IDENTIFYING CUSTOMER SATISFACTION OF SOFTWARE PROJECTS FROM SOFTWARE PROJECT METRICS

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Degree of Master of Science

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Thesis submitted in partial fulfillment of the requirements for the degree Master of Science in Computer Science

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the Masters thesis under my supervision.

Name of the supervisor: ENG. Dr. Indika Perera

Signature of the supervisor: ……………………................. Date: ………………………

Abstract

In the era of modern computing, software companies compete each other on respective fields to withstand in the market. It is hard to retain a customer even though every project might not be same as the other project(s). Reports suggest that huge software companies failed to secure a fortune customer while meager software companies like startups increased their business simply by focusing on customer satisfaction. Some customers tend to end the contract with the software company or move to another vendor although the project is marked as success (e.g. completion of project etc.) since the customer satisfaction is not met. The thesis focuses on identifying the customer satisfaction of software projects from software project metrics in the various stages of software projects such as beginning of the project, while the project is ongoing and during maintenance.

Success of the organization depends on the success of the project(s) they do. Success of the project depends on the delight of the customer(s). Therefore, the customer satisfaction is vital for the existence of the organization. The main objective of the thesis is to find the relationship between the actual customer satisfaction score/index and the software project metrics during the project duration. Based on the relationship built, predict the current/future customer satisfaction of the customer(s) regarding the software project will help decision makers such as project managers, higher management to get an idea about how the project is progressing and take necessary steps to eliminate the customer dissatisfaction if the progress is indicating as such.

As a solution, Composite Customer Satisfaction Rating formula was developed which is derived from the software project metrics. Among all the software project metrics, five main influencing factors of software project metrics which affects the delight of the customer(s) were identified. As the proof of concept, CDI Validation Tool was developed to prove that the concept is applicable in real life situation(s). CDI Validation Tool compares the customer satisfaction score/index and Composite Customer Satisfaction Rating and validate whether the calculated Composite Customer Satisfaction Rating reflects the actual customer satisfaction score/index and advocate of which area of the software project metrics should improve to increase the client delight.

A theoretical and empirical evaluation has been done to prove this concept works in real life cases. Evaluation of CDI Validation Tool comprises two phases: Empirical evaluation and performance evaluation. During Empirical evaluation, the Composite Customer Satisfaction Rating formula was applied to an example and results were recorded accordingly. The results illustrate that the Composite Customer Satisfaction Rating reflects the actual customer satisfaction score/index and it can be applied for real. Performance evaluation results indicate that the CDI Validation Tool exhibit an overall good performance with an average processing time of equivalent to 5 milliseconds per record for a large data set.

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List of Abbreviations

Abbreviation	Description
US	United States of America
IT	Information Technology
CDI	Client Delight Index
PM	Project Manager
AM	Account Manager
CSM	Client Service Manager
ALM	Application Lifecycle Management
ISO	International Organization for Standardization
B2B	Business to Business
B2C	Business to Customer
LOC	Lines of Code
FP	Functional Points
DEV	Development
QA	Quality Assurance
UAT	User Acceptance Testing
ETL	Extract, Transform, Load
FY19Q4	Financial Year 2019 Quarter 4
ERP	Enterprise Resource Planning

BI	Business Intelligence
DB	Database
DD	Defect Density
SQL	Structured Query Language
CCSR	Composite Customer Satisfaction Rating
®	Registered
™	Trade Mark
UI	User Interface
COM	Component Object Model

Chapter 1

Introduction

Chapter 1 provides the introduction and background about the projects in the software industry and customer satisfaction in the background section. Motivational factors which laid path to the research idea is explained in the motivation section. The problem, thesis addressing is stated in the problem statement section. The output of thesis is explained in the aims and research objectives. Thesis outline section gives an overall picture of the thesis format which is followed by scope of the thesis.

1.1 Background

For any kind of business, the existence and survival of the business depends on the kind of business they do. Business firm will not be in the market if the business firm is not doing the business properly with a customer. The same applies to the software industry too. The existence and survival of a software company solely depends on the projects they do. If a software company loses a customer, there is high likely to drop in their' business. There are two types of approach the software companies follow when developing a software.

a) Product based software
b) Tailor made software

Some software companies which follows the product based software development method, where they initially develop in house trade mark software and they sell them to the customers. Customers can buy the software as it is or they may request for addon features which results in extra cost to the customer apart from the tag price for the software. In either case, the ownership of the software will retain with the software company in general. The companies which follows tailor made software development method, develops the software which is specific to a customer based on their requirement. It cannot be sell to another customer since the ownership will remain at the owning customer. Tailor made software may have two kind of billings mechanism [1].

i) Time and material

ii) Fixed cost

In the time and material projects, customers should pay for the duration and for the resources needed for the projects, based on the agreement which customer and the software company agrees upon. In the fixed cost based projects, customers must pay a fixed amount regardless of the duration and the resources needed for the project (but the expenses are calculated based on the estimation for the duration and resources needed for the project) based on the agreement which customer and the software company agrees upon. Most successful software companies follow hybrid method where they built product based software and tailor-made software.

The key to coexist and to be the market leader is to satisfy the customer needs and wants. The success of a software company depends on the project(s) they do and the success of the project depends on the customer satisfaction of the customer(s). The companies which have understood this secret to success will be market dominant while others perish over time [2]. Even though there are other factors (such as employee appreciation, organization cost management etc.) which affects the organization existence, the importance should be given to customer satisfaction while balancing the other factors. Because the other factors are easily recoverable by following suitable processes and procedures, but the customer satisfaction is not.

More than 50% of the customers rate their service(s) or product they receive as “Okay” or less than that [3]. It is observed that, it is much easy to sell to an existing customer than a new prospect. It is six to seven times expensive to serve a new customer rather than serving a current customer. 91% of unhappy customers will not do business if they face bad customer satisfaction [4]. Yearly 62 billion United States (US) dollars are lost due to poor customer satisfaction and it is four times likely to buy a service from a competitor if poor customer satisfaction is experienced. According to Gartner's analysis [5], by 2018 50% of the organizations will implement business model which will cater customer satisfaction better.

1.2 Motivation

The motivation for accepting the challenge of identifying customer satisfaction of software projects from software project metrics came from the Client Delight process of Virtusa Corporation. Virtusa Corporation is a giant in global Information Technology (IT) consulting and outsourcing services company headquartered at Westborough, Massachusetts, United States. The company spans across the globe including most of the continents. Currently the employee base is 24000+ and still growing with 200+ active fortune customers. Client delight process is a measure of the company that how a customer feels about the products and services provided by the company. The process is similar to feedback mechanism but with its own standard and process of Virtusa Corporation. There are two types of feedback used in client delight process.

a) Budget type
b) Project type

During the project duration and/or after completion of the project, client gives feedback on how budget is managed in the project using budget type. Using project type feedback, the client gives rating about how a project has performed during the project duration and/or after completion of the project. A project can request for either project type feedback or budget type feedback or both from client(s). In practice, the feedback is requested per financial quarter but if the project duration is less than a quarter then feedback is requested at the end of the project. Both the budget feedback survey and the project feedback survey have similar set of questions and there are specific set of questions which are unique to each feedback. Feedback survey has rating type question, multiple choice question, yes/no type questions with optional comment section wherever it is applicable.

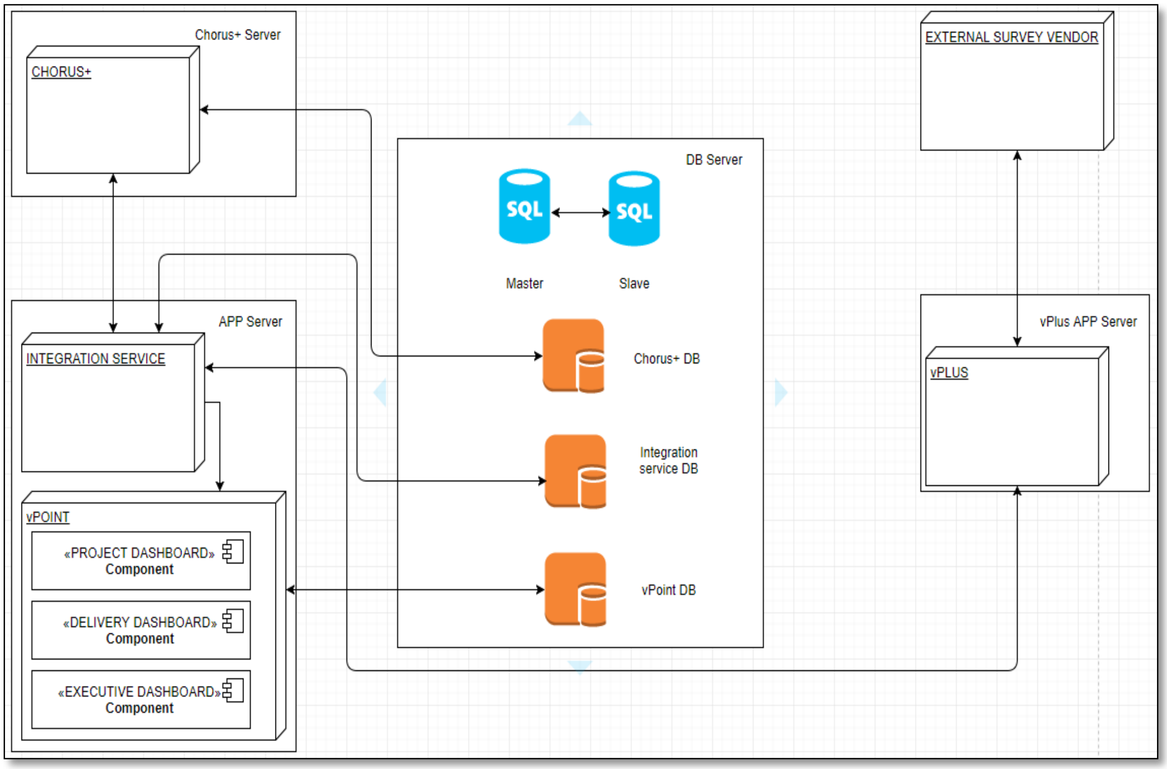


Figure 1-1 : Architecture of Client Delight Index process

The Project Manager (PM)/ Project Coordinator/ Account Manager (AM)/ Program Manager/ Client Service Manager (CSM) initiates the Client Delight Index (CDI) process in the application '*Chorus+*'. Chorus+ is the Application Lifecycle Management (ALM) and process governance tool of the company. As the first step, the person who initiates the process will select the project(s) (internally there may exist one or more project to cater a customer) which needs the feedback, then specify the quarter for which feedback is needed, then specify the clients(s) (there may exist one or more customer contact points for a project) and the date when the survey should get dispatched. Once the process is initiated then it will go for the approval of Program Manager/AM/CSM of the project(s). Once approved, the next step is to send the details to '*vPlus*' which is an internal portal application which handles the sending and receiving of feedbacks. The feedback request is sent to an external survey vendor on the dispatch date by vPlus. After sending the feedback through the external survey vendor, vPlus periodically checks whether any feedback is received from client(s). When a feedback is received then the vPlus retrieves the result and send the details to integration service. Integration service forwards the details to Chorus+ and '*vPoint*' which is an internal dashboard system where all the details related to the project is displayed.

1.3 Problem Statement

Usually the customer satisfaction score/index will be obtained right after a financial quarter which includes the work done in the project/sprint/iteration during the mentioned quarter. If the customer satisfaction score/index is indicating as low, it will be too late to act upon for increasing the customer satisfaction by that time. Naomi [6] affirms in her book as "People tend to rate service higher when delivered by the people they like than by people they don't like". The client feedback rating is perceived feedback than a fair-minded feedback. We should understand that the customer feedback received can be an emotional one. A team member with high performance could get penalized if he/she works for a project which received a negative customer satisfaction score/index while a team member with low performance could get compensated high if he/she works for a project which received a positive customer satisfaction score/index if the company's appraisal process depends on the customer satisfaction feedback. Therefore, the customer satisfaction score obtained from the customer may not reflect the actual image of the project. The rating given by a customer may be unbiased and it might not reflect the feelings of actual users of the system.

Software industry is ranked as 2nd in customer satisfaction with having 95% customer satisfaction in the IT services and consultancy. But there exists a recent trend that even though customer satisfaction is high, the customers are seeking new vendors for their software needs and recent layoff of employees [7] of software companies shows that something is wrong. From recent researches, the results states that the IT industry will spend much money on customer satisfaction from 2017 onwards which leads to a topic where, whether the software industry is having 95% customer satisfaction in real. It is easy to retain the old customers than acquiring new customers since acquiring new customers is costlier than retaining the old customers. Retaining the customers by increasing the customer loyalty will increase the profit by 75% [8]. It is clear, that to run a software business, customers are vital. Having good customer relation and helping the customer(s) to grow will eventually help the organization to grow.

1.4 Aims and Research Objectives

The objective of this thesis is to find a way of improving the software projects via identifying the customer satisfaction from software project metrics during project duration and achieve high results of it. The actual goal of a software company is not only to successfully finish the project(s) but also to retain the customers and gain new projects through them while acquiring new customers and new contracts. The objective itself is self-explanatory that the thesis proposition center on making strides the software project by means of client satisfaction in the different stages of the software projects such as start of the project, while the project is progressing and amid upkeep. Actual customer satisfaction which derived from the software project metrics is free from mood/emotional relationship and project management can work on improving the customer satisfaction before it is too late.

There is enough data we can capture from the client feedback such as how the project is performing and what are the expectations of the customer. From the past and current project customer feedback, we can predict the customer satisfaction expectation level of the customer for a new project (if the customer is same or similar and/or the project is same or similar). If we could come up with a way to map our customer satisfaction to the industrial benchmarks then it’s a win-win situation so that we can predict the current/future trend of customer satisfaction and act according to it.

The outcome of the thesis is the relationship between the customer satisfaction survey, survey results and software project metrics and a framework that is built so that the top-level management or project management can act accordingly. According to my knowledge this is first of its kind research in software industry.

