for grading employees. No matter these criteria were exhaustive but they were often biased.

The research paper "Employee performance evaluation by AHP: A case study "[17] introduced me to the idea of AHP and how it could be used for evaluating employee performance. I decided to incorporate this methodology and came up with the plan which is described below.

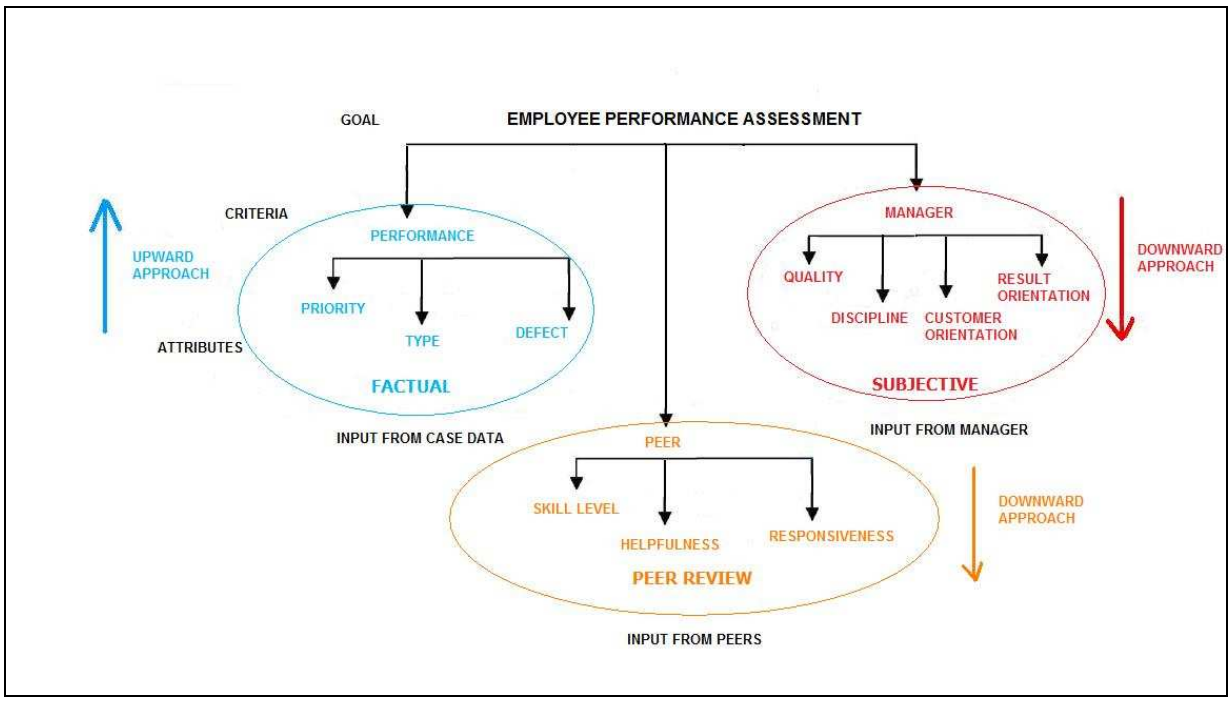

Figure13: Proposed Model (Employee final weight= weight from factual review+ weight from subjective peer review + weight from subjective manager review)

A manager should include Peer reviews (360 reviews) and Factual criterion (actual work done by employee) along with the traditional Subjective criterion (data from manager) for employee assessment. The project takes the multisource data and uses the Analytical Hierarchical Process to calculate the weight for each employee based on 3 different data sources. The final weight is the sum of the weights which is obtained by addition of the three subweights. Employees are then ranked based on the values of the final weight.

7.2 System Requirements

The following are the system requirements to run the software.

1. **Operating System –** Windows 9.x, Windows 2000, Windows XP or Windows Vista
2. **Database Server –** SQL Server 2005

Microsoft Visual Basic 2005 is used to implement the user interface of the system.

7.3 Software used

This section describes the software and technologies used for the implementation.

7.3.1 Defect Manager

Defect Manager is bug tracking software just like Bugzilla. Defect Manager helps companies to properly define, prioritize, correct and track bugs in their products [18]. Defect Manager comes with a free version for up to 5 users. Any request to increase the number of users is charged.

Defect Manager comes in two flavors: Application based and Web based. Web based defect manager can run on any Windows machine using a web browser. Company claims that Defect Manager helps improve client relations by ensuring faster delivery and a bug free product.

The main reason for using Defect Manager is because of its capability to export the reports in XML format. These reports act as a source for factual data. XML files are parsed and results are stored in database. AHP calculations are then done on this mined data to get an overall factual score for each employee.

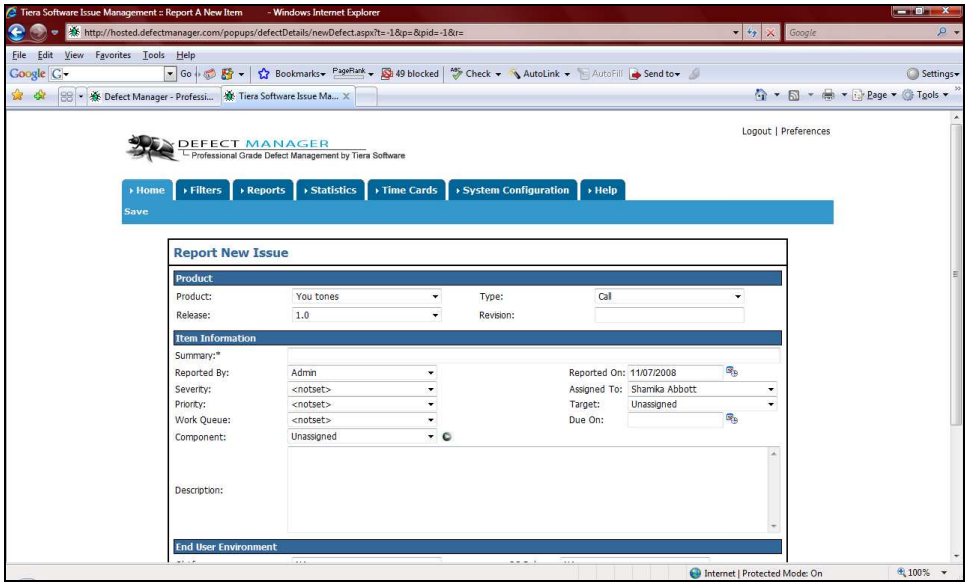

Figure 14: Defect manager screen shot [18]

7.3.2 Visual Basic.NET

The .NET Framework is a windows component used for developing and running next generation windows or web based applications. The common language runtime (CLR) and the .NET framework class library are the two main components of .NET. CLR is often referred to as the backbone of the .NET framework. The main functions of CLR include run time code management, memory management and thread management that provides robustness and security [15]. The other main component of .NET is class library [15]. It's a reusable object-oriented collection used in application development.

Visual Basic is the most powerful tool to build applications for .NET Framework. Simplicity of Visual Basic. NET has let to its popular usage from novice programmers to advanced system architects. Applications build using Visual Basic runs on .NET framework with unsurpassed scalability and reliability [16].

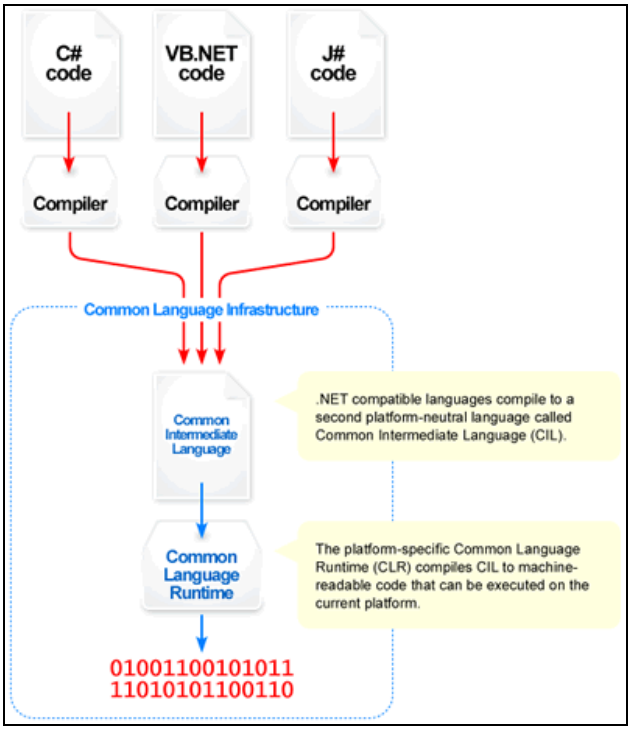

Figure15: Components of .NET Framework [14]

7.3.3 Microsoft SQL Server 2005

SQL Server is a client-server relational Database Management System (RDBMS) developed by Microsoft. SQL Server 2005 provides a platform for organizations to manage data any place, anytime. [13]. SQL Server not only reduces the cost and management for development of an application but also provides security for business critical applications. Trial version of Microsoft SQL Server 2005 is available on Microsoft website.

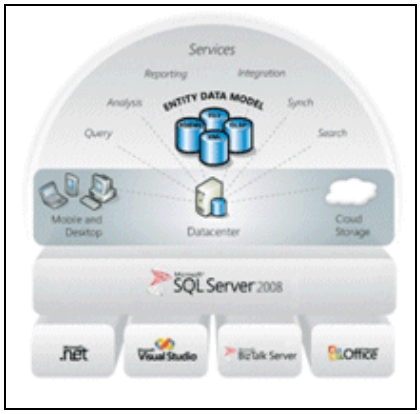

Figure16: Microsoft Data Platform Vision [13]

8. IMPLEMENTATION DETAILS

This project uses Visual Basic.NET for front-end and SQL server 2005 for back-end. Section 7.1 gives details about the screens used, Section 7.2 gives details about data repository and section 7.3 explains the flow of data via DFD.

8.1 Front-end design

The Main Form

The main form of the system provides the user with 5 different menus to work on.

1. Enter Factual Data
2. Enter Subjective Managerial Data
3. Enter Subjective Peer to Peer Data
4. Generate Calculations
5. Exit

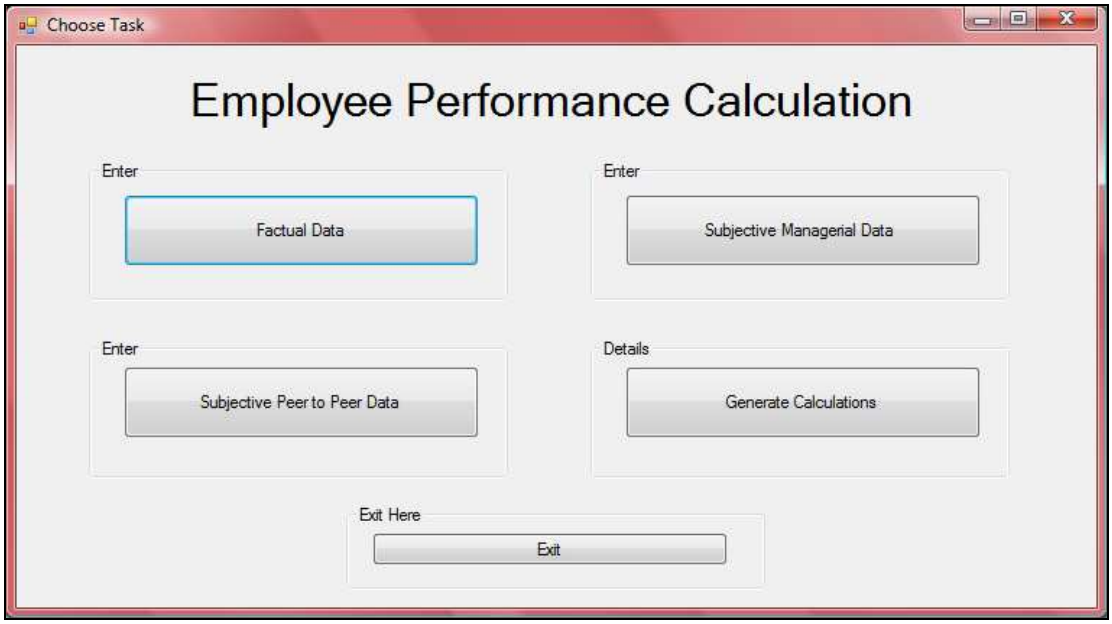

Figure17: Main Menu

Entering Factual Data

1. User clicks on the "Enter Factual Data" button.

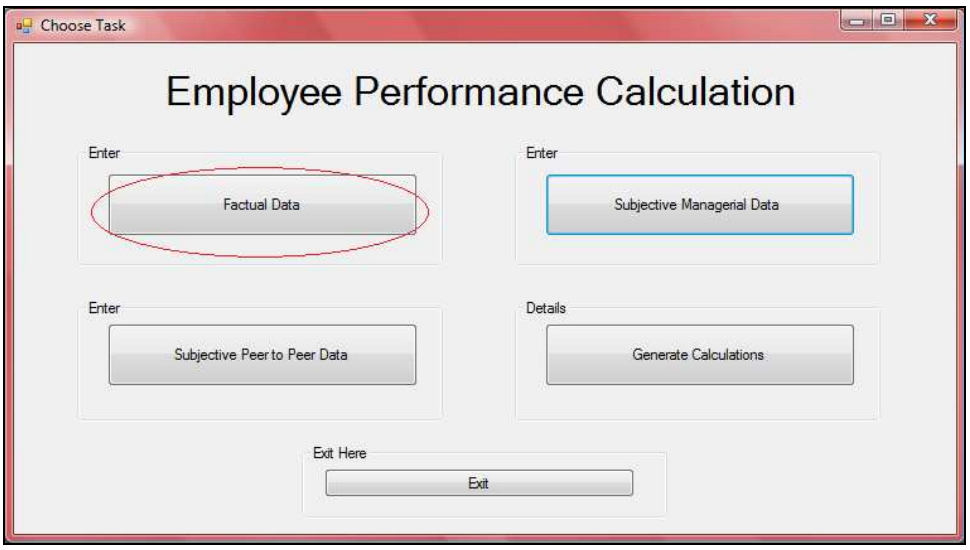

Figure18: Factual Data Selection

2. The user enters the Factual Data using this screen. A xml file generated by Defect Manager is imported and the values are parsed and stored in database.