1.5 Scope of the Thesis

The scope of the thesis is to identify the suitable customer satisfaction score calculation technique which is derived from the software project metrics. Thesis will be limited to proving the concept that the customer satisfaction can be identified from software project metrics and a tool is developed to prove the concept.

1.6 Thesis Outline

This document contains six chapters. The report is divided as follows.

a) Chapter 1 gives the background and motivation of this thesis. Followed by the problem statement of the research then the aims and research objectives which is going to be addressed by this thesis and finally the scope of the thesis.
b) Chapter 2 describes the literature review about the topics related to the thesis which includes what is customer satisfaction, customer satisfaction in the software industry, factors affecting the customer satisfaction, collection of customer feedbacks and how to measure customer satisfaction.
c) Chapter 3 describes the methodology of the thesis which discuss about the high-level approach of the final solution.
d) Chapter 4 explains the implementation of the final solution.
e) Chapter 5 explains the evaluation of the final solution which includes empirical evaluation, theoretical evaluation and performance evaluation.
f) Chapter 6 contains the conclusion of the thesis.

Chapter 1 outlined the information and details regarding the software industry and type of projects in the software industry. Factors which lead to research idea, impact and importance of customer satisfaction and the problems faced by the projects in the software industry are explained in the subsequent sections. The outcome of the thesis and the advantages of the outcome is described in aims and objectives section. Chapter concludes with scope of the project followed by the format of the report structure.

Chapter 2
Literature Review

Topics related to thesis is discussed in the Chapter 2 such as customer satisfaction, details of customer satisfaction in software industry, factors affecting the customer satisfaction, customer feedback collection techniques and customer satisfaction measurements. Customer satisfaction section discuss about the importance of the customer satisfaction, factors lead to the introduction of the customer satisfaction and components of customer satisfaction. Customer satisfaction in software industry section explains the current situation of customer satisfaction in IT industry and factors contributing towards the customer satisfaction in software industry. Factors which affects the overall customer satisfaction is listed in factors affecting customer satisfaction section. Different techniques of collection of feedback is listed in collection of customer feedback section. How to measure customer satisfaction section explains the various methods of calculating customer satisfaction.

2.1 Customer Satisfaction

The definition of customer satisfaction is broad, that it is the estimation we utilize to evaluate the degree to which a client is fulfilled with a product and/or service. In general, nowadays this could be executed by utilizing numerous distinctive overview plan strategies such as varying questions, overview reaction scales, and feedback collection methods. Now and then we collect these measures right after a transaction, or at a settled date in the client relationship. Sometimes we utilize a five-point Likert scale, and in some cases, we utilize a Net Promoter Score (NPS) survey. The point of all this is to degree how a client feels about a brand interaction. On the off chance, if you do not measure the delight of your customer, you can’t recognize who happy and unhappy clients are [9]. If you do not know who is unhappy customer(s) then you do not know who will churn. If individual customer churn speedier than obtaining new clients, then your business will fail.

Organizations outlive in a competitive situation and have higher client delight which are providing value to their clients [10]. Money related execution has high critical implications when the client delight is high. Evidence shows that customer satisfaction surveys are effectively used in organizational decision-making process [11]. Consumption of survey data depends on the statistical analysis of the data. Different organizations use different methods of collecting surveys and customers also have their own preferences. As Jaakko and Tuamas emphasis in the paper [10], there exist methods for collecting customer satisfaction surveys and measuring the customer satisfaction. but there is no any pre-defined framework where an organization could follow. International standards like International Standard Organization (ISO) 9001 strictly advices to have customer satisfaction surveys. In contrast, customers measure their delight based on the golden triangle where they expect the project to end on time while meeting both the cost and scope which is not realistic.

However, Ofer in the paper [12] mentions that the different customers pay attention differently towards meeting schedule, meeting cost and meeting the scope of the project. Most of the clients may concur to amplify the project's duration and increment its budget, as long as it accomplishes its target(s). Index of Consumer Satisfaction by the US Department of Agriculture is the first report on customer satisfaction [13]. According to that, the effects of expectation, disconfirmation and performance have impact on customer satisfaction. Further the authors Claes et al of journal [14] identified several attributes which contributes towards the customer satisfaction and outcome of customer satisfaction.

There are three dominating factors for customer satisfaction: perceived quality, perceived value and customer expectations which are having a devote and positive intend towards the customer satisfaction. Perceived quality is the assessment of the recent involvement of consumption familiarity. Perceived quality determined by the two primary components: 1) Customization and 2) Reliability. Customization is the level to which venture's products and services are customizable to meet clients' needs and wants. Reliability is the unit of measure of the dependability of the products and services of a firm. Perceived value is the quality of the product or service correspond to the amount paid [15]. The three dominating factors are interconnected that positive perceived quality have a positive impact on perceived value and positive customer expectations have positive impact on both perceived quality and perceived value positively.

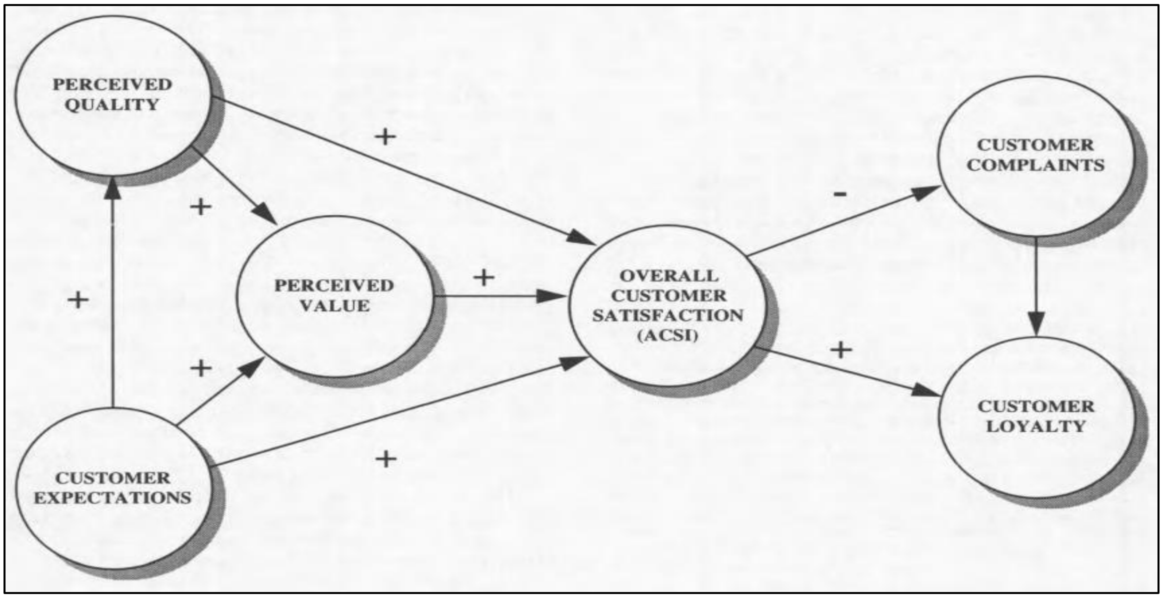


Figure 2-1 : The American Customer Satisfaction Index model

Source: [14]

The yield of customer satisfaction has influence on two crucial elements of an organization: 1) Customer Loyalty and 2) Customer complaints [16]. Customer loyalty is the degree of how a customer is willing to do the business or continue the business with the firm. Customer complaints are the measure of disappoint of customer(s) regarding the product and/or services of the company. The positive customer satisfaction will increase the customer loyalty towards the products and services of the corporation while decreasing the customer complaints. Alternatively, when the customer satisfaction decreases then the customer loyalty will go down and increase in customer complaint, even worse contributes further to customer defection.

Client satisfaction is the finest marker of how likely a client will buy products and services of the organization in future. Asking for a customer satisfaction score/index from a customer will reveal the chances of that he/she will ended up rehash clients or indeed advocates [17]. Higher customer satisfaction will reduce the number of customer churn. Recent study on customer satisfaction has revealed that the customer(s) with high customer satisfaction contribute to revenue 2.6 time more than a somewhat satisfied customer(s) and interestingly they contribute 14 time more towards revenue than customer(s) with low customer satisfaction.

2.2 Customer Satisfaction in Software Industry

A company which belongs to the software industry either product based or project based. Their ultimate goal is to retain old customers as much as possible while gaining new customers, since losing an old customer and acquiring new customer is costlier than retaining an old customer. Some software products are made to cater international clients and some are tailor made. In whichever the situation, the product must satisfy the needs and wants of the international customers while adhere to international quality standards. The competition in the software industry is very high and filled with neck to neck competition. Client delight in software industry is specifically proportional to development of the business as well as it improves the brand picture in the industry.

In the paper [18], Fatima and Deva claim that the client delight can be achieved by combining fulfilment of the needs and wants of the customer while maintaining the ultimate international quality standards by consolidating the quality parameters with the customer oriented software development which fulfills the needs and wants of the customers. The client delight ought to be incorporated in software industry before sales of the product/service, during sales of the product/service and after sales of the product/service.

It is reported that mature behavioral marketers in Business to Business (B2B) companies have bagged their 42% sales pipelines via marketing sourced, while their Business to Customer (B2C) counterparts recorded 47%. Both are significantly higher than the normal which is 35% and 41% respectively [19]. It is evident that the improvement of business of software industry defined by the continual estimation of customer satisfaction because the client delight is directly proportional to the expansion of the business and crucial in building the brand image of the software industry.

Table 2-1 : Hypothesized impact of the seven factors on customer satisfaction

Factors	**Overall Impact**	**Network products**	**Mainframe products**	**Expert users**	**Novice Users**
Capability	+			+	
Usability	+				+
Performance	+	+	+		
Reliability	+	+	+	+	
Installability	+				
Maintainability	+	+	+		
Documentation	+				+

Source: [20] +: Expected

Table 2-1 explains the factors impacting on customer satisfaction for network and mainframe products in the software industry and the impact on the expert and novice users. Even though there are other factors which contributes to the customer satisfaction, significant seven factors which drives customer satisfaction in different customers and product segments is identified [21]. Definition of seven factors are given below-

- **Capability**

  The factor calculates gages of the client delight with the functionality of the products in terms of the key highlights offered in the products. Since customers may utilize the same software for a variety of usage, extend of appropriateness of different modules of the product are considered vital. The measure represents the capability relative to customer needs and wants.

- **Usability**

  Usability can be progressed by "instinctive nature" of the user interface. Clients create a negative demeanor towards a system on the off chance when they discover it is difficult to use. The usability measure reflects the intrinsic usability of the software.

- **Performance**

  In software products, the response time for an operation is a critical attribute for the end user. Despite the different client base with shifted hardware configurations and application needs, more noteworthy processing ability is wanted by all end users. Performance is a vital in multi user environments. Efficient usage of hardware equipment such as central processors, communication units and storage unit is necessary to accomplish superior performance in software products.

- **Reliability**

  The reliability assesses the degree of disturbance by failure at the customer perspective. Customers were coordinated to base their reactions on the frequency of disturbances as well as the time taken to settle the disturbance. Hence the measure is composite evaluation of two basic measures.

- **Installability**

  With expanding complexity of the software, the clients may discover establishment repetitive and cumbersome. Regularly, clients spend significant time looking for help from support sites. The installability degree surveys the ease with the product which clients have introduced at their premises.

- **Maintainability**

  Varieties in customer specified requirements, individual programmer productivity, and frequent design plan changes cause defects in the software products. Great error detection and error correction procedures are basic to play down the disturbance of service at the client end. The maintainability measure reflects the quality of fixes, vendor service, and error correction procedures.

- **Documentation**

  Reports such as design charts, test reports, common product descriptions, and client manuals are offered with software products. Significant amount of time is expended to guarantee that the documents are outlined to provide some data on software capabilities. Good documentation is a basic figure in ensuring the efficient utilize of the product, particularly in the case of amateur clients.

Researchers Sunder et al [20] has proven that among the seven influencing factors, capability and usability which is nearly followed by performance are the vital factors which contributes to the customer satisfaction in the software industry. It is also evident that from deciphering client feedback data, showcase important data for computer program architects and project managers to capture.

Most of the companies in software industry has offshore team(s). An outsourcing to the exceptional far off area with the noteworthy distinction in time and all the related aces and cons of such choice like lower cost and culture distinction. Writers Jonathan et al of the conference paper [22] have seen an increase trend in offshoring IT and business processes of software organizations. Through the seller or company-owned benefit center, a company can empower the business to accomplish scale in faculty abilities and specialized assets via outsourcing and shared services. This will enable to eliminate repetitive assets and improve quality by drawing in and holding the skilled assets which will eventually results cost reduction. To increase the customer satisfaction in software industry it is recommended to do offshoring which also improves the cost reduction and improve the quality of the products and services.

2.3 Factors Affecting Customer Satisfaction

Client delight is established when a brand does a bang-up job in achieving the requirements and desires of customers. The variables which are dependable to make fulfillment among the clients for a brand can be identified by the factors affecting the customer satisfaction of a brand. The customer services and price fairness plays a major role is defining the customer satisfaction of a brand [23]. Customer services is the set of activities which includes how the customer support system works, handling complaints, at which speed complaints are handled and report generation out of them. Prices fairness is the level of customers assessments regarding the organization's price for products and/or services are reasonable compared to the counterpart and the quality of service provided. Being individual variables, both the customer services and prices fairness contributing much towards customer satisfaction while complementing each other. Customers with positive customer satisfaction will have positive word of mouth with other consumers.

What can be indifferent for an organization than an unsatisfied customer viva voce their experience with the other customers. It is estimated that 95% of customers talk about their bad experience with others which is illustrated as they tell 15 people about their negative client encounters, versus the 11 people they will tell about their positive experiences. According to the post [24], 91% of clients who had a terrible client encounter won't will to trade along with the company again. It takes 12 positive client encounters to form up for one negative involvement. If an organization wants to increase their profit anywhere between 25% to 95% then they just have to increase the customer retention by 5% [25]. Above all points explains one thing, that the company ought to contribute intensely in measuring client fulfillment over time and work reliably to allow superior benefit.