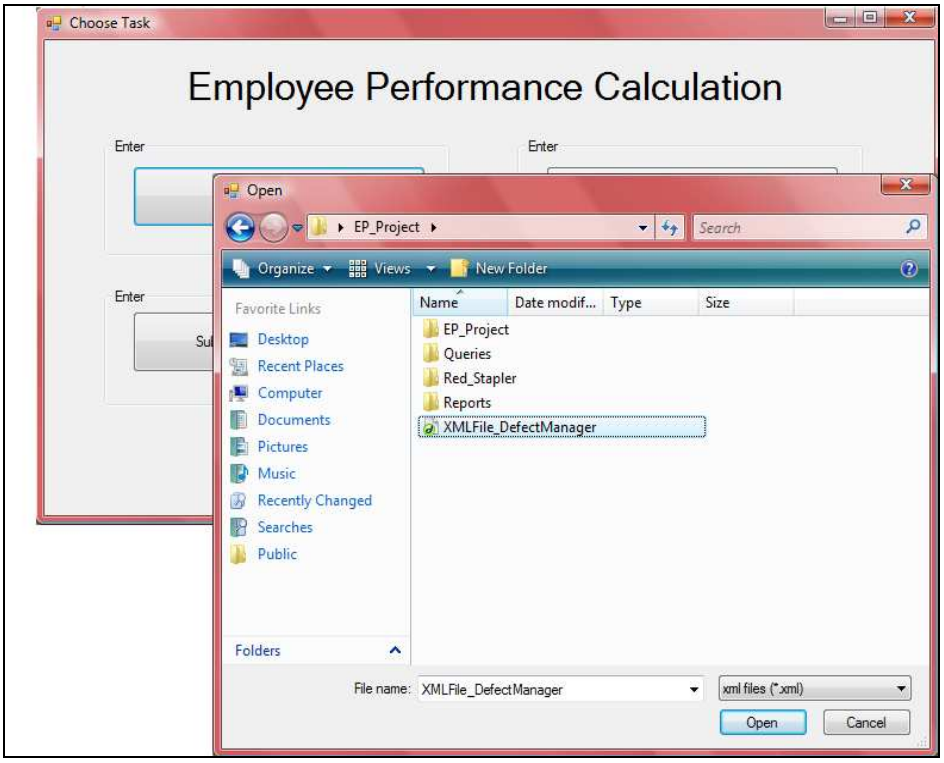

Figure19: Importing a XML file

Entering Subjective Managerial Data

1. User clicks on the "Enter Subjective Data" button.

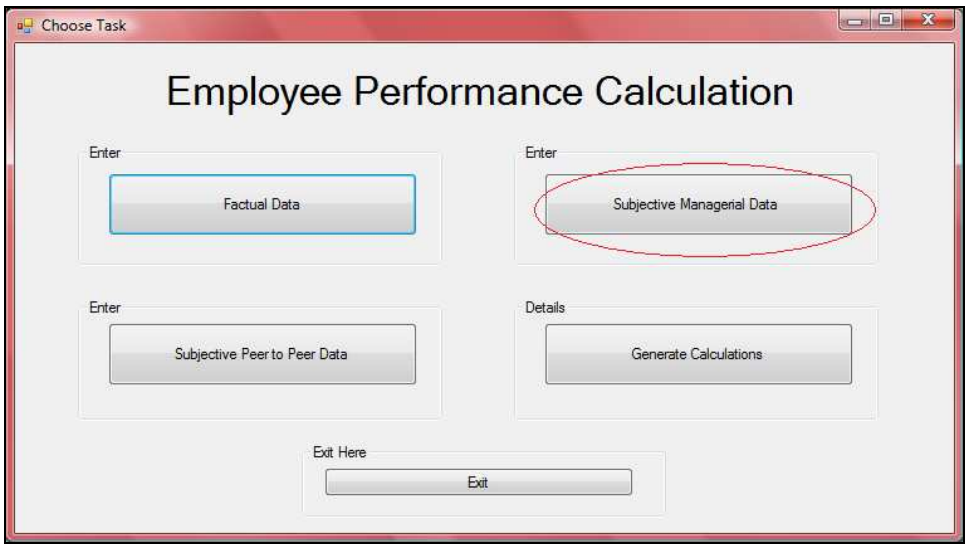

Figure20: Subjective Data Selection

2. Manager is presented with a screen where he rates each employee on a scale of 1 to5.

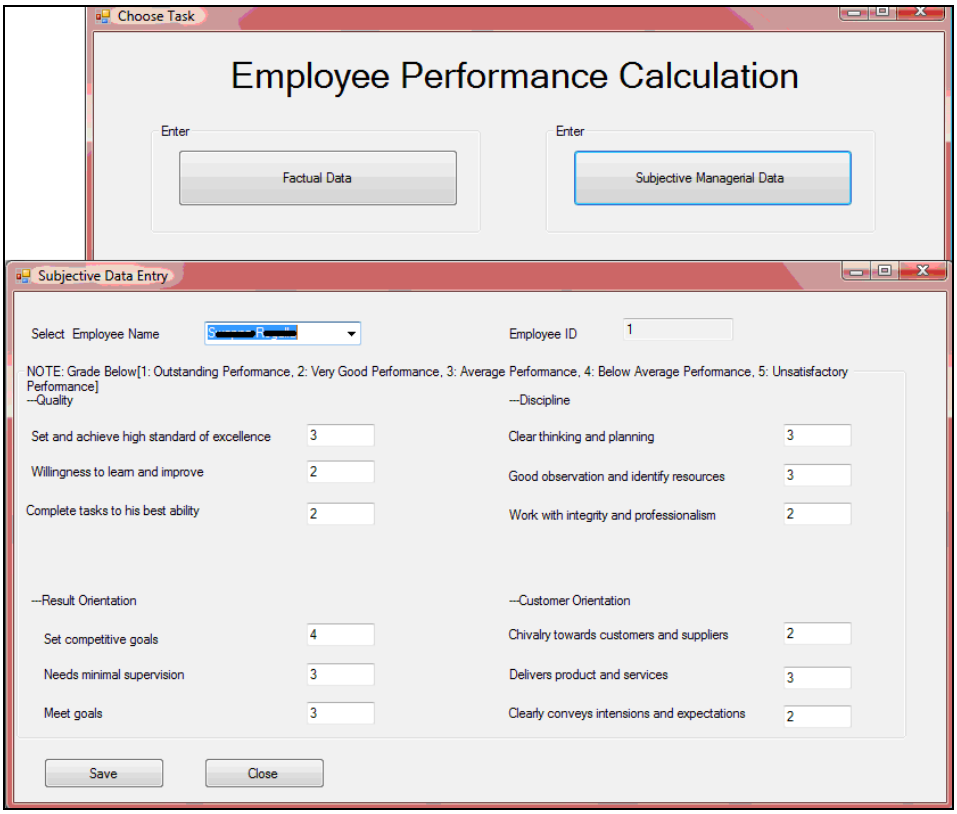

Figure21: Subjective Data Entry

3. Screen shot below shows the list of the entire employees that are present in the system.

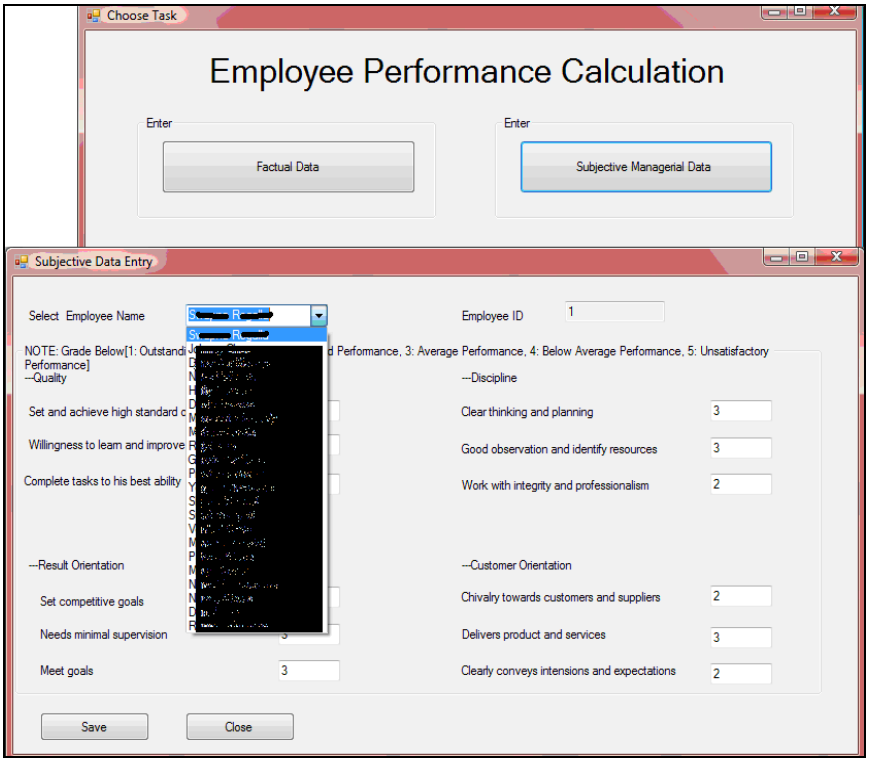

Figure22: Employee list

Entering Subjective Peer-Peer Data

1. User clicks on the "Enter Peer to Peer Data" button.

2. Each employee reviews his/her coworkers based on scale of 1 to 5.

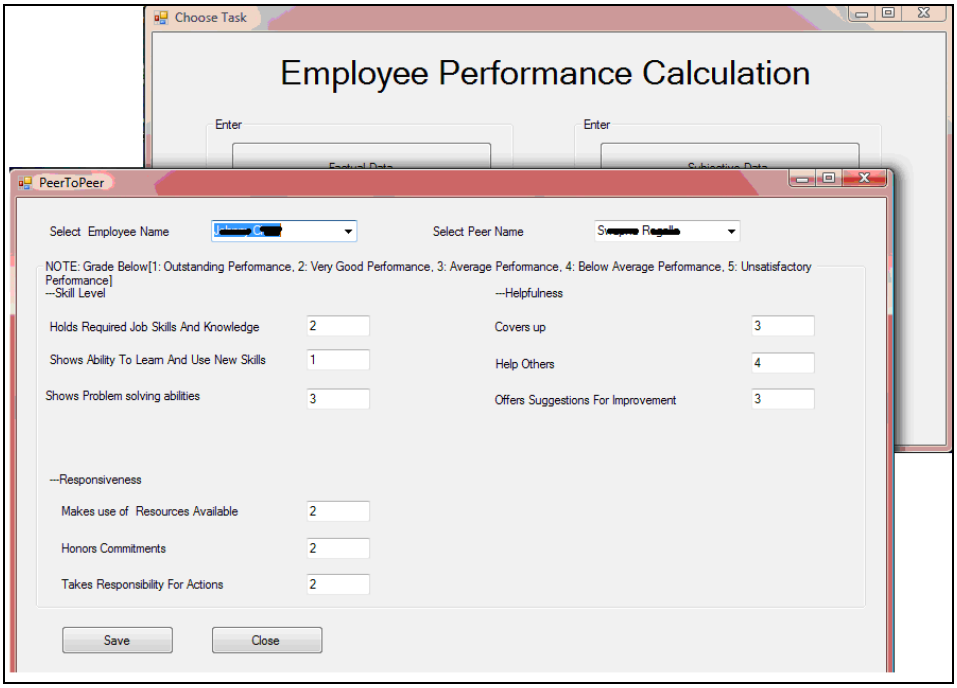

Figure23: Peer to Peer Data Entry

3. An employee can not review himself.

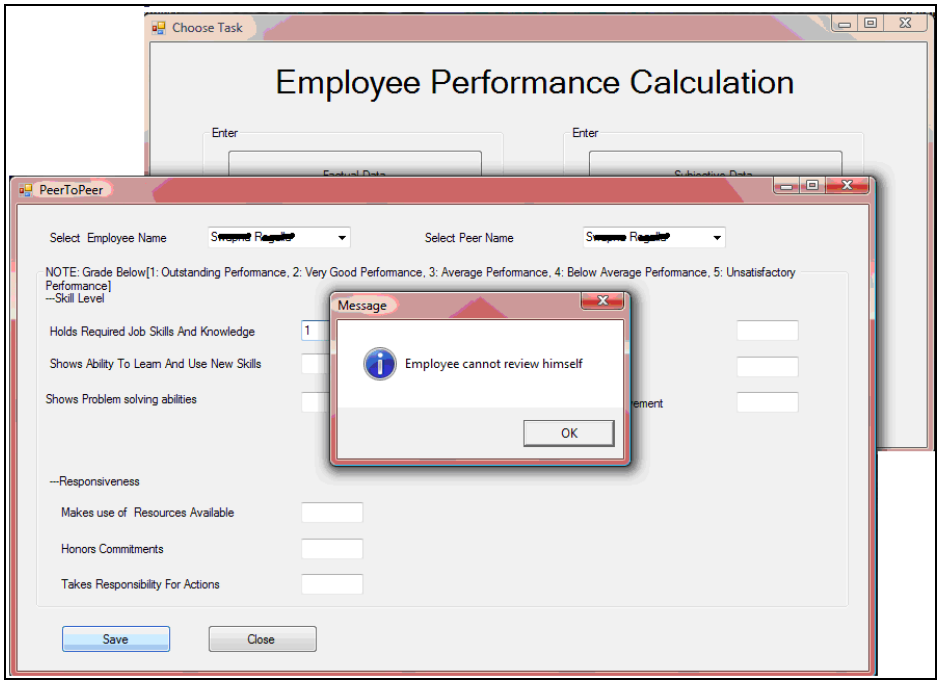

Figure24: Peer to Peer Data Entry Self Review

Generate Calculations

1. User clicks on "Generate Calculations" button.

2. User has an option to select any of the 4 reports.

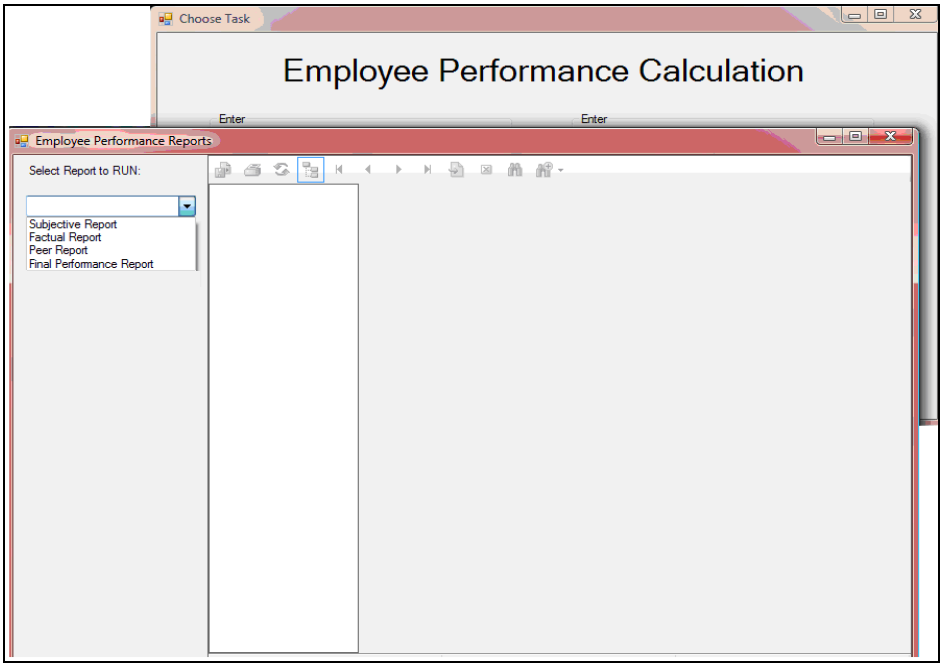

Figure25: Report Type

- Subjective report

  Gives ranking of employees based on the subjective data. It also shows the weight for each employee.

- Factual report

  Gives ranking of employees based on the factual data. It also shows the weight for each employee.

- Peer report

  Gives ranking of employees based on the peer data. It also shows the weight for each employee.

- Final Performance report:

  Gives the cumulative ranking based on 3 data sources.

Exit

User clicks on "Exit" button to exit the application.

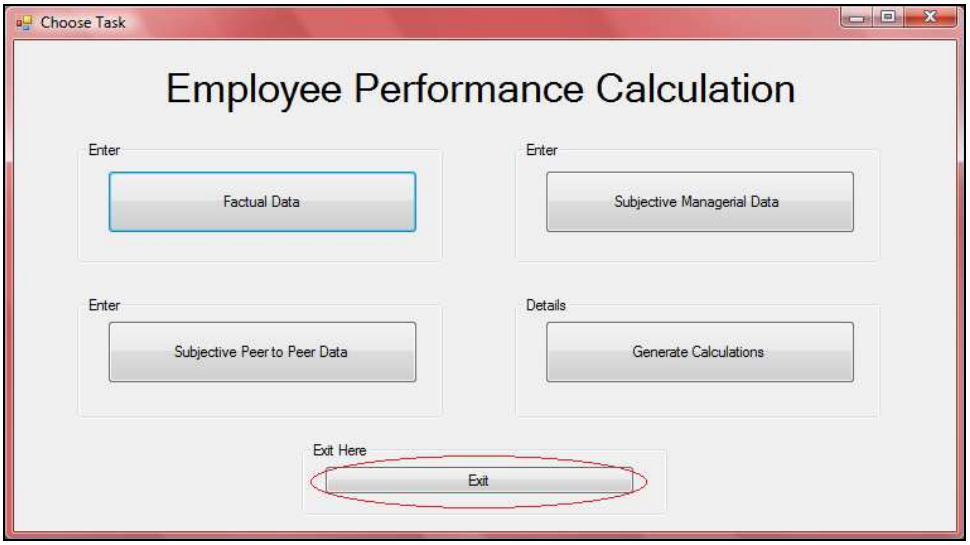

Figure26: Exit

8.2 Back-end design

Normalization principals were used to enhance and develop the database design for the system.

Normalization

Normalization is used widely when designing relational databases. Normalization is a process of organizing data in a database efficiently. It is a two step process that is used to efficiently organize data in a database. First step is to make sure there are no data redundancy and removing if any. Second step to make sure that data dependencies make sense. Normal forms are the guidelines set by database community to ensure that databases are normalized. Normal forms are numbered from one (1NF) through five (5NF) with one being the lowest level. Relational databases are expected to be in the third normal form (3NF). Most common normal forms are 1NF, 2NF and 3NF. 5NF is considered to be complex and not that widely used.

Definition of Normal Form

First Normal Form

A relational table by definition is considered to be in first normal form represented as 1NF. It means that all values of the columns are atomic and has no repeating values [28].

Second Normal Form

A relational table in 1NF has every non key column is fully dependent upon the primary key then it is considered to be in second normal form 2NF [28].

Third Normal Form

A relational table is in 2NF and every non-key column is non-transitively dependent upon its primary key then it is considered to be in third normal form (3NF) [28]. Data normalization is applied to remove redundancy.

Normalization on the schema is applied and the following tables are obtained:

1. **Table name: Employee**

This table stores the names of the different employees of the organization and associates each name with an Id, which uniquely identifies each employee.

Field Name	**Type**	**Description**
EID	Integer	Specifies employee id, primary key
Name	nvarchar(50)	Specifies employee name
Hire date	Date time	Specified the hire date of the employee
Manager_ID	Integer	Specifies the ID of the manager of the employee, foreign key
Is_manager	Integer	Specified whether the employee is a manager or not to other employees
PID	Integer	Specifies the project ID on which the employee works, foreign key
JobTitle	nvarchar(50)	Specifies the job title of the employee
Gender	nvarchar(50)	Specifies the Gender of the employee
Department	nvarchar(50)	Specifies the Department in which the employee works

2. **Table name: Factual_Criteria**

This table stores the different factual criteria on the basis of which the employees are reviewed along with the weights assigned to these criterias.

Field Name	**Type**	**Description**
ID	Integer	Specifies criteria id, primary key
Description	nvarchar(50)	Specifies name of the criteria
Weight	nvarchar(50)	Specified the weight of the criteria

Explanation is provided in Appendix A for detailed Back-end design.

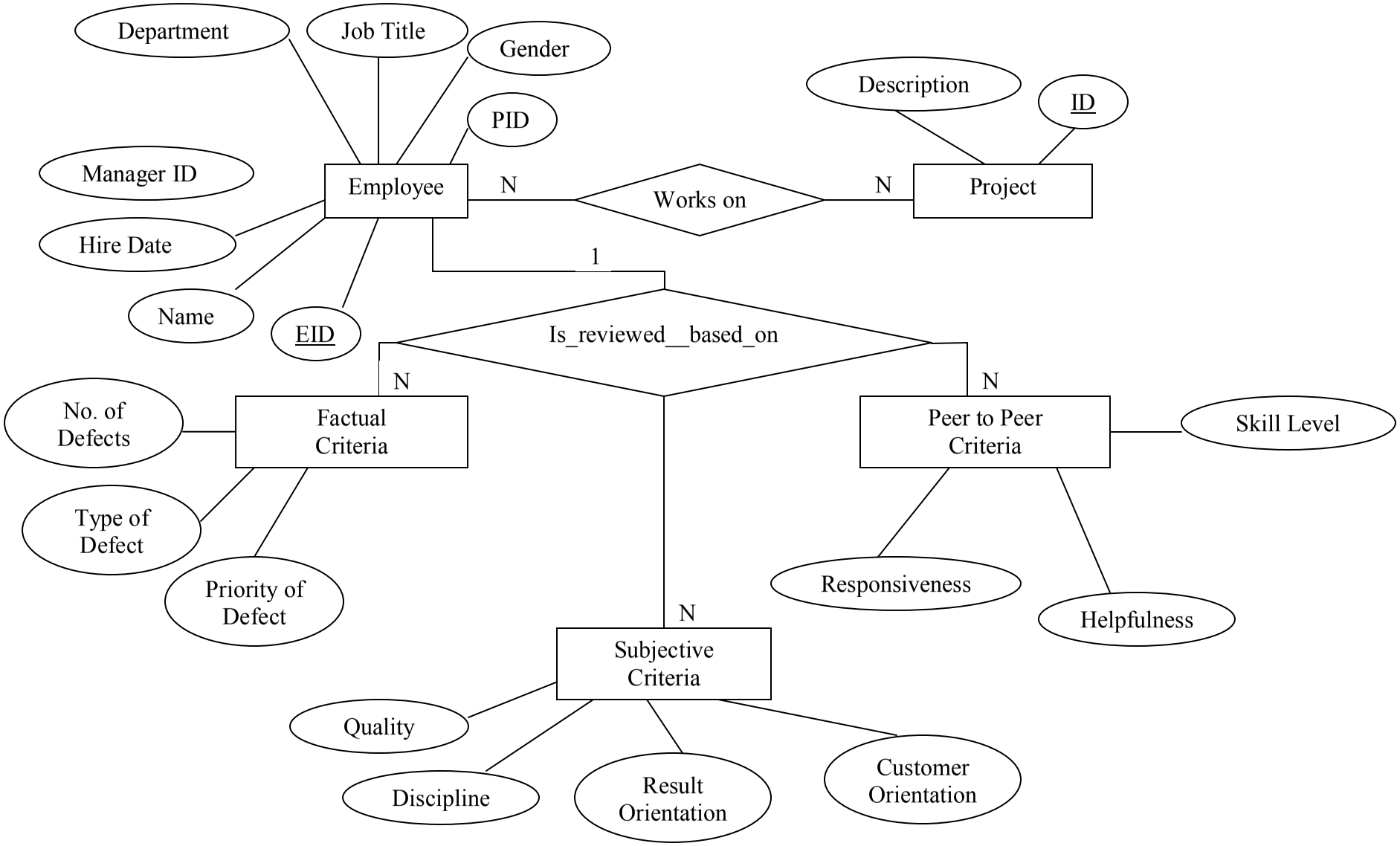

Figure 27: Entity Relationship Model (ER Model)

8.3 Data Flow Diagram

This section provides graphical representation of the flow of data. Level 0, Level1 and Level 2 DFD's are show below.

Level 0

Level 0 DFD represents the scope of the system. The DFD indentifies any external entity and its input and output. All internal processes are ignored at this level.

Level 1

Level 1 DFD recognizes the major processes of the system. The DFD analyses the data flow alias interaction that occurs between the processes and data stores.

Level 2

Level 2 DFD shows all level 1 processes into more details. The processes are broken down into its constituent processes and children are shown.

Explanation is provided in Appendix A for detailed DFD.

9. AHP CALCULATION

9.1 Subjective: Manager Ratings

Criteria	Subcriteria
1) Quality(C1)	• Set and achieve and high standard of excellence(C11) • Willingness to learn and improve(C12) • Complete task at best of his ability(C13)
2) Discipline(C2)	• Clear thinking and planning(C21) • Good observation and identify resources(C22) • Work with integrity and professionalism(C23)
3) Result Orientation(C3)	• Set competitive goals(C31) • Need minimal supervision(C32) • Meet goals(C33)
4) Customer Orientation(C4)	• Chivalry towards customers and suppliers (C41) • Delivers product and services(C42) • Clearly conveys intentions and expectations(C43)

Table1: Subjective Criteria and Sub criteria list

Determining the Criteria and Subcriteria Weights

The manager along with management staff develops the pairwise comparison matrices which determine the criteria and subcriteria weights [17]. Expert Choice decision software was used to compute the weights for all pairwise comparison matrices [17].

Criteria

	C1	C2	C3	C4	Weights
C1	1	8	4	6	.633
C2		1	4	7	.214
C3			1	5	.111
C4				1	.042

Sub Criteria

1. **Quality**

	C11	C12	C13	Weights
C11	1	8	9	.804
C12		1	2	.122
C13			1	.074

2. **Discipline**

	C21	C22	C23	Weights
C21	1	4	8	.699
C22		1	5	.237
C23			1	.064

3. **Result Orientation**

	C31	C32	C33	Weights
C31	1	8	9	.804
C32		1	2	.122
C33			1	.074

4. **Customer Orientation**

	C41	C42	C43	Weights
C41	1	8	8	.796
C42		1	2	.125
C43			1	.079

Intensity Weights

NOTE: Grading [1: Outstanding Performance, 2: Very Good Performance, 3: Average Performance, 4: Below Average Performance, 5: Unsatisfactory Performance]

	1	2	3	4	5	Weights
1	1	3	5	6	8	.501
2		1	3	5	6	.262
3			1	3	5	.133
4				1	3	.067
5					1	.036

Table2: Subjective Intensity Weights

Global Intensities Weights

Intensity	C1			C2			C3			C4		
	C11	C12	C13	C21	C22	C23	C31	C32	C33	C41	C42	C43
1	0.2550	0.0387	0.0235	0.0749	0.0254	0.0069	0.0447	0.0068	0.0041	0.0167	0.0026	0.0017
2	0.1333	0.0202	0.0123	0.0392	0.0133	0.0036	0.0234	0.0035	0.0022	0.0088	0.0014	0.0009
3	0.0677	0.0103	0.0062	0.0199	0.0067	0.0018	0.0119	0.0018	0.0011	0.0044	0.0007	0.0004
4	0.0341	0.0052	0.0031	0.0100	0.0034	0.0009	0.0060	0.0009	0.0006	0.0022	0.0004	0.0002
5	0.0183	0.0028	0.0017	0.0054	0.0018	0.0005	0.0032	0.0005	0.0003	0.0012	0.0002	0.0001

Explanation is provided in Appendix A for detailed Subjective Managerial Rating

Based on the managers input the Subjective managerial weights are calculated.

Employee	Overall Weights	Rank
S R	0.1497	12
J C	0.1077	18
D K	0.0911	19
N H	0.1348	16
H H	0.2411	4
D O	0.1083	17
M M	0.1481	14
M C	0.242	3
R J	0.2654	2
G S	0.2319	6
P A	0.2412	5
Y A	0.1616	13
S P	0.2163	7
S K	0.2132	8
V G	0.4084	1
M D	0.0664	22
P O	0.0824	21
M H	0.144	20
N L	0.1601	11
N C	0.1418	15
D B	0.1547	10
Ra J	0.1611	9

9.2 Factual Data Ratings

Criteria	Subcriteria
1) Priority(C1)	• Priority 1(C11) • Priority 2(C12) • Priority 3(C13)
2) Defect(C2)	• 1-10(C21) • 11-20(C22) • 21 or more(C23)
3) Type(C3)	• Defect(C31) • Enhancement(C32) • Misc(C33)

Table3: Factual Criteria and Sub criteria list

Determining the Criteria and Subcriteria Weights
Criteria

	C1	C2	C3	Weights
C1	1	8	4	.717
C2		1	6	.205
C3			1	.078

Sub Criteria

1. **Priority**

	C11	C12	C13	Weights
C11	1	7	8	.763
C12		1	5	.178
C13			1	.059

2. **Defect**

	C21	C22	C23	Weights
C21	1	4	8	.691
C22		1	6	.249
C23			1	.060

3. **Type**

	C31	C32	C33	Weights
C31	1	5	8	.719
C32		1	6	.223
C33			1	.058

Factual Rating of 22 Employees

Employee	C1			C2			C3		
	C11	C12	C13	C21	C22	C23	C31	C32	C33
Employee 1	# of Priority 1 Defects * 0.763	# of Priority 2 Defects * 0.178	# of Priority 3 Defects * 0.059	If number of Defects fall in 1-10 use weight 0.691	If number of Defects fall in 11-20 use weight 0.249	If number of Defects fall in 21 or more use weight 0.060	# of Type that are Defects * 0.719	# of Type that are Defects * 0.223	# of Type that are Defects * 0.058
Employee 2	Do	Do	Do	Do	Do	Do	Do	Do	Do
Employee 3	Do	Do	Do	Do	Do	Do	Do	Do	Do
Employee nth	Do	Do	Do	Do	Do	Do	Do	Do	Do

Total weight for any employee is given by:

Number of Priority 1 Defects * corresponding weight+ Number of Priority 2 Defects * corresponding weight + Number of Priority 3 Defects * corresponding weight + Range the defect falls in * corresponding weight + Number of Type that are defects * corresponding weight+ Number of type of Type that are Enhancement * corresponding weight + Number of types that are Miscellaneous * corresponding weight

Based on the above procedure and after complex calculations we get the following output

Employee	Overall Weights	Rank
S R	1.28	13
J C	1.72	8
D K	1.42	12
N H	3.21	1
H H	2.01	4
D O	1.76	5
M M	1.68	9
M C	1.20	15
R J	2.29	2
G S	1.08	17
P A	1.04	20
Y A	0.48	21
S P	1.59	10
S K	1.59	11
V G	1.25	13
M D	1.74	6
P O	1.07	19
M H	0.36	22
N L	2.03	3
N C	1.11	16
D B	1.23	14
Ra J	1.73	7

9.3 Subjective: Peer Ratings

Criteria	Subcriteria
1) Skill Level(C1)	• Holds required job skill and knowledge(C11) • Show ability to learn and use new skills(C12) • Shows Problem solving abilities(C13)
2) Helpfulness(C2)	• Covers up(C21) • Help others (C22) • Offers suggestions for improvements(C23)
3) Responsiveness(C3)	• Makes use of resources available(C31) • Honors Commitment(C32) • Takes Responsibility for actions(C33)

Table4: Peer Criteria and Sub criteria list

Determining the Criteria and Subcriteria Weights
Criteria

	C1	C2	C3	Weights
C1	1	8	4	.748
C2		1	4	.203
C3			1	.049

Sub Criteria

1. **Skill Level**

	C11	C12	C13	Weights
C11	1	8	9	.752
C12		1	2	.051
C13			1	.197

2. **Helpfulness**

	C21	C22	C23	Weights
C21	1	4	8	.767
C22		1	5	.171
C23			1	.061

3. **Responsiveness**

	C31	C32	C33	Weights
C31	1	8	9	.731
C32		1	2	.081
C33			1	.188

Intensity Weights:

NOTE: Grading [1: Outstanding Performance, 2: Very Good Performance, 3: Average Performance, 4: Below Average Performance, 5: Unsatisfactory Performance]

	1	2	3	4	5	Weights
1	1	3	5	6	8	.501
2		1	3	5	6	.262
3			1	3	5	.133
4				2	3	.067
5					1	.036

Table5: Peer Intensity Weights

Global Intensity Weights:

Intensity	C1			C2			C3		
	C11	C12	C13	C21	C22	C23	C31	C32	C33
1	0.2818	0.0191	0.0738	0.0780	0.0174	0.0062	0.0179	0.0020	0.0046
2	0.1474	0.0100	0.0386	0.0408	0.0091	0.0032	0.0094	0.0010	0.0024
3	0.0748	0.0051	0.0196	0.0207	0.0046	0.0016	0.0048	0.0005	0.0012
4	0.0377	0.0026	0.0099	0.0104	0.0023	0.0008	0.0024	0.0003	0.0006
5	0.0202	0.0014	0.0053	0.0003	0.0012	0.0004	0.0013	0.0001	0.0003

Peer review rating for 22 employees

Each employee is reviewed by 21 other employees i.e. for each employee there are 21 cycles of peer review. Total peer weight for an employee equals sum of weights from 21 cycles

Peer review rating for Employee: S R

Employee:	C1			C2			C3		
S R	C11	C12	C13	C21	C22	C23	C31	C32	C33
J C	3	3	3	4	4	4	3	3	3
D K	3	4	3	5	4	4	3	3	4
N H	3	3	4	4	5	4	5	4	3
H H	3	2	2	3	3	3	2	1	2
D O	2	3	3	4	4	5	3	3	3
M M	2	1	1	3	4	2	2	2	2
M C	1	2	2	3	3	3	1	2	1
R J	4	3	4	1	1	2	3	4	3
G S	4	3	5	2	2	1	5	3	4
P A	4	3	5	2	2	3	3	4	4
Y A	3	2	3	3	4	2	4	2	3
S P	2	3	2	3	2	4	2	1	4
S K	3	4	4	2	4	2	2	2	2
V G	2	3	3	1	1	1	3	4	3
M D	4	3	3	3	4	4	2	3	3
P O	3	3	4	3	3	4	3	2	3
M H	3	3	3	3	4	5	2	4	4
N L	2	1	3	3	4	3	2	2	3
N C	1	1	2	3	3	4	2	1	1
D B	1	3	4	3	3	4	2	4	1
Ra J	1	3	1	4	5	2	3	1	2

Explanation is provided in Appendix A for detailed Subjective Peer Rating

Based on the peer input the Subjective peer weights are calculated.