2.4 Collection of Customer Feedbacks

Client delight surveys empathies the bits of knowledge you require to make management decisions. In recent study conducted on client delight have found that businesses who measure client delight are 33% more likely to depict themselves more fruitful than those who do not. A client delight survey will offer assistance to get customers likes, dislikes and most importantly where the business require to make improvements. Even you can win back customers who have halt trade with you by conducting client delight surveys and discover how you can avoid client misfortunes in the future [26]. Via customer feedback, we can empower employees to meet milestones which are based on client needs. In case if you are creating a new product or updating an existing product, clients can give you with priceless criticism about the design and functionalities. Oftentimes clients will point out the issues that would have missed by the business [27].

There are various forms of collecting customer feedback such as,

1. Quick chat with the customer
2. Through email
3. Usability testing
4. Via Analytics
5. Anonymous comment/Suggestion box
6. Customer delight surveys forms

The basic and old style of collection of customer satisfaction is via exploratory customer interviews. This method is the most underrated one. Customers are humans. Business deal is between companies but interactions are between humans. The best way to understand a human is to talk to them. We can gain contextual information (which lacks in other survey methods) via a quick chat with a customer.

Most valuable ways to gather candid customer feedback is using email [28]. People are busy and they sometimes will not respond to mail. But we can ensure that we can maximize the channel’s effectiveness by following simple rules. By adding a clause to the mail saying “Thanks for your valuable time. We will get back to you as soon as possible” will ensure customer will respond to the email. The real problem arises when organizing the client feedback in a mail. The best way to organize a feedback mail is to use some organizing system (e.g. Trello). You can do lot more than organizing, even you can work on the suggestions given by the customers using an organizing system.

The best way to learn how a customer uses your product is to watch them using it through usability tests. That information is vital and invaluable. You give a task for the end user and sit in front of him/her. Record (Video and/or Audio) what he/she does with the service/product. It is that simple. But some customers (even most of us) does not like when someone is watching us while we do something. This method is very suitable if you are trying out some new thing (e.g. new sign in process).

Most products use analytics to track the pattern of usage of the product. This will reveal most used features of the product and least used features of the product. Even though we can’t gain straight feedback from the analytics, we can gain valuable insights from the analytics of individual customer analytics.

Let’s say you don’t want to get specific survey results but you want to get suggestions to improve the product, and customers may be willing to give suggestions/improvements for the product which business may have not captured in the survey. For a situation like this, feedback/suggestions boxes come in handy. When you are waiting at cashier counter at a departmental store you might have seen that there is a box with the label “Suggestions”. The same concept is applied when selling products/services.

The most effective way of receiving client delight feedback is feedback surveys [29]. Creating a useful customer delight survey is not an easy task. You can conduct a short survey. Generally, let the user test your product for several times and present them with the short survey asking about the experience. Another method is conducting a long survey. But we must be mindful when doing a long survey. When collecting client delight surveys, we should make sure that surveys are designed in a way that questions are clear and on point. Be clear or be specific on what you are asking from them. Specific targeted questions will make easy to identify areas which can be improved based on the answers. Asking one general question and asking multiple specific question about an area have loads of difference. If you are asking several specific questions about a general topic then you will gain loads of data to analyze and act on.

Table 2-2 : Effectiveness of customer feedback collection tools

Collection tools	**Multi-Level Measurement**			**Actionable**	**Representative, Reliable**	**Potential for Service Recovery**	**First Hand Learning**	**Cost Effective**
	Service Satisfaction	Process Satisfaction	Specific Feedback					
Focus Group Discussions	○	◍	●	●	○	○	●	◍
Annual Survey on overall satisfaction	●	◍	○	○	●	○	○	○
Mystery Shopping (service testers)	○	○	●	◍	○	○	○	○
Service Reviews	○	◍	●	●	○	●	●	◍
Online feedback system	○	◍	●	●	○	●	◍	●

Source: [30] Meet requirements: Fully ● Moderate ◍ Little/Not at all ○

Table 2-2 explains the effectiveness of the customer feedback collection tools. The table depicts whether each of the feedback collection tools (rows) meet the feedback collection requirements (columns) fully or moderately or little/not at all.

Recent studies [31] have showed that there is a new trend in collecting customer feedback. Social media platforms like Facebook, Twitter, and LinkedIn have become popular source of customer feedback as they are globally visible and transparent with 59%. The next place is for online surveys with 54% followed by Telephone interviews with 34%, followed by inbound emails via the website with 27% and the list grows.

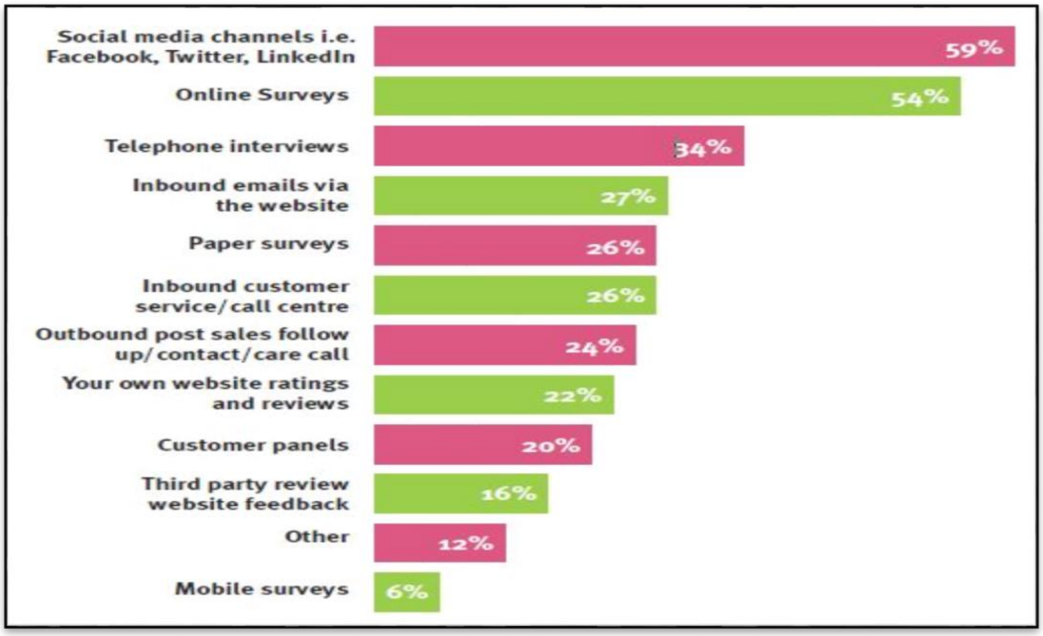


Figure 2-2 : Usage of feedback collection tools 2017

2.5 How to Measure Customer Satisfaction

If customer feedback collection is hassle job then measuring the customer satisfaction is more hassle than that. In the article [32], David and Charles describe not to measure customer satisfaction, instead the authors recommending to use customer perceived value. But there is no theoretical/practical proof that customer perceived value can be used instead of measuring customer satisfaction. Following are the some of the customer satisfaction calculation techniques [33].

2.5.1 Customer Satisfaction Score

The old school method of measuring customer satisfaction is Customer Satisfaction Score (CSAT). very unsatisfactory/unsatisfactory/neutral/satisfactory/very satisfactory are the sample scale values. Customer satisfaction score is appropriate to small changes or new process/product/service. Customer satisfaction score is quick since the organization will get exact input relative to product and services it offers. It is flexible because it represents any interactions between the firm and the customer. Customer Satisfaction Score is not a complete one since it will not reflect the overall picture of the company by the customer.

2.5.2 Net Promoter Score

Net Promoter Score (NPS) is introduced to overcome the incompleteness of the Customer Satisfaction Score. Net promoter score is calculated by the sum of difference between the percentages of promoters and distractors. Net promoter score has predictive power.

2.5.3 Customer Effort Score

Calculation of Customer Effort Score is different from Customer Satisfaction Score and Net Promoter Score since both CSAT and NPS follow the ‘higher the score, the better’ principle while ‘lower the score, the better’ principle is followed in Customer Effort Score. It is calculated based on the effort put on by the customer to get a job done. Customer loyalty can be increased by focusing on improving the Customer Effort Score.

2.5.4 Composite Customer Satisfaction Rating

The Customer Satisfaction Score, Net Promoter Score and Customer Effort Score are influenced by the mood and emotional relationship (with the company/ company’s single point of contact(s)) of the customer [34]. Throughout the lifetime of a project, customer does not have a record of what project has accomplished and there can be many changes in customer contact point during the project duration. Therefore, the rating given by the customer does not reflect the actual image of the project. This can lead to a phenomenon called “rewarding the under performers and punishing the better performers” where a person (with high self-performance) who is working in a low rating project will get low hikes while a person (with low self-performance) who is working ins a high rating project will get better hikes.

The better and correct way of measuring the customer satisfaction would be through the software project metrics. Software project metrics does not influence by the mood/emotional relationship of the customer(s). It is un biased and will not change over time. Once the project metrics are defined and calculated, it is forever. There are numerous software project metrics for a project. Among them, there are five main important factors which contributes towards customer satisfaction having tangible and that can be measured objectively. Following five project metrics were identified as important factors which determines customer satisfaction by reverse-engineering the actual customer satisfaction score/index.

1. Quality

Quality is closely associated with the defects in the system. It is not that always a product is shipped with defects. But it is mostly discovered after it is delivered to the client. Some defects are tolerable by clients. They will live with it.

2. On-time Delivery

Clients expect their product to be delivered within the said day. Because of this, companies tend to compromise on quality rather than delay in delivery since customers will accept product with defect but not product with delay.

3. Price

Customers like when the price of their software product is low and no vendor can bill their customer high amount than agreed in the purchase order. But usually purchase order are made based on hourly rate with some variance allowed on either side.

4. Issue Factor

Issues arises when there is lack of understanding of requirements or lack of clarity in the specifications or conflicts in requirements. Customer satisfaction will get affected if the raised issue is due to improper understanding of the requirements by the software company.

5. Accommodation and Cooperation

During the project duration, the company will get loads of change request from a customer. Change request have impacts on delivery schedule and the cost because it is an extra work for the software company. Most of the time vendor absorbs both, sometimes vendor absorbs the cost but let the client to absorb the delivery schedule. Rarely vendor absorbs delivery schedule and pass the price to the customer.

Chapter 2 described the customer satisfaction, details of customer satisfaction in software industry, factors affecting the customer satisfaction, customer feedback collection methods and customer satisfaction measurements. The importance is given to individual factors contributing towards customer satisfaction and factors affecting the customer satisfaction. Detailed explanation of customer satisfaction measurements is given in the last section of the chapter.

Chapter 3
Methodology

Chapter 3 describes the methodology of the thesis. High level approach and high-level design in explained in the high-level design of the proposed solution section. Proposed solution section depicts the individual steps in high-level design in detail. Rest of the sections define the suitable customer satisfaction measurement for proof of concept and how proof of concept is developed.

3.1 High Level Design of the Proposed Solution

To make progress in the research we should find the customer satisfaction survey details as mentioned in the Chapter 2. After gathering the necessary data, it should be processed so that only needed information is extracted while unnecessary details are omitted. From the collected information and history data, we should be able to find the relation between the collected data and current/upcoming trend of the customer satisfaction. Information such as on time delivery metrics, features/components delivered, defect (Development (DEV), Quality Assurance (QA), User Acceptance Testing (UAT), Post production) related metrics, customer satisfaction score, project cost details, issue details etc. are collected. Some of the metrics are already developed metrics and some of the metrics will be developed (Such as Cooperation Rating, Issue Rating, Price Rating and Delivery Rating) during the research to support the proposed concept and to declare the output of the proposed concept.

Following will be the major steps of the research which will result in the customer satisfaction framework concept.

- Data preprocessing and produce information.
- Find the relation between the information and software project metrics.
- Predict past, present trends.

- Suggest improvement/suggestions that can be made to the project to achieve high customer appreciation and grow in fortune.

3.2 Proposed Solution

Figure 3-1 contains the high-level architecture for the proposed system. The gathered data is stored in two databases where one is master and other one is slave. The reason for using two databases is to ensure availability and partition tolerance. Gathered data is collected from master database and transformed into the form which is needed by analytical process. Transformation is mostly done by the Extract Transform Load (ETL) process. At the end of ETL process, the intermediate result is given for data mining. Data mining can be done by tools such as Microsoft SQL server, WEKA etc. Data mining and data mining tools are not discussed in this paper since the focus of the thesis is not much deeply into data mining. The focus is to first to come up with the framework for customer delight process and then the second phase can be enhanced with data mining.

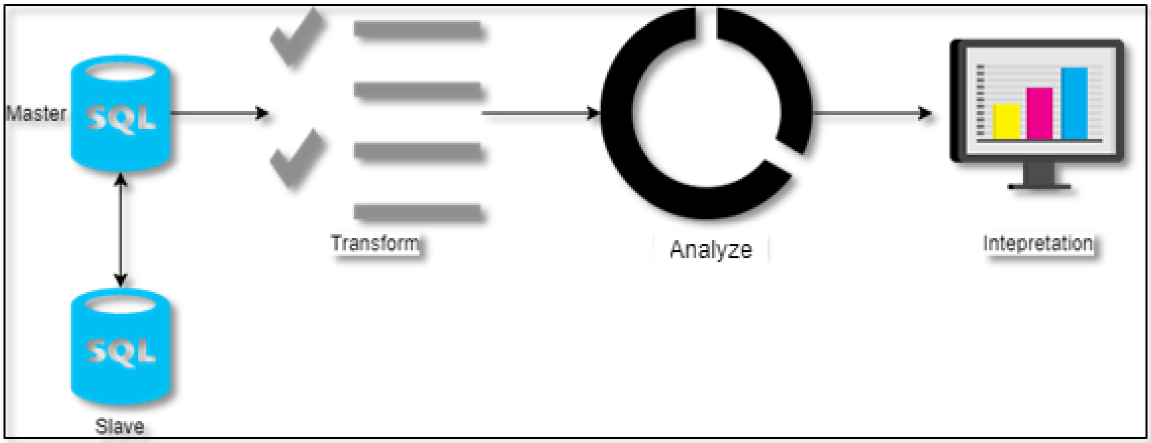


Figure 3-1 : Proposed architecture

The customer satisfaction framework concept will follow proper design patterns, software architecture patterns and produce a piece of world class art of software engineering. The detailed implementation information will be provided during the implementation phase.