Employee	Overall Weights	Rank	No. of Reviews
S R	4.20	3	21
J C	3.27	19	21
D K	2.51	22	21
N H	3.59	12	21
H H	3.62	9	21
D O	2.75	21	21
M M	4.06	4	21
M C	3.94	7	21
R J	2.99	20	21
G S	3.95	6	21
P A	3.48	16	21
Y A	3.55	13	21
S P	4.02	5	21
S K	3.54	14	21
V G	3.60	10	21
M D	4.32	1	21
P O	3.43	17	21
M H	3.53	15	21
N L	4.22	2	21
N C	3.60	11	21
D B	3.42	18	21
Ra J	3.63	8	21

10. RESULTS

The following results are based on the test data obtained from a company called S Corporation. A test data for 22 employees working on the same project was mined and used for testing the system. Subjective managerial data and factual data were successfully obtained however subjective peer review data could not be obtained due to proprietary constraints. Peer review data was designed keeping the characteristics of employee in mind to get as close as possible. The results obtained are shown below.

10.1 Subjective Managerial Output

Employees are ranked based on the calculations done on the subjective data. Here we can see that Employee named **(V G)** tops the list with a weight of **.40**.

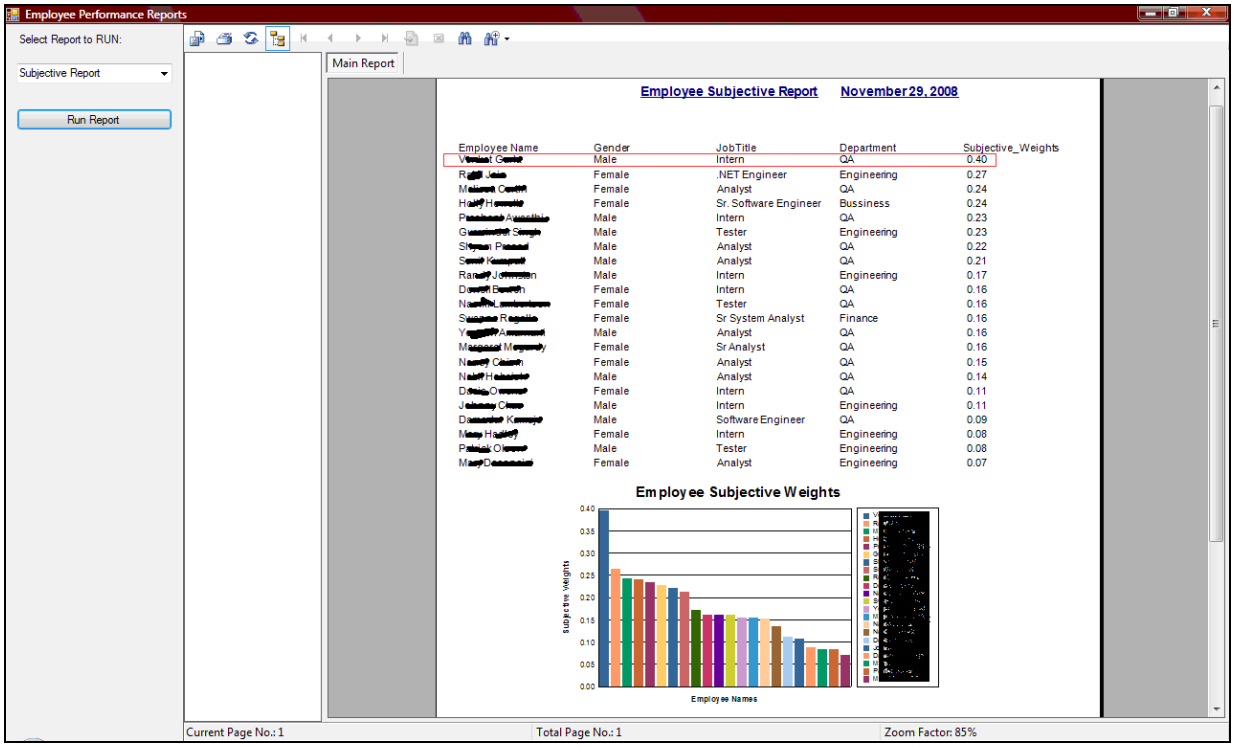

Figure28: Subjective output screen

Taking a closer look at the output, let's analyze where employee N H stand. If this was the conventional employee appraisal method, then N H would have been **ranked 16th** (see the figure below) **out of 22 employees.**

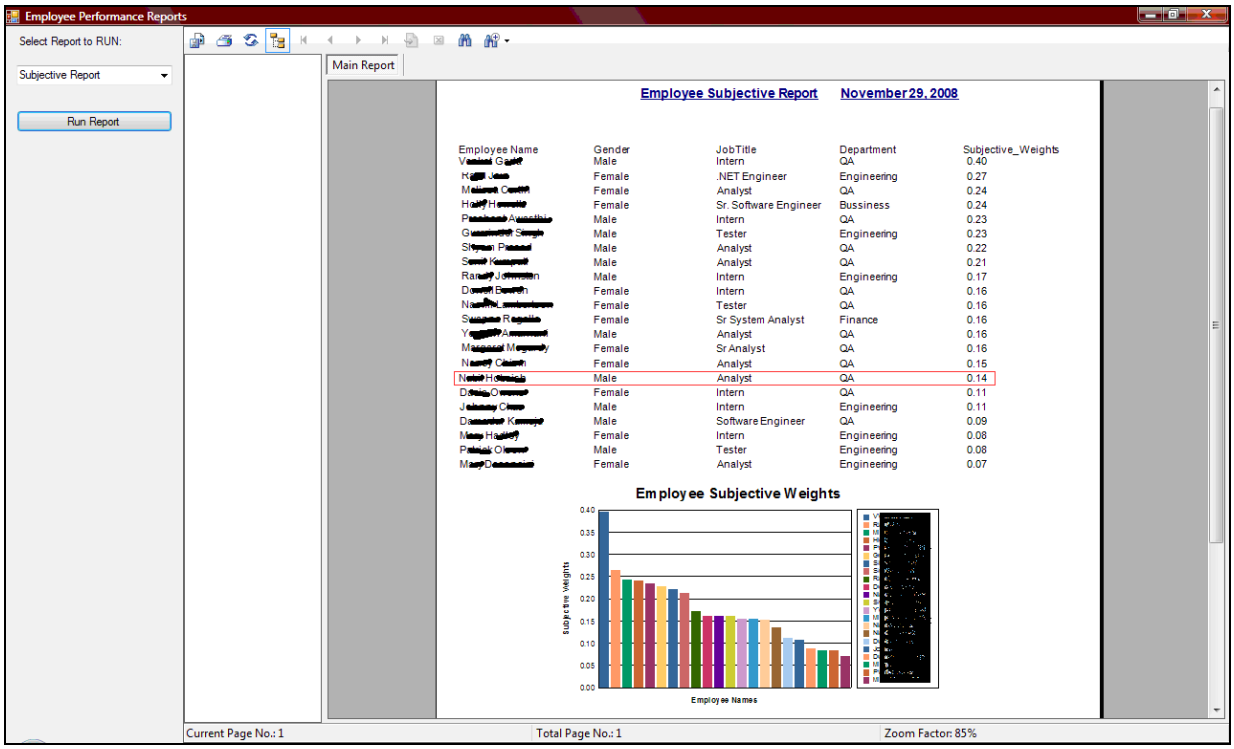

Figure29: Subjective output screen for N H

10.2 Factual Output

Employees are ranked based on the calculations done on the Factual data. In figure 28 we can see that Employee named **(N H)** tops the list with a weight of **3.21**.

It is here where the new system takes advantage over the old conventional appraisal system. The new methodology takes factual data into consideration. The XML file exported from defect manager act as a factual data source there by giving information about the bugs logged by an employee, priority and type of those bugs, current project and so on. The XML file is parsed for the relevant data and results are stored in database for AHP evaluations.

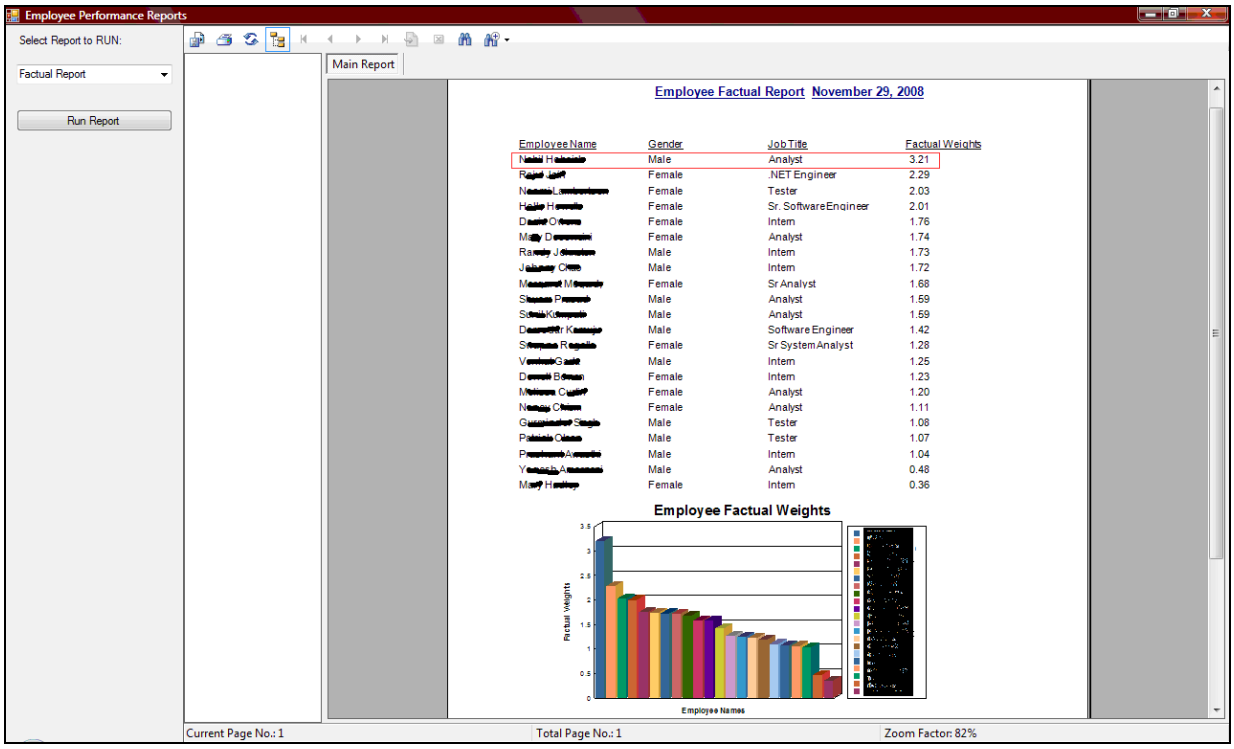

Figure30: Factual output screen

Factual data is the most important aspect of the project. Had the appraisal been given just on subjective managerial data, N H would have lost long before. Factual data adds a whole new dimension to the employee performance evaluation system. It not only shows the efforts N H puts in, but it also rewards him by moving him up and still keeping him in the race to be a star performer.

10.3 Subjective Peer to Peer Output

Employees are ranked based on the calculations done on the Peer data. Each employee in here is reviewed by 21 peers. Here we can see that Employee named **(M D)** tops the list with a weight of **4.32**.

Employee N H stands at 12th position with weight of **3.40**. Let's look at the cumulative report to see who finally holds rank 1st.