3.3 Identifying Suitable Customer Satisfaction Measurement for Proof of Concept

There are numerous ways for measuring the customer satisfaction. Apart from Composite Customer Satisfaction Rating, other measurements are either noncomplete measurements or influenced by the mood/emotional relationship of the customer. Therefore, they cannot be taken for proof of concept and they do not derive from the software project metrics. The suitable candidate measurement for the proof of concept is Composite Customer Satisfaction Rating because the calculation is based on five important software project metrics (Quality, On-time delivery, Price, Issue factor and Accommodation and cooperation) and the rating does not get affected by the mood/emotional relationship of the customer.

3.4 Developing the Proof of Concept

In order to prove this research proposal actually contributes towards software project(s), a tool called "CDI Validation Tool" is developed. The software project metrics and customer satisfaction rating/score from the motivation example stated in the Chapter 1 will be used to prove this concept is applicable for real software project(s) in any organization. To calculate the Composite Customer Satisfaction Rating, individual ratings (Quality, Delivery, Price, Issue and Cooperation) should be identified and calculated. Following sub sections explains the calculation of individual ratings and Composite Customer Satisfaction Rating.

3.4.1 Quality Rating

Quality Rating of the project is determined by the quality of the project. When the author is saying “Quality”, it refers to the defect(s) in the product/service. To find the quality rating, the number of defects predicted in the project is to be contrasted with the actual number of defects introduced in the project should be considered. In general defects are classified into three categories critical, major and minor. Following is the formula to compute the quality rating of a software product.

Quality Rating = (Actual Defect Density – Accepted Defect Density) / Accepted Defect Density.

Defect density is the defects which is found per unit size. Lines of Code (LOC) or Function Point (FP) is the size measurement for defect density. Actual defect density is the defect density of the system due to actual number of defects. Accepted defect density is the agreed threshold value of the defect density. Quality rating will be negative if the actual number of defects are less than the accepted number of defects which hints that the client satisfaction is exceeded. Quality rating will be zero if the actual number of defects are equal to the accepted number of defects which hints that the client expectations are met. Quality rating will be positive if the actual number of defects is more than the accepted number of defects which hints that the client satisfaction is not met.

3.4.2 Delivery Rating

Delivery Rating is always associated with the on-time delivery of the promised items on agreed date. Organizations oftentimes compromise on quality of the item(s) delivered instead of compromising the delivery date since customer(s) get hindered when the delivery is delayed. Following is the formula to compute delivery rating of a software product.

Delivery Rating = (Actual Days taken for the delivery – Accepted Days for delivery) / Accepted days for delivery.

The difference between the days of actual delivery date and the date specified on the purchase order is known as the actual days taken for the delivery. The difference between the days of predicted delivery date and the date specified on the purchase order is known as the accepted days for delivery. Delivery rating will be negative if the actual delivery date is before the accepted delivery date which hints that the client satisfaction is exceeded. Delivery rating will be zero if the actual delivery date falls on the accepted delivery date which hints that the client satisfaction is met. Delivery rating will be positive if the actual delivery date is beyond the accepted delivery date which hints that the client satisfaction is not met.

3.4.3 Price Rating

Customer will be dissatisfied if the software firm asks them to pay additional money than the amount which is specified in the purchase order which directly influences the customer satisfaction rating/score. It is a known fact that client will be satisfied when the organization charges less money than the sum indicated on the purchase order. Following is the formula to compute price rating of a software product.

Price Rating = (Actual amount billed – Price on the purchase order) / Price on the purchase order

Price rating will be negative if the value paid is less than the amount stated in the purchase order which hints that the customer satisfaction is exceeded. Price rating will be zero if the value paid is equal to the amount stated in the purchase order which hints that the customer satisfaction is met. Price rating will be positive if the value paid is greater than the amount stated in the purchase order which hints that the customer satisfaction is not met.

3.4.4 Issue Rating

Issues are raised for unclear requirements or improper understanding of the specifications. Customer satisfaction does not get affected if the issue is raised by software company which is accountable by the customer. Customer satisfaction will get affected if the requirements or specifications are not well understood by the software vendor. Issue rating depends on the issue density. Following is the formula to compute the issue density of a software product.

Issue Density = Number of issue raised / Software size

LOC, FP are the software size that can be used to find the issue density. Following is the formula to compute the issue rating of a software product.

Issue Rating = (Actual issue density – Standard issue density) / Standard issue density

There is no universal accepted issue density therefore organizations must define their own standard issue density. Issue rating will be negative if the issue density of the project is less than the standard issue density which hints that the customer satisfaction is exceeded. Issue rating will be zero if the issue density of the project is equal to the standard issue density which hints that the customer satisfaction is met. Issue rating will be positive if the issue density of the project is greater than the standard issue density which hints that the customer satisfaction is not met.

3.4.5 Cooperation Rating

Clients will be happy if the change request made are attended without altering the delivery schedule or cost. But always this cannot be accommodated by the software firm. Following is the formula to compute cooperation rating of the software product.

Cooperation Rating = (Number of change request received – Number of change request implemented without affecting delivery date or cost) / Number of change request received

Cooperation rating will be zero if the total number of change requests received is equal to the total number of change requests implemented without any alterations either to delivery date or cost which hints that the customer satisfaction is met. Cooperation rating will be positive if the total number of change requests received is greater than the total number of change requests implemented without any alterations either to delivery date or cost which hints that the customer satisfaction is not met. Good point to note here is that there is no way of exceeding the customer satisfaction because always the change requests affects the delivery date and/or cost.

3.4.6 Composite Customer Satisfaction Rating

Composite Customer Satisfaction Rating depends on the ratings (Quality rating, Delivery rating, Price Rating, Issue Rating, Cooperation Rating) we have calculated above. All the ratings do not weigh equally and the weight may vary from customer to customer and /or organization to organization. Individual customer or organization can define their desired weight for each of the rating but sum of them should be equal to 1. Following is an example weight.

Table 3-1 : Composite Customer Satisfaction Rating Weights

Rating	**Weight**
Quality Rating	W1 = 0.35
Delivery Rating	W2 = 0.30
Price Rating	W3 = 0.25
Issue Rating	W4 = 0.05
Cooperation Rating	W5 = 0.05
Total Weight	**1.00**

The following is the formula to compute the Composite Customer Satisfaction Rating of a software product.

Composite Customer Satisfaction Rating = 5 – ((Quality Rating * W1) + (Delivery Rating * W2) + (Price Rating * W3) + (Issue Rating * W4) + (Cooperation Rating * W5))

The above formula gives rating in a 5-point scale. If the rating is less than 5 then the customer expectations are not met. If the rating is equal to 5 then it implies that customer expectations are met. If the rating goes beyond 5 means that customer expectations are highly achieved.

Methodology chapter defined the high-level architecture of the proposed architecture explaining the individual steps in proposed architecture. The next section rationalized the reasons behind the choose of Composite Customer Satisfaction Rating formula as the measure for proof of concept and the chapter ended with explanation of building blocks of Composite Customer Satisfaction Rating formula.

Chapter 4

Implementation

Chapter 4 implementation explains the architectural implementation of database and application structure. Data extraction section describes the individual steps in data extraction and database architecture. Features and individual components of the CDI Validation tool is explained in CDI Validation Tool section.

4.1 Data Extraction

The first step is to gather all the required information to prove the concept is correct. The prove of concept will be done using the information gathered from Virtusa Corporation systems. The dataset collected will be before 01-01-2019 because customer satisfaction score will not be available for the FY19Q4 (January 2019, February 2019 and March 2019) at the time of this thesis. Microsoft SQL Management Studio is used to access, configure, manage, administrate the Microsoft SQL server and Microsoft SQL Server is used to extract, store and process data.

All the information will be based on the projects created in the Chorus+. The source of the Chorus+ projects is the financial projects created in the '*Velocity*' which is the Enterprise Resource Planning (ERP) system of Virtusa Corporation. Chorus+ projects are considered as execution projects. Therefore, always the information will be referred to Chorus+ projects and Velocity projects. As mentioned in the Chapter 1, customer satisfaction score is received for each financial quarter. From vPoint Database (DB), following attributes are extracted: internal project id of the Chorus+, customer satisfaction score and financial quarter. Customer satisfaction score is already calculated and stored in the database for each project quarter wise.

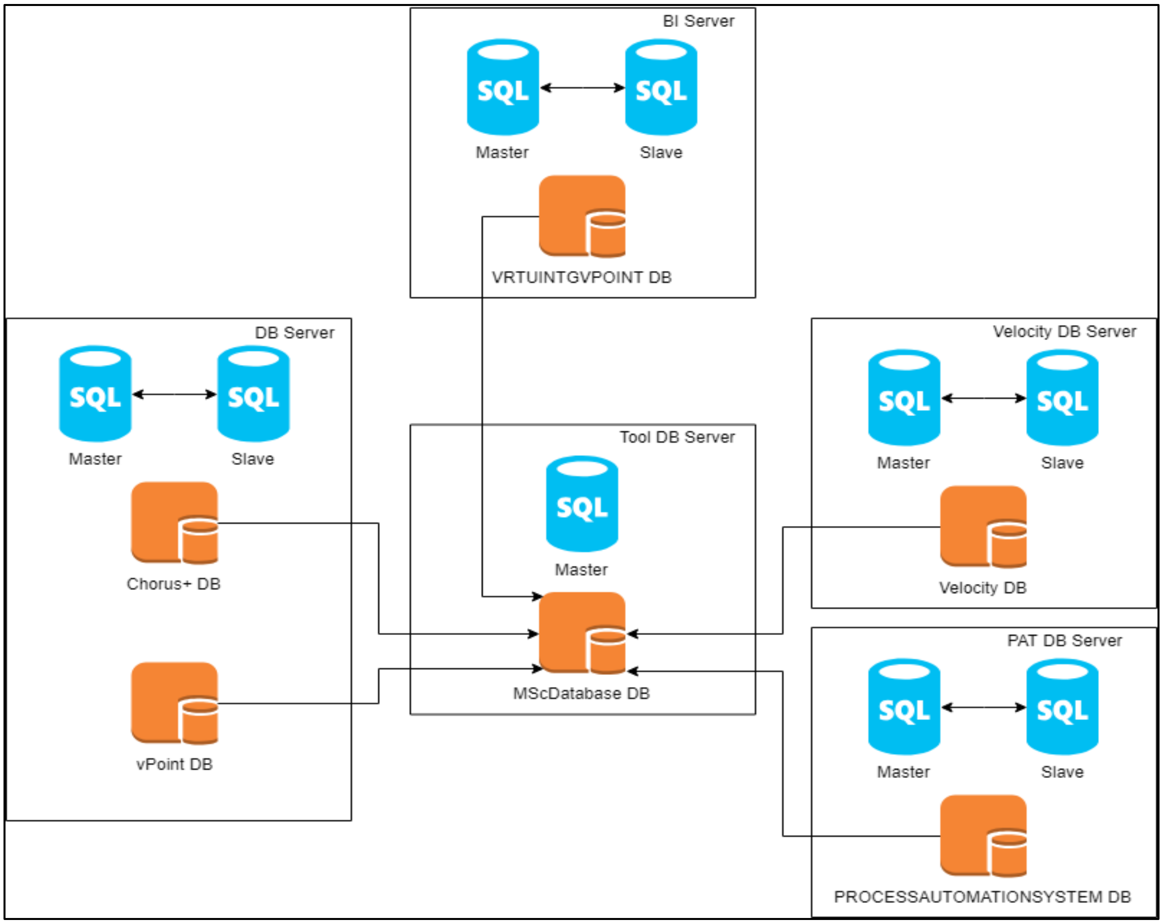
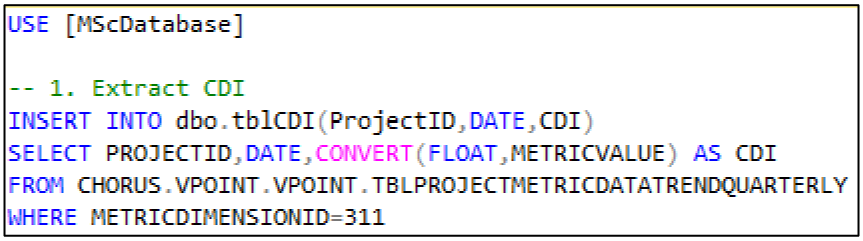


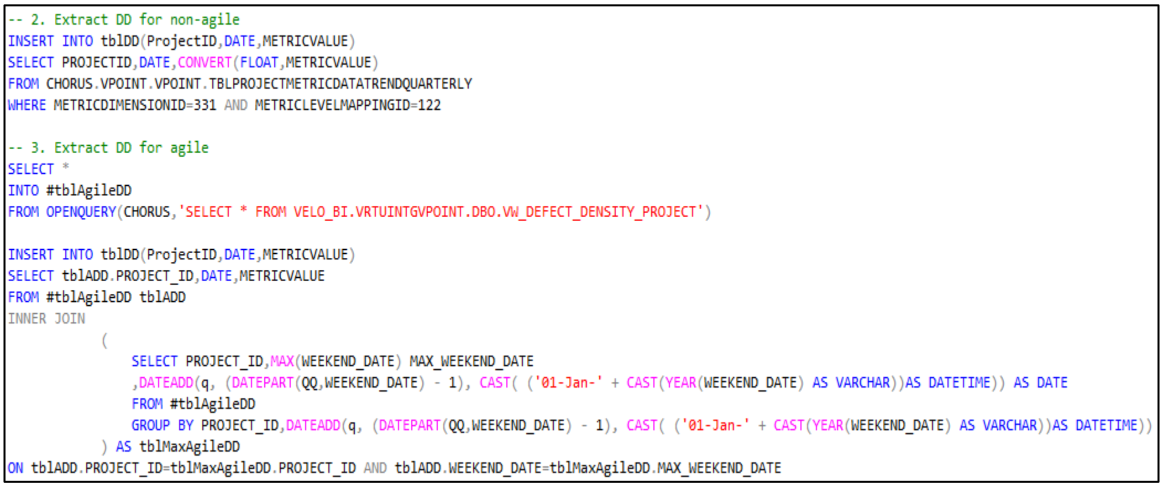
Figure 4-1 : High-level database architecture of the CDI Validation Tool



```sql
USE [MScDatabase]

-- 1. Extract CDI
INSERT INTO dbo.tblCDI(ProjectID,DATE,CDI)
SELECT PROJECTID,DATE,CONVERT(FLOAT,METRICVALUE) AS CDI
FROM CHORUS.VPOINT.VPOINT.TBLPROJECTMETRICDATATRENDQUARTERLY
WHERE METRICDIMENSIONID=311
```