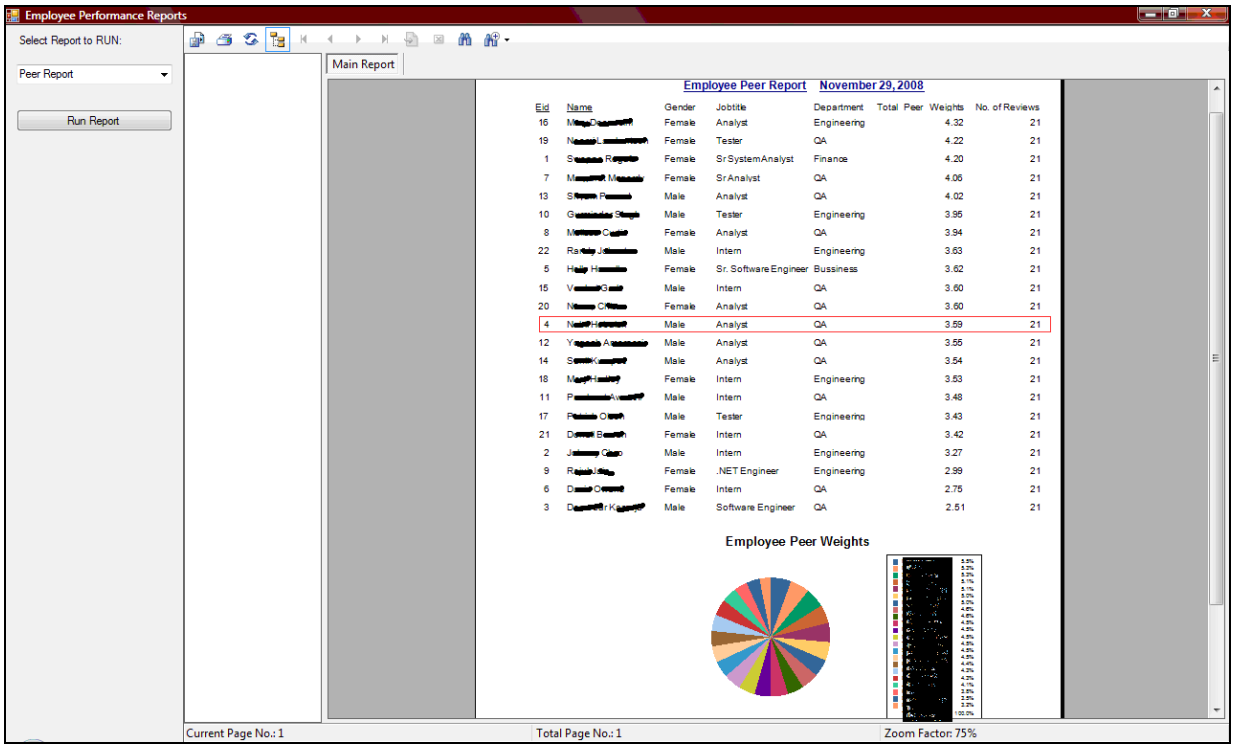

Figure31: Peer to Peer output screen for N H

9.4 Final Performance Report

The final performance report adds up the weights from Subjective Managerial data output, Factual data output and Subjective Peer data output to give cumulative report with the final ranking. The final cumulative report shows that **Employee N H is ranked number 1** among the list of 22 employees. Had the manager not considered the factual criteria and peer to peer data for appraisal, **N H** would have never achieved what he got.

An efficient appraisal system not only means that employees get proper value for their dollars but it also prevents dissatisfaction from creeping into the top employees of the company. So the new system proposed here clearly states that **N H is the star performer for the company.**

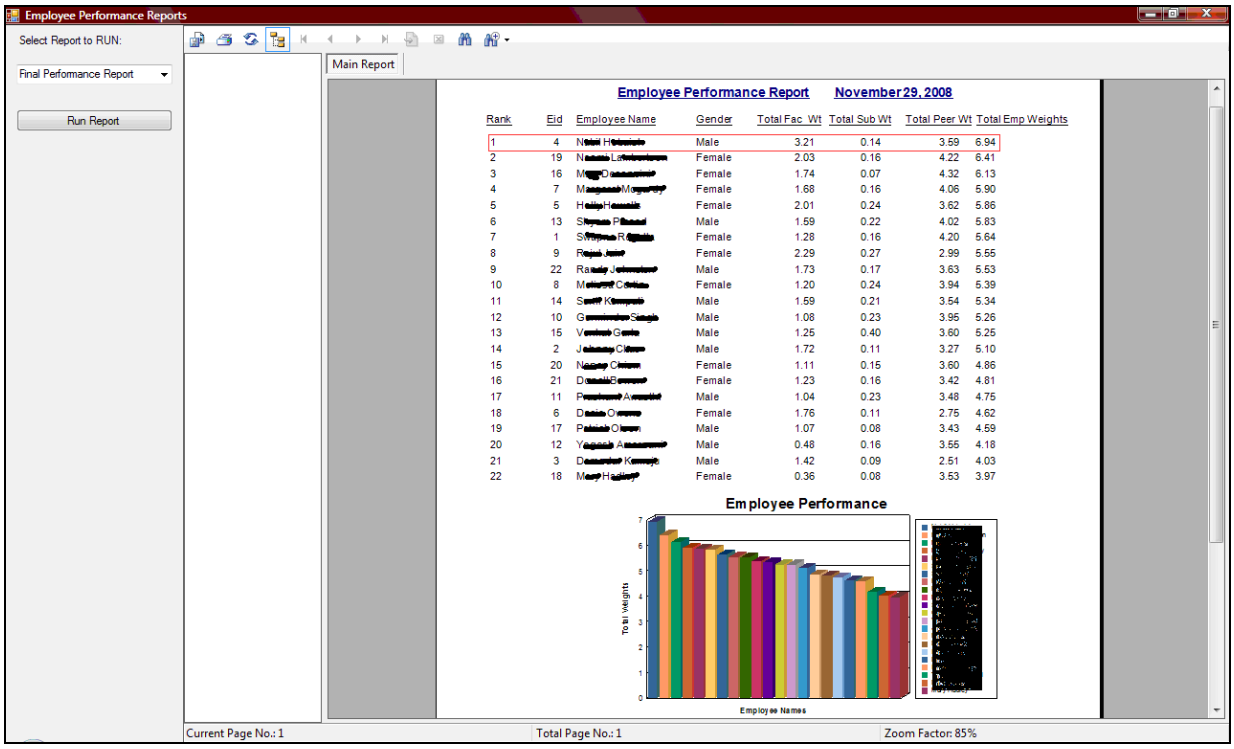

Figure32: Final Performance screen shot

11. CONCLUSION

After successful implementation of the idea, I conclude by saying multi-source data should be taken into consideration to develop an efficient Employee performance appraisal system. Taking into account just the subjective managerial data is not sufficient in returning employees what they deserve. The new technique mentioned in this paper not only takes care of the manager's review and peer reviews of the employee but also takes care of the factual data. It was also observed that the use of Factual data helps to overcome self influence by reflecting the work an employee does. Factual data also helps to calculate optimum employee performance.

AHP plays an important role in analysis of the multi-source data and giving up a composite value. Pairwise comparisons are done for criteria of each data source and weights for each employee is calculated based on three data sources. The composite value for each employee is the sum of weights obtained by addition of three subweights. The computed values are displayed to the manager graphically so that he can better conceptualize the complex multi-source data. AHP acts as a good methodology when it comes to making complex decisions such as in this particular case of Employee performance appraisal. I hope that companies use the methodology being proposed in this project to provide a fair appraisal for the employee.

Employee performance appraisal using single source data and AHP are two techniques that have been in use for decades. But the use of multi-source data along with AHP is being proposed for the very first time. While both the techniques can stand by themselves, they are more effective when used together and that is the essence of this project.

12. FUTURE WORK

Although comprehensive efforts were made to cover all aspects in this project, this system has potential for further improvement. To better enhance the system, following developments can be made, which can be easily incorporated in the system.

1. The current design of the system is focused on employees in a QA department. A more generalized version can be made that fits to developer and other software personnel.
2. Efforts were made to get as accurate data as possible, but due to proprietary constraints getting peer to peer data was difficult. The main reason responsible for this was the lack of cooperation from companies as they would not give out the peer data.
3. A fuzzy aspect could also be taken into consideration. For example, let's say we want to make list of things that are important for washing clothes or I could say a good wash. Some people say factors such as quality of detergent, efficiency of machine play an important role, while some say load criteria (such as heavy, medium and light) are the deciding factors. To end this debate, fuzzy logic comes into play where lets say any 3 criterion are picked up which effect the wash to the maximum extent. A fuzzy logic can also be applied to pick employee appraisal criteria.
4. To better enhance peer data and to neutralize the factor where one employee deliberately gives poor review for his colleague, network messages can be studied. Messages and emails sent over the company's intranet are usually termed as social messages. These messages can be studied and data can be mined for factors such as who gets most emails seeking help, who replies promptly and so on. Numerical figures can be deduced that can enhance peer review data.

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APPENDIX A – Tables and Figures

Subjective Managerial Rating of 22 Employees

Employee	C1			C2			C3			C4		
	C11	C12	C13	C21	C22	C23	C31	C32	C33	C41	C42	C43
S R	3	2	2	3	3	2	4	3	3	2	3	2
J C	4	3	3	3	2	2	3	3	3	3	3	3
D K	4	4	3	3	3	3	3	4	3	4	3	3
N H	3	4	2	3	3	2	3	4	3	3	3	3
H H	2	2	2	3	2	2	2	3	2	2	2	2
D O	3	3	3	5	4	3	4	4	3	3	3	3
M M	3	2	3	3	3	2	3	4	3	2	3	3
M C	2	2	2	2	2	2	3	4	3	3	2	3
R J	2	2	2	2	2	1	2	2	2	2	2	2
G S	2	3	2	2	2	2	3	3	2	4	2	3
P A	2	3	2	2	3	2	2	2	2	3	2	2
Y A	3	4	3	2	3	2	2	3	3	3	2	2
S P	2	2	3	3	3	3	3	2	2	2	2	3
S K	2	3	2	3	2	2	3	4	3	3	3	3
V G	1	2	2	2	2	1	1	2	2	2	2	2
M D	4	5	4	4	4	4	4	5	4	3	4	4
P O	4	5	3	3	3	3	4	5	3	4	3	3
M H	4	5	3	3	3	2	4	5	3	4	3	4
N L	3	2	3	3	3	2	2	4	3	2	3	2
N C	3	2	3	3	3	2	4	5	3	2	3	3
D B	3	2	3	3	2	2	3	4	3	2	3	3
Ra J	3	3	3	2	2	1	4	5	3	2	3	3

Subjective Managerial Rating of 22 Employees (contd.)

Employee	C1			C2			C3			C4		
	C11	C12	C13	C21	C22	C23	C31	C32	C33	C41	C42	C43
S R	0.0677	0.0202	0.0123	0.0199	0.0067	0.0036	0.006	0.0018	0.0011	0.0088	0.0007	0.0009
J C	0.0341	0.0103	0.0062	0.0199	0.0133	0.0036	0.0119	0.0018	0.0011	0.0044	0.0007	0.0004
D K	0.0341	0.0052	0.0062	0.0199	0.0067	0.0018	0.0119	0.0009	0.0011	0.0022	0.0007	0.0004
N H	0.0677	0.0052	0.0123	0.0199	0.0067	0.0036	0.0119	0.0009	0.0011	0.0044	0.0007	0.0004
H H	0.1333	0.0202	0.0123	0.0199	0.0133	0.0036	0.0234	0.0018	0.0022	0.0088	0.0014	0.0009
D O	0.0677	0.0103	0.0062	0.0054	0.0034	0.0018	0.006	0.0009	0.0011	0.0044	0.0007	0.0004
M M	0.0677	0.0202	0.0062	0.0199	0.0067	0.0036	0.0119	0.0009	0.0011	0.0088	0.0007	0.0004
M C	0.1333	0.0202	0.0123	0.0392	0.0133	0.0036	0.0119	0.0009	0.0011	0.0044	0.0014	0.0004
R J	0.1333	0.0202	0.0123	0.0392	0.0133	0.0069	0.0234	0.0035	0.0022	0.0088	0.0014	0.0009
G S	0.1333	0.0103	0.0123	0.0392	0.0133	0.0036	0.0119	0.0018	0.0022	0.0022	0.0014	0.0004
P A	0.1333	0.0103	0.0123	0.0392	0.0067	0.0036	0.0234	0.0035	0.0022	0.0044	0.0014	0.0009
Y A	0.0677	0.0052	0.0062	0.0392	0.0067	0.0036	0.0234	0.0018	0.0011	0.0044	0.0014	0.0009
S P	0.1333	0.0202	0.0062	0.0199	0.0067	0.0018	0.0119	0.0035	0.0022	0.0088	0.0014	0.0004
S K	0.1333	0.0103	0.0123	0.0199	0.0133	0.0036	0.0119	0.0009	0.0022	0.0044	0.0007	0.0004
V G	0.255	0.0202	0.0123	0.0392	0.0133	0.0069	0.0447	0.0035	0.0022	0.0088	0.0014	0.0009
M D	0.0341	0.0028	0.0031	0.01	0.0034	0.0009	0.006	0.0005	0.0006	0.0044	0.0004	0.0002
P O	0.0341	0.0028	0.0062	0.0199	0.0067	0.0018	0.006	0.0005	0.0011	0.0022	0.0007	0.0004
M H	0.0341	0.0028	0.0062	0.0199	0.0067	0.0036	0.066	0.0005	0.0011	0.0022	0.0007	0.0002
N L	0.0677	0.0202	0.0062	0.0199	0.0067	0.0036	0.0234	0.0009	0.0011	0.0088	0.0007	0.0009
N C	0.0677	0.0202	0.0062	0.0199	0.0067	0.0036	0.006	0.0005	0.0011	0.0088	0.0007	0.0004
D B	0.0677	0.0202	0.0062	0.0199	0.0133	0.0036	0.0119	0.0009	0.0011	0.0088	0.0007	0.0004
Ra J	0.0677	0.0103	0.0062	0.0392	0.0133	0.0069	0.006	0.0005	0.0011	0.0088	0.0007	0.0004