Figure 4-2 : Extract CDI values of the projects

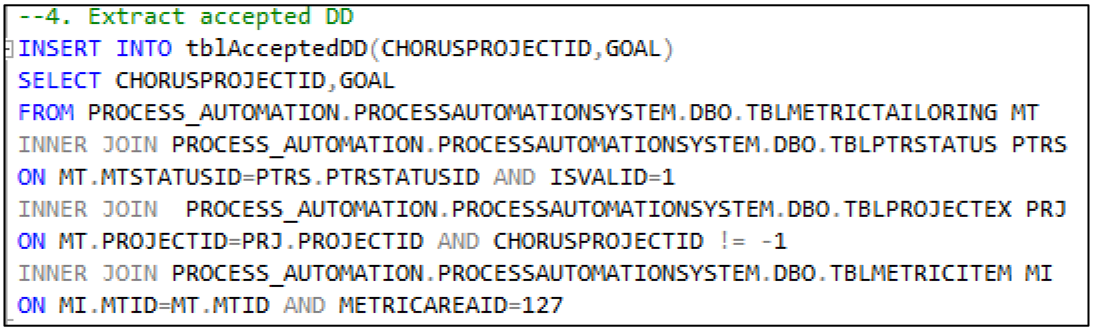
Chorus+ supports projects which follows traditional waterfall method and as well as it supports projects which follows Agile methodology. To find the quality ratings of the project, the actual defect density and accepted defect density of the project is needed. Actual defect density of projects which follows the waterfall methodology is extracted from vPoint and the actual defect density of projects which follows the agile methodology is calculated from Business Intelligence (BI) Platform of Virtusa Corporation. For actual defect density, following attributes are extracted: internal project id of Chorus+, financial quarter and the actual defect density of the project. Actual defect density of the project is calculated based on the commonly accepted defect density formula and stored on the database for each project quarter wise.



```
-- 2. Extract DD for non-agile
INSERT INTO tblDD(ProjectID,DATE,METRICVALUE)
SELECT PROJECTID,DATE,CONVERT(FLOAT,METRICVALUE)
FROM CHORUS.VPOINT.VPOINT.TBLPROJECTMETRICDATATRENDQUARTERLY
WHERE METRICDIMENSIONID=331 AND METRICLEVELMAPPINGID=122

-- 3. Extract DD for agile
SELECT *
INTO #tblAgileDD
FROM OPENQUERY(CHORUS,'SELECT * FROM VELO_BI.VRTUINTGVPOINT.DBO.VW_DEFECT_DENSITY_PROJECT')

INSERT INTO tblDD(ProjectID,DATE,METRICVALUE)
SELECT tblADD.PROJECT_ID,DATE,METRICVALUE
FROM #tblAgileDD tblADD
INNER JOIN
            (
                SELECT PROJECT_ID,MAX(WEEKEND_DATE) MAX_WEEKEND_DATE
                ,DATEADD(q, (DATEPART(QQ,WEEKEND_DATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(WEEKEND_DATE) AS VARCHAR))AS DATETIME)) AS DATE
                FROM #tblAgileDD
                GROUP BY PROJECT_ID,DATEADD(q, (DATEPART(QQ,WEEKEND_DATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(WEEKEND_DATE) AS VARCHAR))AS DATETIME))
            ) AS tblMaxAgileDD
ON tblADD.PROJECT_ID=tblMaxAgileDD.PROJECT_ID AND tblADD.WEEKEND_DATE=tblMaxAgileDD.MAX_WEEKEND_DATE
```

Figure 4-3 : Extract Actual Defect Density of the projects

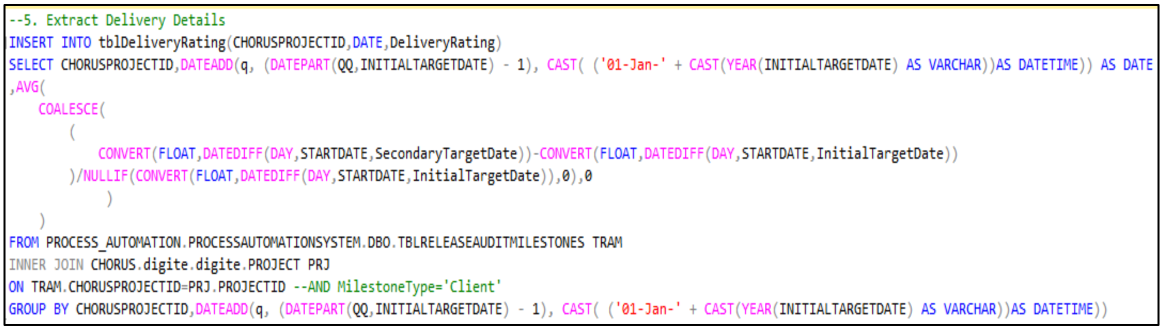
Accepted defect density of the project is defined in the Process Automation Tool (PAT) of Virtusa Corporation where project metrics, project process and project tools are tailored. For accepted defected density following attributes are extracted: internal project id of Chorus+ and the accepted defect density of the project. Project Manager of the project should declare the accepted defect density of the project based on the organizational average defect density values, experience of the project manager, experience of the project manager in the project and nature of the project.



```
--4. Extract accepted DD
INSERT INTO tblAcceptedDD(CHORUSPROJECTID,GOAL)
SELECT CHORUSPROJECTID,GOAL
FROM PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLMETRICTAILORING MT
INNER JOIN PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLPTRSTATUS PTRS
ON MT.MTSTATUSID=PTRS.PTRSTATUSID AND ISVALID=1
INNER JOIN  PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLPROJECTEX PRJ
ON MT.PROJECTID=PRJ.PROJECTID AND CHORUSPROJECTID != -1
INNER JOIN PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLMETRICITEM MI
ON MI.MTID=MT.MTID AND METRICAREAID=127
```

Figure 4-4 : Extract Accepted Defect Density of the projects

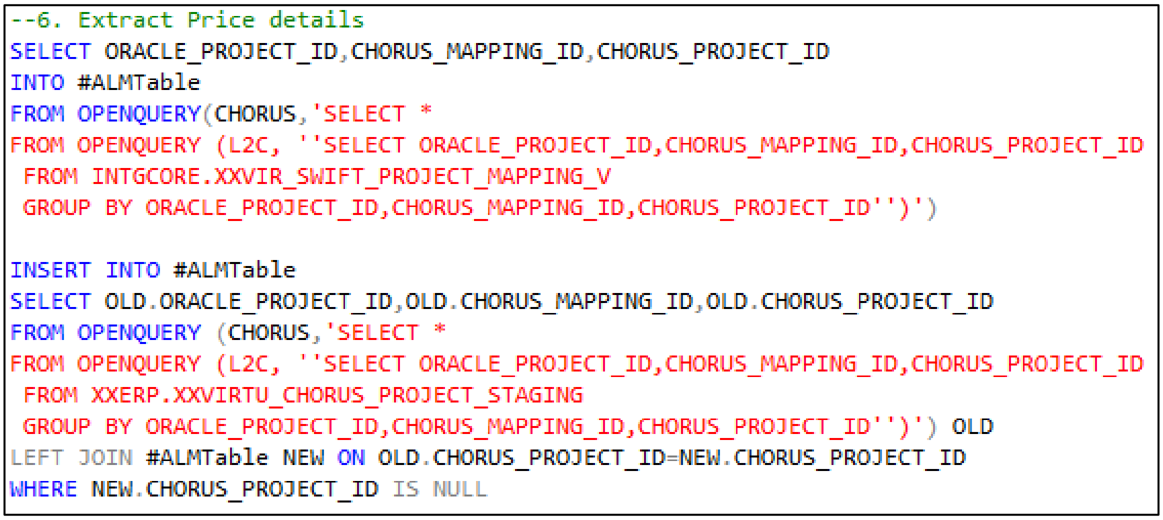
To find the delivery ratings of the projects, the accepted delivery dates and the actual delivery dates of the client releases are needed. The client release milestones are specified in Chorus+ and it is extracted by PAT for release auditing. Every client release undergoes an audit process and during the audit process checks are in place to check whether the release is capable of releasable to the client. Following attributes are extracted from PAT DB: internal project id of the Chorus+, initial target release date and the actual release date. Accepted delivery date is calculated based on the difference between the start date of the project and the initial target release date of the client release milestone. Actual delivery date is calculated from the difference between the start date of the project and the actual release date of the client release milestone.



```sql
--5. Extract Delivery Details
INSERT INTO tblDeliveryRating(CHORUSPROJECTID,DATE,DeliveryRating)
SELECT CHORUSPROJECTID,DATEADD(q, (DATEPART(QQ,INITIALTARGETDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(INITIALTARGETDATE) AS VARCHAR))AS DATETIME)) AS DATE
,AVG(
    COALESCE(
        (
            CONVERT(FLOAT,DATEDIFF(DAY,STARTDATE,SecondaryTargetDate))-CONVERT(FLOAT,DATEDIFF(DAY,STARTDATE,InitialTargetDate))
        )/NULLIF(CONVERT(FLOAT,DATEDIFF(DAY,STARTDATE,InitialTargetDate)),0),0
             )
    )
FROM PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLRELEASEAUDITMILESTONES TRAM
INNER JOIN CHORUS.digite.digite.PROJECT PRJ
ON TRAM.CHORUSPROJECTID=PRJ.PROJECTID --AND MilestoneType='Client'
GROUP BY CHORUSPROJECTID,DATEADD(q, (DATEPART(QQ,INITIALTARGETDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(INITIALTARGETDATE) AS VARCHAR))AS DATETIME))
```

Figure 4-5 : Extract Delivery Ratings of the projects

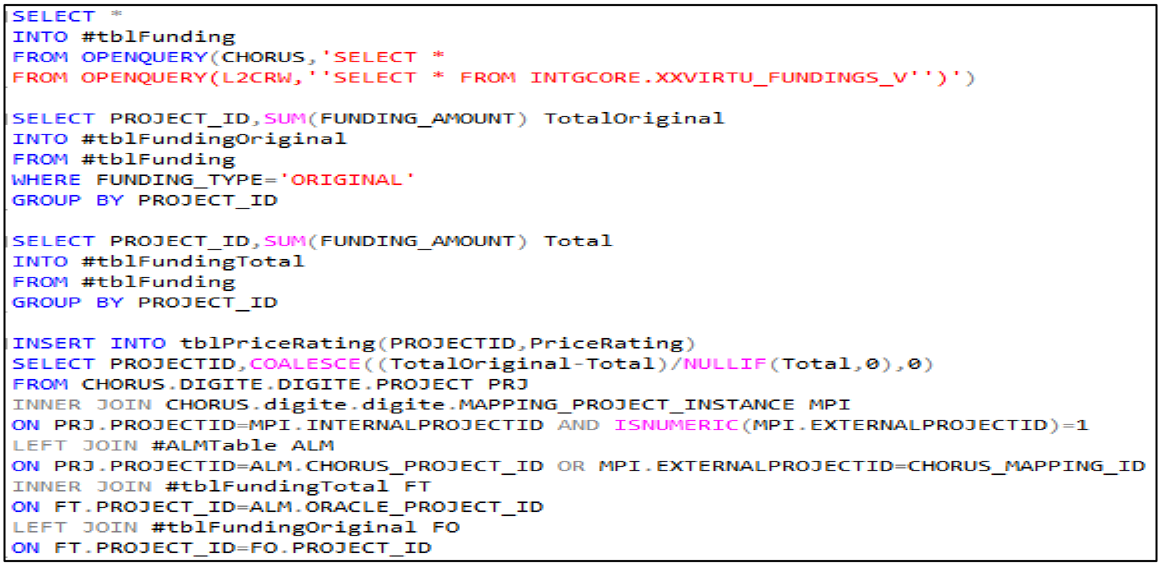
From the Velocity projects, following attributes are extracted: internal project id, external destination system project id, internal destination system project mapping id. From the Chorus+ projects following attributes are extracted: internal project id.



```sql
--6. Extract Price details
SELECT ORACLE_PROJECT_ID,CHORUS_MAPPING_ID,CHORUS_PROJECT_ID
INTO #ALMTable
FROM OPENQUERY(CHORUS,'SELECT *
FROM OPENQUERY (L2C, ''SELECT ORACLE_PROJECT_ID,CHORUS_MAPPING_ID,CHORUS_PROJECT_ID
 FROM INTGCORE.XXVIR_SWIFT_PROJECT_MAPPING_V
 GROUP BY ORACLE_PROJECT_ID,CHORUS_MAPPING_ID,CHORUS_PROJECT_ID'')')

INSERT INTO #ALMTable
SELECT OLD.ORACLE_PROJECT_ID,OLD.CHORUS_MAPPING_ID,OLD.CHORUS_PROJECT_ID
FROM OPENQUERY (CHORUS,'SELECT *
FROM OPENQUERY (L2C, ''SELECT ORACLE_PROJECT_ID,CHORUS_MAPPING_ID,CHORUS_PROJECT_ID
 FROM XXERP.XXVIRTU_CHORUS_PROJECT_STAGING
 GROUP BY ORACLE_PROJECT_ID,CHORUS_MAPPING_ID,CHORUS_PROJECT_ID'')') OLD
LEFT JOIN #ALMTable NEW ON OLD.CHORUS_PROJECT_ID=NEW.CHORUS_PROJECT_ID
WHERE NEW.CHORUS_PROJECT_ID IS NULL
```