Subjective Peer review rating for Employee: S R

S R	C1			C2			C3			
	C11	C12	C13	C21	C22	C23	C31	C32	C33	
J C	0.0748	0.0051	0.0196	0.0104	0.0023	0.0008	0.0048	0.0005	0.0012	0.1195
D K	0.0748	0.0026	0.0196	0.0003	0.0023	0.0008	0.0048	0.0005	0.0006	0.1063
N H	0.0748	0.0051	0.0099	0.0104	0.0012	0.0008	0.0013	0.0003	0.0012	0.105
H H	0.0748	0.01	0.0386	0.0207	0.0046	0.0016	0.0094	0.002	0.0024	0.1641
D O	0.1474	0.0051	0.0196	0.0104	0.0023	0.0004	0.0048	0.0005	0.0012	0.1917
M M	0.1474	0.0191	0.0738	0.0207	0.0023	0.0032	0.0094	0.001	0.0024	0.2793
M C	0.2818	0.01	0.0386	0.0207	0.0046	0.0016	0.0179	0.001	0.0046	0.3808
R J	0.0377	0.0051	0.0099	0.078	0.0174	0.0032	0.0048	0.0003	0.0012	0.1576
G S	0.0377	0.0051	0.0053	0.0408	0.0091	0.0062	0.0013	0.0005	0.0006	0.1066
P A	0.0377	0.0051	0.0053	0.0408	0.0091	0.0016	0.0048	0.0003	0.0006	0.1053
Y A	0.0748	0.01	0.0196	0.0207	0.0023	0.0032	0.0024	0.001	0.0012	0.1352
S P	0.1474	0.0051	0.0386	0.0207	0.0091	0.0008	0.0094	0.002	0.0006	0.2337
S K	0.0748	0.0026	0.0099	0.0408	0.0023	0.0032	0.0094	0.001	0.0024	0.1464
V G	0.1474	0.0051	0.0196	0.078	0.0174	0.0062	0.0048	0.0003	0.0012	0.28
M D	0.0377	0.0051	0.0196	0.0207	0.0023	0.0008	0.0094	0.0005	0.0012	0.0973
P O	0.0748	0.0051	0.0099	0.0207	0.0046	0.0008	0.0048	0.001	0.0012	0.1229
M H	0.0748	0.0051	0.0196	0.0207	0.0023	0.0004	0.0094	0.0003	0.0006	0.1332
N L	0.1474	0.0191	0.0196	0.0207	0.0023	0.0016	0.0094	0.001	0.0012	0.2223
N C	0.2818	0.0191	0.0386	0.0207	0.0046	0.0008	0.0094	0.002	0.0046	0.3816
D B	0.2818	0.0051	0.0099	0.0207	0.0046	0.0008	0.0094	0.0003	0.0046	0.3372
Ra J	0.2818	0.0051	0.0738	0.0104	0.0012	0.0032	0.0048	0.002	0.0024	0.3847
									Total Peer Review Weight	4.20

Back-end design

Table name: Factual_Sub_Criteria

The factual criteria are further divided into sub criteria. This table stores information of the sub criteria along with the weights assigned to these sub criteria.

Field Name	Type	Description
ID	Integer	Primary Key
FC_ID	Integer	Refers to the ID of the factual criteria, Foreign Key
Description	nvarchar(50)	Specifies the name of the sub criteria
Weight	nvarchar(50)	Specifies the weight of the sub criteria

Table name: Factual_Information

This table stores the factual information of the employees of the organization. In other words it stores information of the employee for the different factual criteria.

Field Name	Type	Description
ID	Integer	Primary key
Defect_ID	nvarchar(50)	Specified the Defect ID
Priority	nvarchar(50)	Specifies the priority of the defect
Type	nvarchar(50)	Specifies the type of the defect
EID	Integer	Specifies the employee ID, Foreign Key
PID	Integer	Specifies the Project ID, Foreign Key

Table name: Intensity_Weights

This table stores the weights of the values inputted by the user.

Field Name	Type	Description
ID	Integer	Primary Key
Description	nvarchar(50)	Specifies the name
Weight	nvarchar(50)	Specifies the associated weight.

Table name: Peer_to_Peer_Criteria

This table stores the information of the various peer criteria on the basis of which the employees are reviewed.

Field Name	Type	Description
ID	Integer	Primary key
Criteria_Description	nvarchar(50)	Specifies the name of the criteria
Weight	nvarchar(50)	Specifies the weight associated with the criteria.

Table name: Peer_to_Peer_Sub_Criteria

The peer criteria are further divided into sub criteria. This table stores information of the sub criteria along with the weights assigned to these sub criteria.

Field Name	Type	Description
ID	Integer	Primary Key
PP_ID	Integer	Refers to the ID of the Peer criteria, Foreign Key
Description	nvarchar(50)	Specifies the name of the sub criteria
Weight	nvarchar(50)	Specifies the weight of the sub criteria

Table name: Subjective_Criteria

This table stores the different subjective criteria on the basis of which the employees are reviewed along with the weights assigned to these criteria.

Field Name	Type	Description
ID	Integer	Specifies criteria id, primary key
Criteria_Description	nvarchar(50)	Specifies name of the criteria
Weight	nvarchar(50)	Specified the weight of the criteria

Table name: Project_Info

This table stores the information of the different Projects.

Field Name	Type	Description
ID	Integer	Primary Key
Description	nvarchar(50)	Specifies the name of the project

Table name: Peer_to_Peer_Information

This table stores the information of the employees of the organization as entered by their peers. In other words ii stores the information of the employee for the different peer criteria.

Field Name	Type	Description
ID	Integer	Primary Key
EID	Integer	Specifies the Employee ID, Foreign Key
PID	Integer	Specifies the Peer ID, Foreign Key
Job_Skills	nvarchar(50)	Specifies the value of the employee for the criteria
Learn_New_Skills	nvarchar(50)	Specifies the value of the employee for the criteria
Problem_Solving	nvarchar(50)	Specifies the value of the employee for the criteria
Covers_up	nvarchar(50)	Specifies the value of the employee for the criteria
Help_others	nvarchar(50)	Specifies the value of the employee for the criteria
Suggestions_Improvement	nvarchar(50)	Specifies the value of the employee for the criteria
Resources_Use	nvarchar(50)	Specifies the value of the employee for the criteria
Honors_Committments	nvarchar(50)	Specifies the value of the employee for the criteria
Actions_Responsibility	nvarchar(50)	Specifies the value of the employee for the criteria

Table name: Subjective_Information

This table stores the subjective information of the employees of the organization. In other words it stores the information of the employee for the different subjective criteria.

Field Name	Type	Description
ID	Integer	Primary Key
EID	Integer	Specifies the Employee ID, Foreign Key
Qulaity_Excellence	nvarchar(50)	Specifies the value of the employee for the criteria
Quality_Willingness	nvarchar(50)	Specifies the value of the employee for the criteria
Quality_CompleteTasks	nvarchar(50)	Specifies the value of the employee for the criteria
Discipline_ClearThinking	nvarchar(50)	Specifies the value of the employee for the criteria
Discipline_GoodObservation	nvarchar(50)	Specifies the value of the employee for the criteria
Discipline_Integrity	nvarchar(50)	Specifies the value of the employee for the criteria
Result_Orient_Goals	nvarchar(50)	Specifies the value of the employee for the criteria
Result_Orient_Supervision	nvarchar(50)	Specifies the value of the employee for the criteria
Result_Orient_MeetGoals	nvarchar(50)	Specifies the value of the employee for the criteria
Cust_Orient_Chivalry	nvarchar(50)	Specifies the value of the employee for the criteria
Cust_Orient_Delivers	nvarchar(50)	Specifies the value of the employee for the criteria
Cust_Orient_Intentions	nvarchar(50)	Specifies the value of the employee for the criteria

Table name: Subjective_Sub_Criteria

The subjective criteria are further divided into sub criteria. This table stores information of the sub criteria along with the weights assigned to these sub criteria.

Field Name	**Type**	**Description**
ID	Integer	Primary Key
SC_ID	Integer	Refers to the ID of the Subjective criteria, Foreign Key
Description	nvarchar(50)	Specifies the name of the sub criteria
Weight	nvarchar(50)	Specifies the weight of the sub criteria