Figure 4-6 : Extract Velocity project details

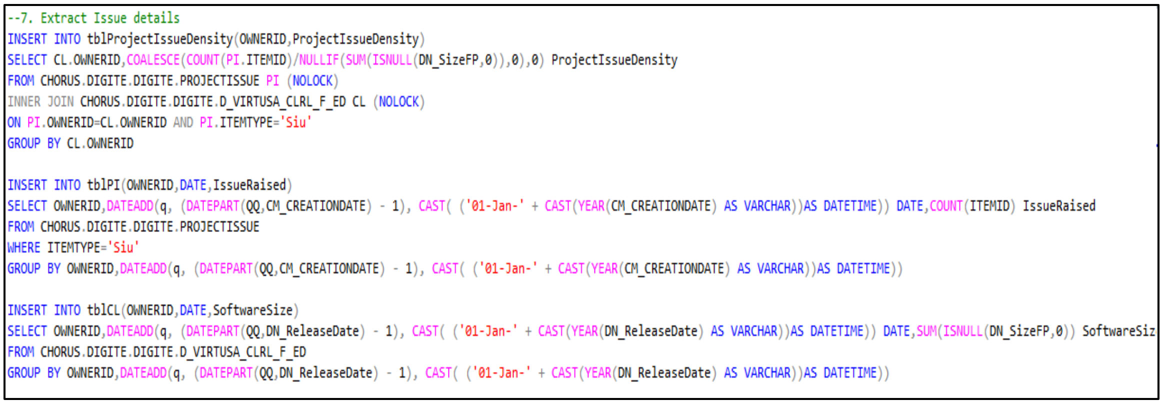
Cost is calculated for the financial project which is created in the ERP system. Therefore, the actual amount billed and the price on the purchase order is calculated from Velocity project. Following attributes are extracted from Velocity: internal project id and amount funded for the project. The actual amount billed can be found by adding the total of the attribute ‘amount funded’. Price on the purchase order can be calculated by summing up the ‘amount funded’ with the tag ‘Original’.



```
SELECT *
INTO #tblFunding
FROM OPENQUERY(CHORUS,'SELECT *
FROM OPENQUERY(L2CRW,''SELECT * FROM INTGCORE.XXVIRTU_FUNDINGS_V'')')

SELECT PROJECT_ID,SUM(FUNDING_AMOUNT) TotalOriginal
INTO #tblFundingOriginal
FROM #tblFunding
WHERE FUNDING_TYPE='ORIGINAL'
GROUP BY PROJECT_ID

SELECT PROJECT_ID,SUM(FUNDING_AMOUNT) Total
INTO #tblFundingTotal
FROM #tblFunding
GROUP BY PROJECT_ID

INSERT INTO tblPriceRating(PROJECTID,PriceRating)
SELECT PROJECTID,COALESCE((TotalOriginal-Total)/NULLIF(Total,0),0)
FROM CHORUS.DIGITE.DIGITE.PROJECT PRJ
INNER JOIN CHORUS.digite.digite.MAPPING_PROJECT_INSTANCE MPI
ON PRJ.PROJECTID=MPI.INTERNALPROJECTID AND ISNUMERIC(MPI.EXTERNALPROJECTID)=1
LEFT JOIN #ALMTable ALM
ON PRJ.PROJECTID=ALM.CHORUS_PROJECT_ID OR MPI.EXTERNALPROJECTID=CHORUS_MAPPING_ID
INNER JOIN #tblFundingTotal FT
ON FT.PROJECT_ID=ALM.ORACLE_PROJECT_ID
LEFT JOIN #tblFundingOriginal FO
ON FT.PROJECT_ID=FO.PROJECT_ID
```

Figure 4-7 : Extract cost details of the projects

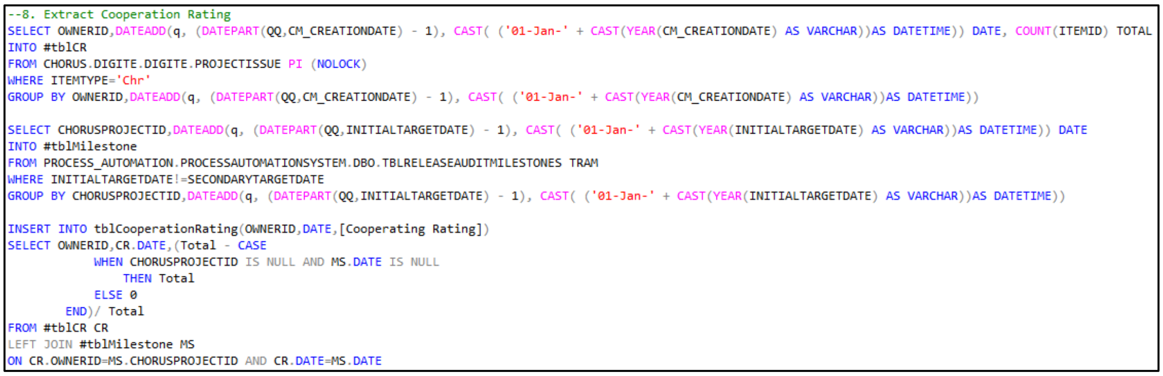
To find the issue rating of the projects, issue density of the projects should be calculated. Issue density is calculated from number of issue raised for the project and the software size for the project. Raised issues and the software size are specified for each client release are extracted from the Chorus+ DB. Actual issue density is calculated by dividing the total number of issues raised for a project by the software size. Standard issue density is calculated by averaging the total project issue density available at the organization.



```
--7. Extract Issue details
INSERT INTO tblProjectIssueDensity(OWNERID,ProjectIssueDensity)
SELECT CL.OWNERID,COALESCE(COUNT(PI.ITEMID)/NULLIF(SUM(ISNULL(DN_SizeFP,0)),0),0) ProjectIssueDensity
FROM CHORUS.DIGITE.DIGITE.PROJECTISSUE PI (NOLOCK)
INNER JOIN CHORUS.DIGITE.DIGITE.D_VIRTUSA_CLRL_F_ED CL (NOLOCK)
ON PI.OWNERID=CL.OWNERID AND PI.ITEMTYPE='Siu'
GROUP BY CL.OWNERID

INSERT INTO tblPI(OWNERID,DATE,IssueRaised)
SELECT OWNERID,DATEADD(q, (DATEPART(QQ,CM_CREATIONDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(CM_CREATIONDATE) AS VARCHAR))AS DATETIME)) DATE,COUNT(ITEMID) IssueRaised
FROM CHORUS.DIGITE.DIGITE.PROJECTISSUE
WHERE ITEMTYPE='Siu'
GROUP BY OWNERID,DATEADD(q, (DATEPART(QQ,CM_CREATIONDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(CM_CREATIONDATE) AS VARCHAR))AS DATETIME))

INSERT INTO tblCL(OWNERID,DATE,SoftwareSize)
SELECT OWNERID,DATEADD(q, (DATEPART(QQ,DN_ReleaseDate) - 1), CAST( ('01-Jan-' + CAST(YEAR(DN_ReleaseDate) AS VARCHAR))AS DATETIME)) DATE,SUM(ISNULL(DN_SizeFP,0)) SoftwareSiz
FROM CHORUS.DIGITE.DIGITE.D_VIRTUSA_CLRL_F_ED
GROUP BY OWNERID,DATEADD(q, (DATEPART(QQ,DN_ReleaseDate) - 1), CAST( ('01-Jan-' + CAST(YEAR(DN_ReleaseDate) AS VARCHAR))AS DATETIME))
```

Figure 4-8 : Extract Issue Ratings of the projects

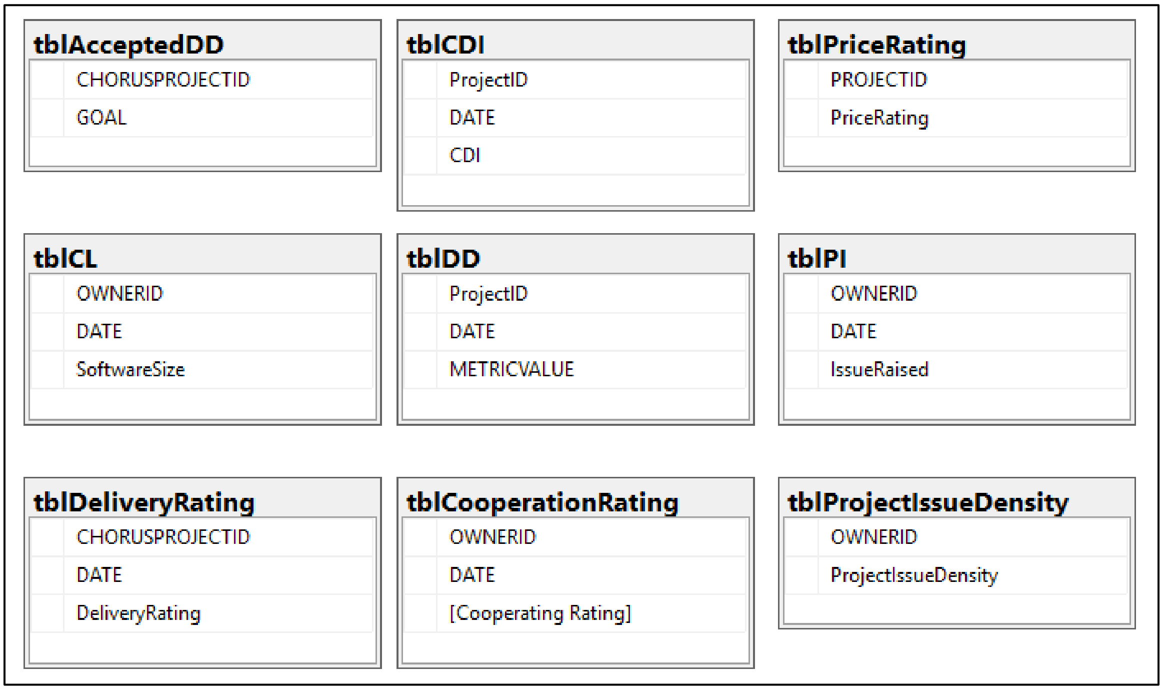
To find the cooperation rating of the project, total number of change requests received and total number of change request implemented without affecting the delivery date should be extracted. Total number of change requests are extracted from the Chorus+ DB and actual delivery date of each client release milestones are extracted from the PAT DB.



```
--8. Extract Cooperation Rating
SELECT OWNERID,DATEADD(q, (DATEPART(QQ,CM_CREATIONDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(CM_CREATIONDATE) AS VARCHAR))AS DATETIME)) DATE, COUNT(ITEMID) TOTAL
INTO #tblCR
FROM CHORUS.DIGITE.DIGITE.PROJECTISSUE PI (NOLOCK)
WHERE ITEMTYPE='Chr'
GROUP BY OWNERID,DATEADD(q, (DATEPART(QQ,CM_CREATIONDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(CM_CREATIONDATE) AS VARCHAR))AS DATETIME))

SELECT CHORUSPROJECTID,DATEADD(q, (DATEPART(QQ,INITIALTARGETDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(INITIALTARGETDATE) AS VARCHAR))AS DATETIME)) DATE
INTO #tblMilestone
FROM PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLRELEASEAUDITMILESTONES TRAM
WHERE INITIALTARGETDATE!=SECONDARYTARGETDATE
GROUP BY CHORUSPROJECTID,DATEADD(q, (DATEPART(QQ,INITIALTARGETDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(INITIALTARGETDATE) AS VARCHAR))AS DATETIME))

INSERT INTO tblCooperationRating(OWNERID,DATE,[Cooperating Rating])
SELECT OWNERID,CR.DATE,(Total - CASE
            WHEN CHORUSPROJECTID IS NULL AND MS.DATE IS NULL
                THEN Total
            ELSE 0
        END)/ Total
FROM #tblCR CR
LEFT JOIN #tblMilestone MS
ON CR.OWNERID=MS.CHORUSPROJECTID AND CR.DATE=MS.DATE
```

Figure 4-9 : Extract Cooperation Ratings of the projects

After extracting the necessary details (CDI details of the projects, DD of the projects, Accepted DD of the projects, Delivery ratings of the projects, Price ratings of the projects, Issues created for the projects, client releases created for the projects and Cooperation ratings of the projects) they will be stored in the tables shown in the Figure 4-10.



tblAcceptedDD
CHORUSPROJECTID
GOAL

tblCDI
ProjectID
DATE
CDI

tblPriceRating
PROJECTID
PriceRating

tblCL
OWNERID
DATE
SoftwareSize

tblDD
ProjectID
DATE
METRICVALUE

tblPI
OWNERID
DATE
IssueRaised

tblDeliveryRating
CHORUSPROJECTID
DATE
DeliveryRating

tblCooperationRating
OWNERID
DATE
[Cooperating Rating]

tblProjectIssueDensity
OWNERID
ProjectIssueDensity

Figure 4-10 : Database tables of the CDI Validation Tool

4.2 CDI Validation Tool

CDI Validation Tool is created to validate the concept will work in real life scenarios. Microsoft Visual Studio is used to create the CDI Validation Tool and C# is used as programming language for the CDI Validation Tool. Following are the main components of the tool-