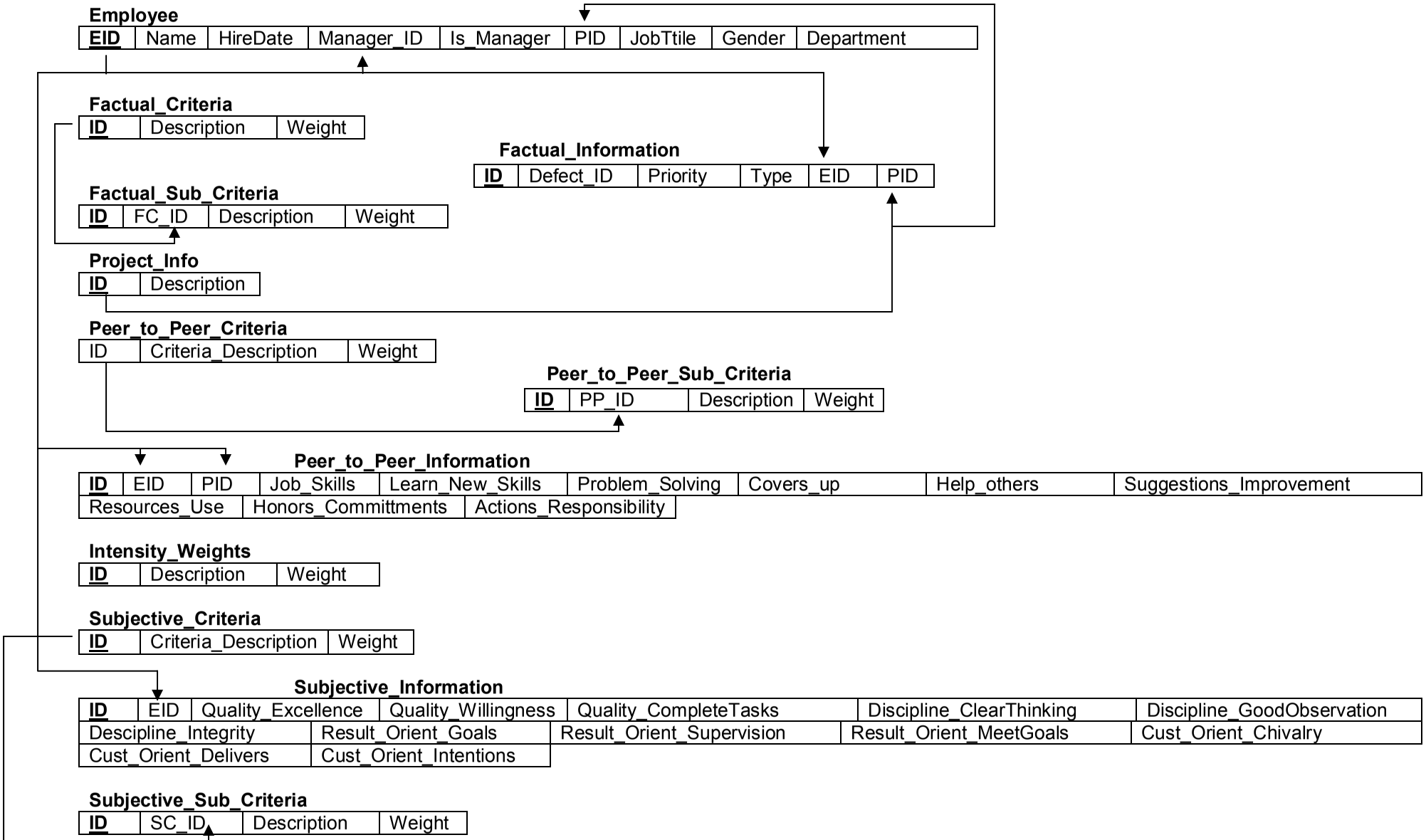

Figure33: Schema for Employee Performance Review

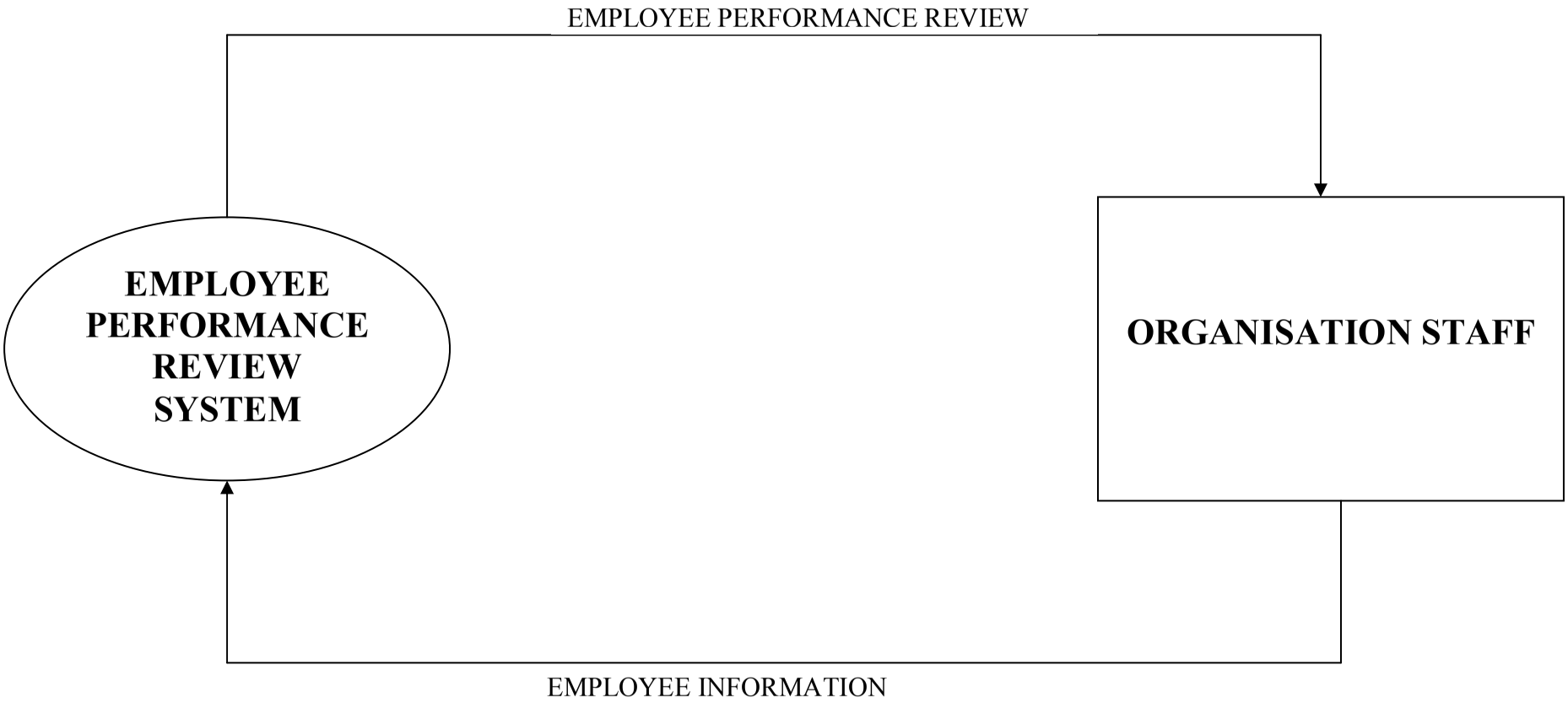

Figure34: LEVEL 0 DATAFALOW DIAGRAM

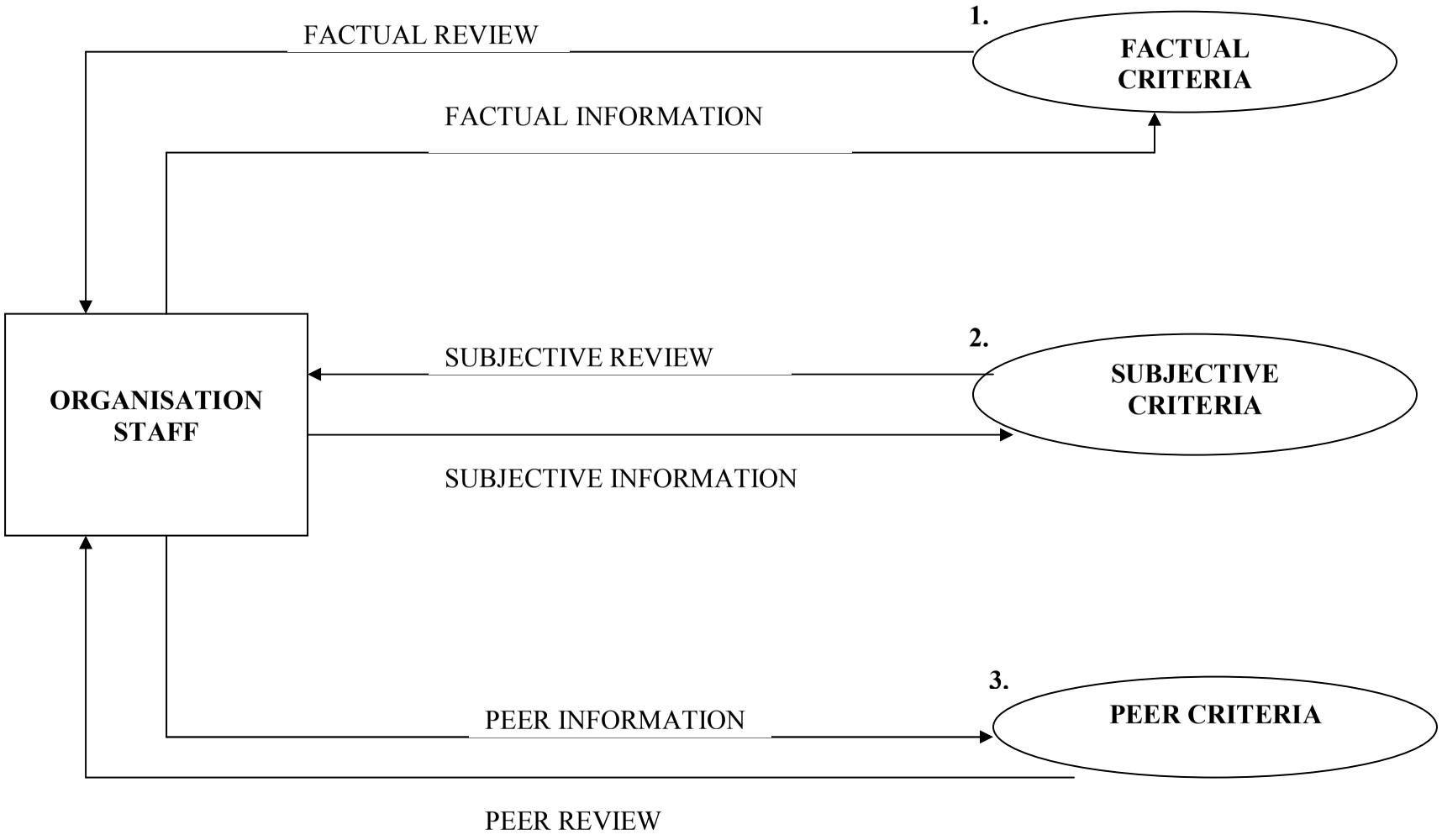

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Figure35: LEVEL 1 DATAFLOW DIAGRAM

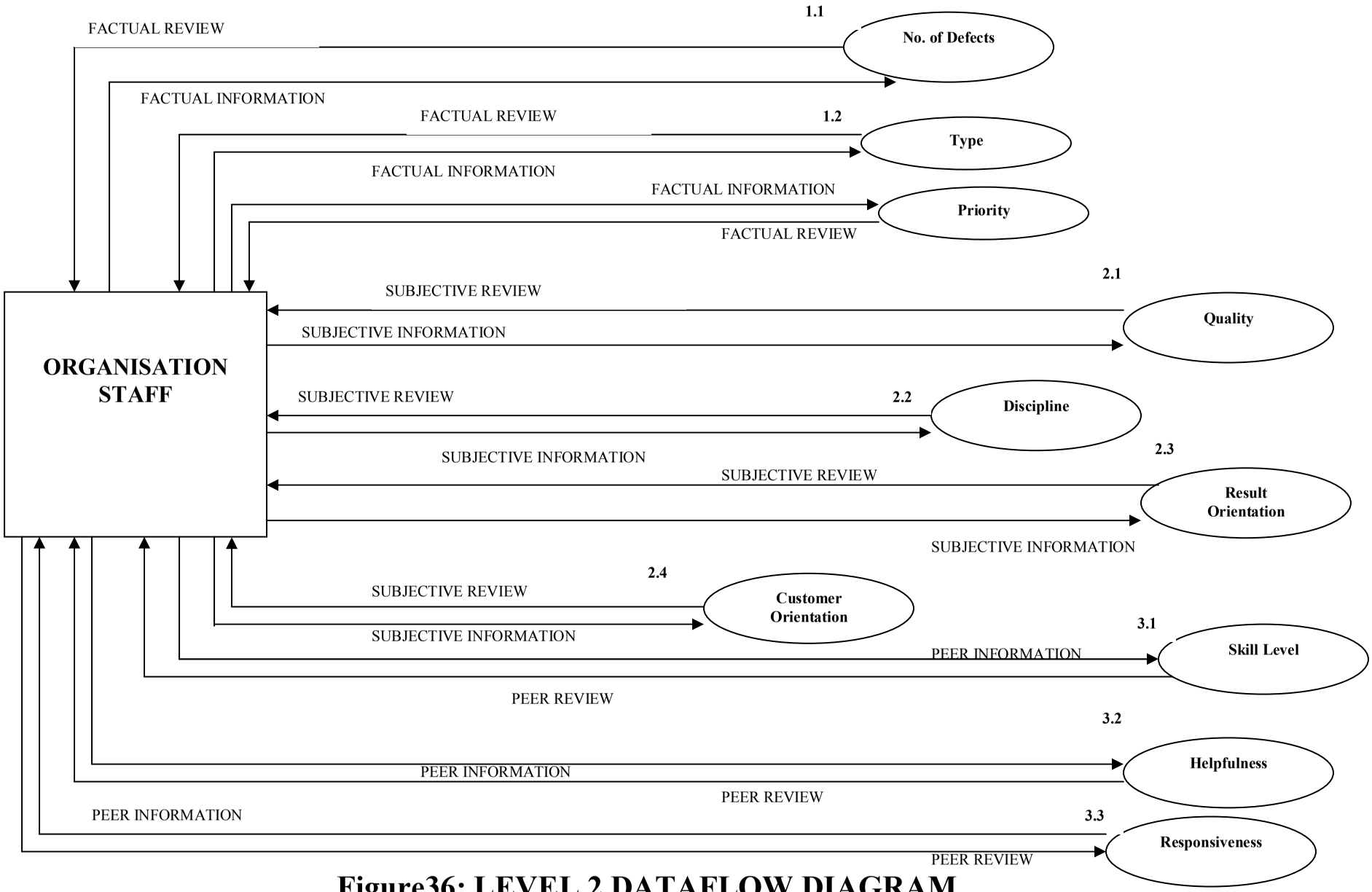

Figure36: LEVEL 2 DATAFLOW DIAGRAM