- Service/Presentation Layer
- Business Layer
- Data Layer
- Common component

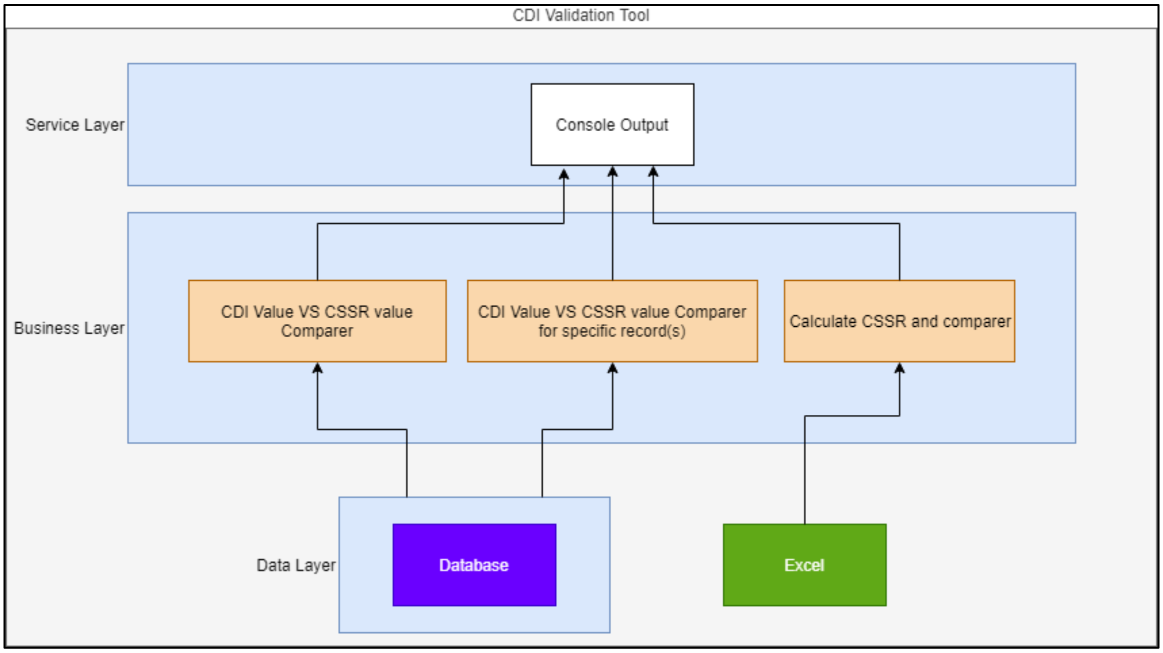
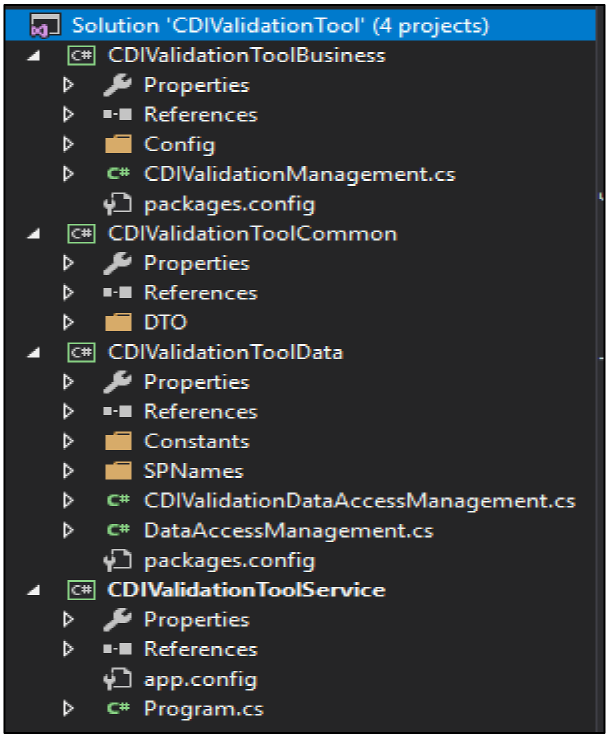

CDI Validation Tool
Service Layer
Console Output
Business Layer
CDI Value VS CSSR value Comparer
CDI Value VS CSSR value Comparer for specific record(s)
Calculate CSSR and comparer
Data Layer
Database
Excel

Figure 4-11 : High-level architecture of the CDI Validation Tool



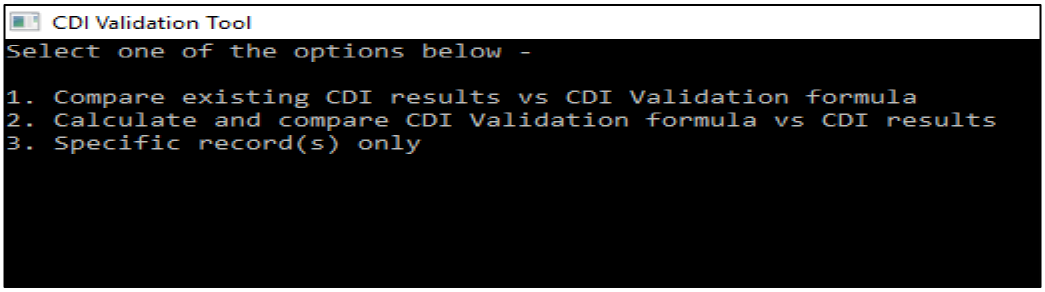
```
Solution 'CDIValidationTool' (4 projects)
◢ CDIValidationToolBusiness
    ▷ Properties
    ▷ References
    ▷ Config
    ▷ CDIValidationManagement.cs
      packages.config
◢ CDIValidationToolCommon
    ▷ Properties
    ▷ References
    ▷ DTO
◢ CDIValidationToolData
    ▷ Properties
    ▷ References
    ▷ Constants
    ▷ SPNames
    ▷ CDIValidationDataAccessManagement.cs
    ▷ DataAccessManagement.cs
      packages.config
◢ CDIValidationToolService
    ▷ Properties
    ▷ References
      app.config
    ▷ Program.cs
```

Figure 4-12 : CDI Validation Tool solution architecture

4.2.1 Service/Presentation Layer

Service/Presentation layer is responsible to get the inputs from the user and display the details to the user. Output will be displayed in console/command line. Service/Presentation layer request the data from the business layer based on the input given by the user. The sequence of job of the service/presentation layer will be: getting the input from user, validating the input from user, get the data from the business layer based on the input and present it to the user in a way that he/she can understand. Users are given with three options to choose.

- Option 1 - Compare existing CDI results vs CDI Validation formula
- Option 2 - Calculate and compare CDI Validation formula vs CDI results
- Option 3 - Specific record(s) only

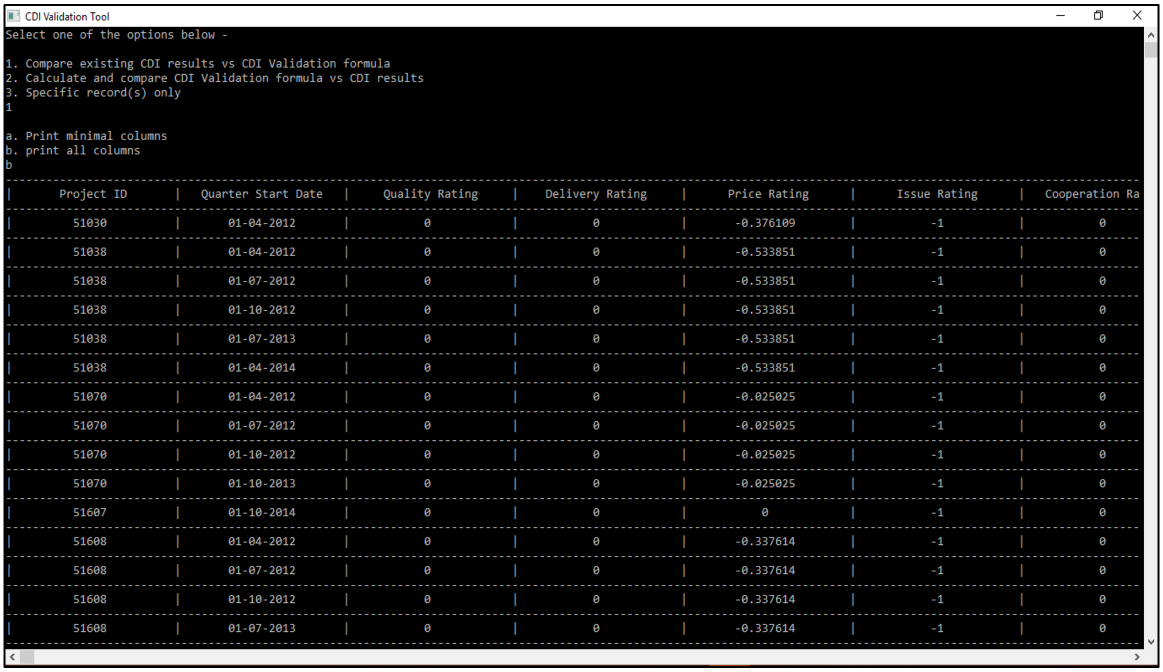


```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
```

Figure 4-13 : CDI Validation Tool options

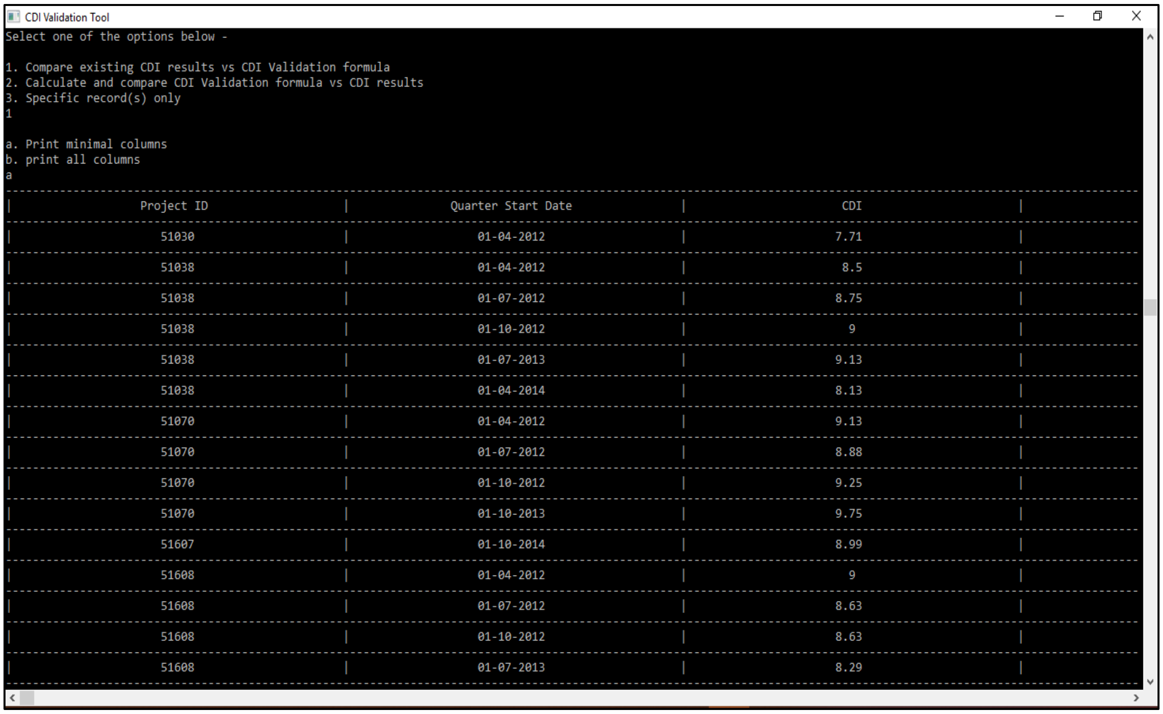
Option 1 - Compare existing CDI results vs CDI Validation formula:

Using this option, user can view the Quality Rating, Delivery Rating, Price Rating, Issue Rating, Cooperation Rating, CDI, Composite Customer Satisfaction Rating for each of the project respect to each financial quarter with comments. Users also have an option to view only the CDI and Composite Customer Satisfaction Rating for each of the project respect to each financial quarter with comments.



```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
1

a. Print minimal columns
b. print all columns
b
-----------------------------------------------------------------------------------------------------------------------------------
|      Project ID      |  Quarter Start Date  |    Quality Rating    |   Delivery Rating    |     Price Rating     |     Issue Rating     |  Cooperation Ra
-----------------------------------------------------------------------------------------------------------------------------------
|        51030         |      01-04-2012      |          0           |          0           |      -0.376109       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51038         |      01-04-2012      |          0           |          0           |      -0.533851       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51038         |      01-07-2012      |          0           |          0           |      -0.533851       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51038         |      01-10-2012      |          0           |          0           |      -0.533851       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51038         |      01-07-2013      |          0           |          0           |      -0.533851       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51038         |      01-04-2014      |          0           |          0           |      -0.533851       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51070         |      01-04-2012      |          0           |          0           |      -0.025025       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51070         |      01-07-2012      |          0           |          0           |      -0.025025       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51070         |      01-10-2012      |          0           |          0           |      -0.025025       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51070         |      01-10-2013      |          0           |          0           |      -0.025025       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51607         |      01-10-2014      |          0           |          0           |          0           |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51608         |      01-04-2012      |          0           |          0           |      -0.337614       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51608         |      01-07-2012      |          0           |          0           |      -0.337614       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51608         |      01-10-2012      |          0           |          0           |      -0.337614       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
|        51608         |      01-07-2013      |          0           |          0           |      -0.337614       |          -1          |        0
-----------------------------------------------------------------------------------------------------------------------------------
```

Figure 4-14 : Option 1 - print all columns

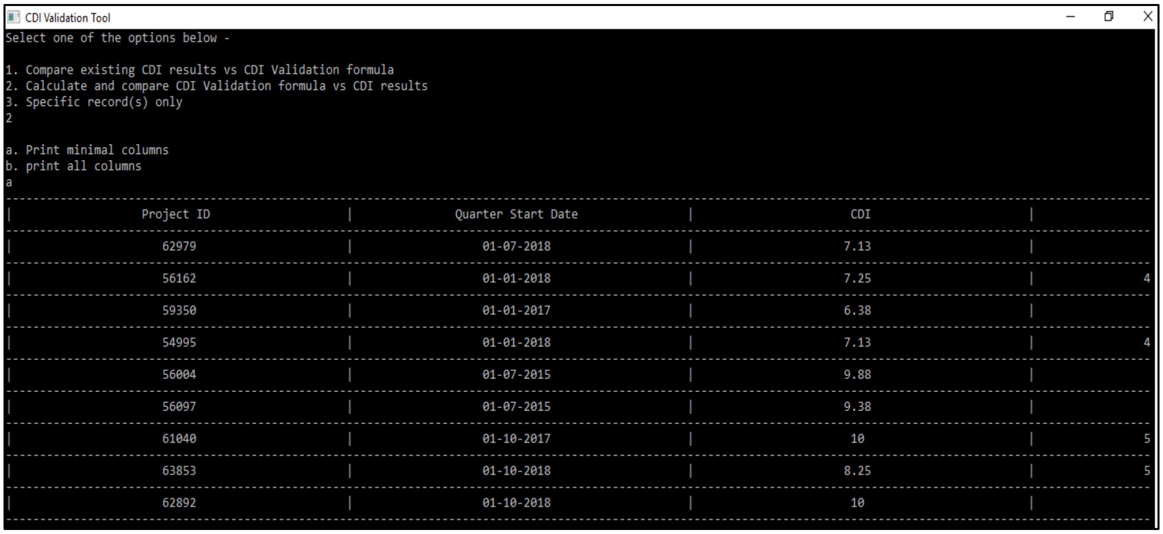


```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
1

a. Print minimal columns
b. print all columns
a
------------------------------------------------------------------------------------------------------------------------
|            Project ID            |         Quarter Start Date         |              CDI              |
------------------------------------------------------------------------------------------------------------------------
|              51030               |             01-04-2012             |             7.71              |
------------------------------------------------------------------------------------------------------------------------
|              51038               |             01-04-2012             |              8.5              |
------------------------------------------------------------------------------------------------------------------------
|              51038               |             01-07-2012             |             8.75              |
------------------------------------------------------------------------------------------------------------------------
|              51038               |             01-10-2012             |               9               |
------------------------------------------------------------------------------------------------------------------------
|              51038               |             01-07-2013             |             9.13              |
------------------------------------------------------------------------------------------------------------------------
|              51038               |             01-04-2014             |             8.13              |
------------------------------------------------------------------------------------------------------------------------
|              51070               |             01-04-2012             |             9.13              |
------------------------------------------------------------------------------------------------------------------------
|              51070               |             01-07-2012             |             8.88              |
------------------------------------------------------------------------------------------------------------------------
|              51070               |             01-10-2012             |             9.25              |
------------------------------------------------------------------------------------------------------------------------
|              51070               |             01-10-2013             |             9.75              |
------------------------------------------------------------------------------------------------------------------------
|              51607               |             01-10-2014             |             8.99              |
------------------------------------------------------------------------------------------------------------------------
|              51608               |             01-04-2012             |               9               |
------------------------------------------------------------------------------------------------------------------------
|              51608               |             01-07-2012             |             8.63              |
------------------------------------------------------------------------------------------------------------------------
|              51608               |             01-10-2012             |             8.63              |
------------------------------------------------------------------------------------------------------------------------
|              51608               |             01-07-2013             |             8.29              |
------------------------------------------------------------------------------------------------------------------------
```

Figure 4-15 : Option 1 - print minimal columns

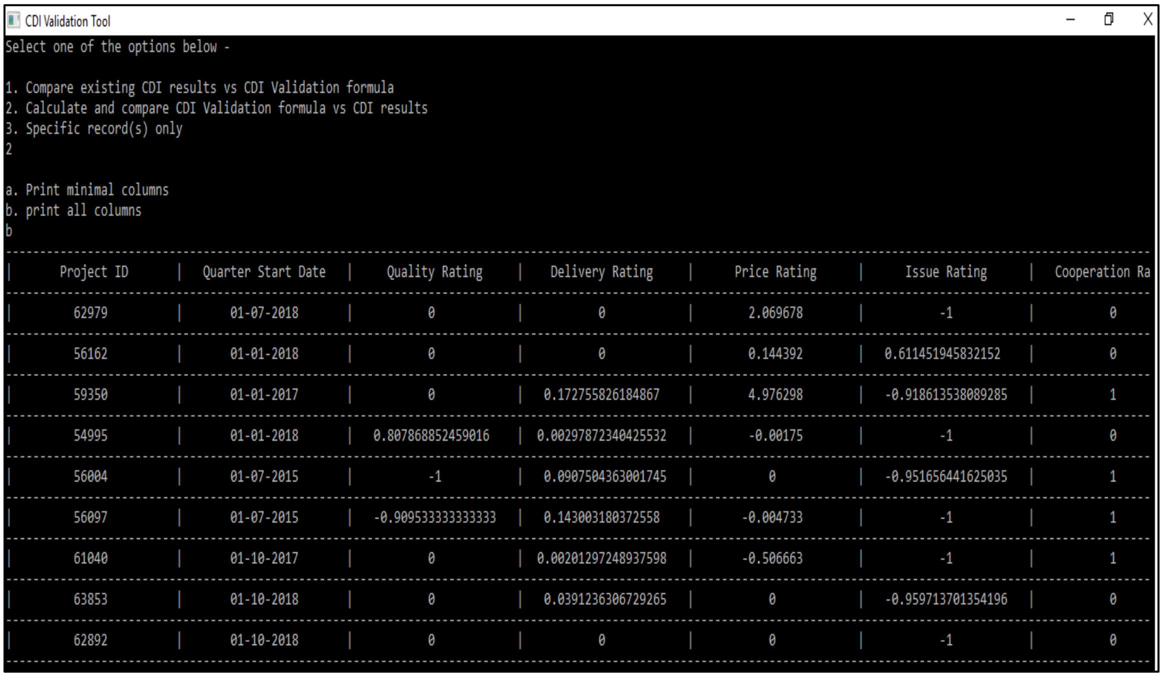
Option 2 - Calculate and compare CDI Validation formula vs CDI results:

Using this option, users can generate Composite Customer Satisfaction Rating for a given project respect to a quarter and compare it with the CDI value obtained. Users also have an option to view only the CDI and Composite Customer Satisfaction Rating for each of the project respect to each financial quarter wise. For this option, users should give Quality Rating, Delivery Rating, Price Rating, Issue Rating and Cooperation Rating in an Excel sheet as shown in the Figure 4-18. Path to Excel file is configurable and following values are mandatory: Project ID, Quarter Start Date, Quality Rating, Delivery Rating, Price Rating, Issue Rating and Cooperation Rating.



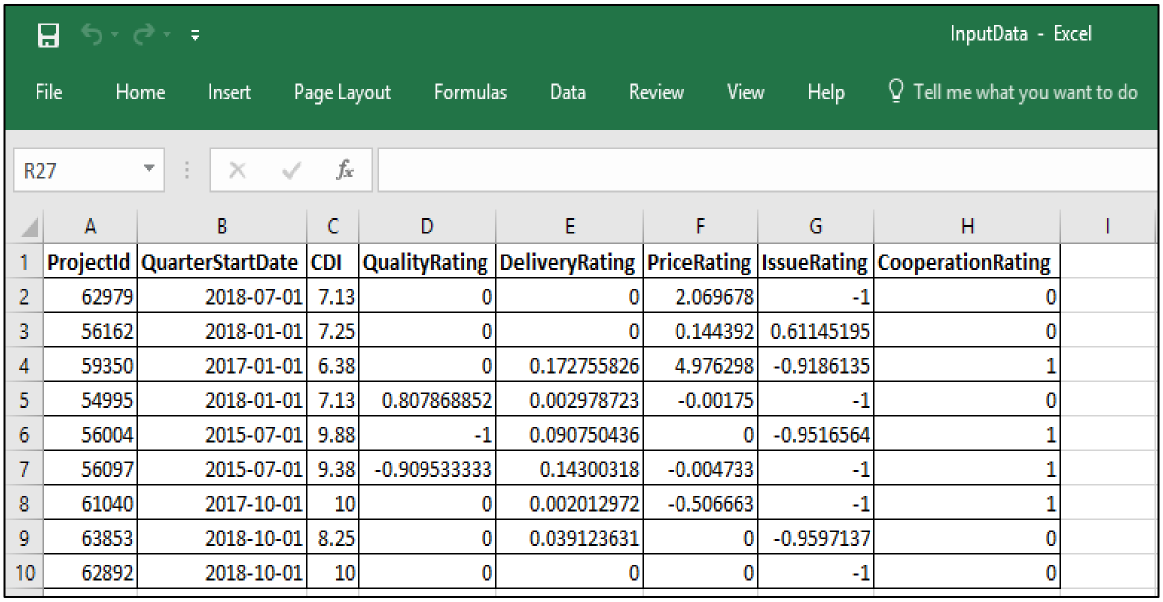
```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
2

a. Print minimal columns
b. print all columns
a
------------------------------------------------------------------------------------------------------
|          Project ID           |       Quarter Start Date       |             CDI             |
------------------------------------------------------------------------------------------------------
|             62979             |           01-07-2018           |            7.13             |
------------------------------------------------------------------------------------------------------
|             56162             |           01-01-2018           |            7.25             |        4
------------------------------------------------------------------------------------------------------
|             59350             |           01-01-2017           |            6.38             |
------------------------------------------------------------------------------------------------------
|             54995             |           01-01-2018           |            7.13             |        4
------------------------------------------------------------------------------------------------------
|             56004             |           01-07-2015           |            9.88             |
------------------------------------------------------------------------------------------------------
|             56097             |           01-07-2015           |            9.38             |
------------------------------------------------------------------------------------------------------
|             61040             |           01-10-2017           |             10              |        5
------------------------------------------------------------------------------------------------------
|             63853             |           01-10-2018           |            8.25             |        5
------------------------------------------------------------------------------------------------------
|             62892             |           01-10-2018           |             10              |
------------------------------------------------------------------------------------------------------
```

Figure 4-16 : Option 2 - print minimal columns



```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
2

a. Print minimal columns
b. print all columns
b
----------------------------------------------------------------------------------------------------------------------------------
|   Project ID   |  Quarter Start Date  |   Quality Rating    |   Delivery Rating    |  Price Rating  |    Issue Rating     | Cooperation Ra
----------------------------------------------------------------------------------------------------------------------------------
|     62979      |      01-07-2018      |          0          |          0           |    2.069678    |         -1          |       0
----------------------------------------------------------------------------------------------------------------------------------
|     56162      |      01-01-2018      |          0          |          0           |    0.144392    |  0.611451945832152  |       0
----------------------------------------------------------------------------------------------------------------------------------
|     59350      |      01-01-2017      |          0          |  0.172755826184867   |    4.976298    | -0.918613538089285  |       1
----------------------------------------------------------------------------------------------------------------------------------
|     54995      |      01-01-2018      |  0.807868852459016  | 0.00297872340425532  |    -0.00175    |         -1          |       0
----------------------------------------------------------------------------------------------------------------------------------
|     56004      |      01-07-2015      |         -1          |  0.0907504363001745  |       0        | -0.951656441625035  |       1
----------------------------------------------------------------------------------------------------------------------------------
|     56097      |      01-07-2015      | -0.909533333333333  |  0.143003180372558   |   -0.004733    |         -1          |       1
----------------------------------------------------------------------------------------------------------------------------------
|     61040      |      01-10-2017      |          0          | 0.00201297248937598  |   -0.506663    |         -1          |       1
----------------------------------------------------------------------------------------------------------------------------------
|     63853      |      01-10-2018      |          0          |  0.0391236306729265  |       0        | -0.959713701354196  |       0
----------------------------------------------------------------------------------------------------------------------------------
|     62892      |      01-10-2018      |          0          |          0           |       0        |         -1          |       0
----------------------------------------------------------------------------------------------------------------------------------
```

Figure 4-17 : Option 2 - print all columns

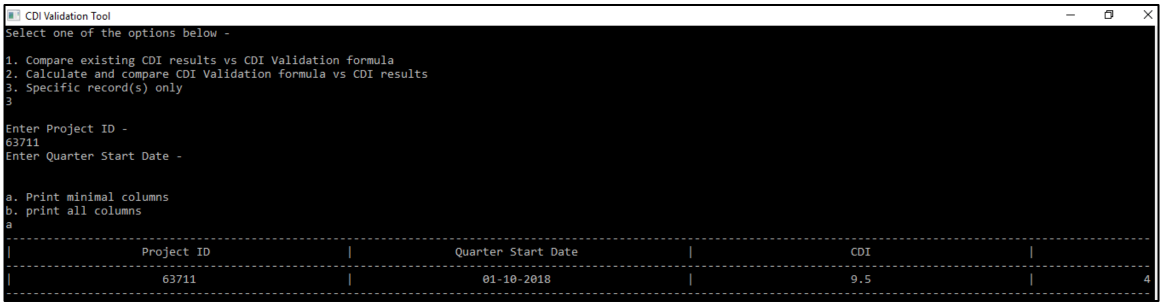


	A	B	C	D	E	F	G	H	I
1	ProjectId	QuarterStartDate	CDI	QualityRating	DeliveryRating	PriceRating	IssueRating	CooperationRating	
2	62979	2018-07-01	7.13	0	0	2.069678	-1	0	
3	56162	2018-01-01	7.25	0	0	0.144392	0.61145195	0	
4	59350	2017-01-01	6.38	0	0.172755826	4.976298	-0.9186135	1	
5	54995	2018-01-01	7.13	0.807868852	0.002978723	-0.00175	-1	0	
6	56004	2015-07-01	9.88	-1	0.090750436	0	-0.9516564	1	
7	56097	2015-07-01	9.38	-0.909533333	0.14300318	-0.004733	-1	1	
8	61040	2017-10-01	10	0	0.002012972	-0.506663	-1	1	
9	63853	2018-10-01	8.25	0	0.039123631	0	-0.9597137	0	
10	62892	2018-10-01	10	0	0	0	-1	0	

Figure 4-18 : Sample Excel Input Data

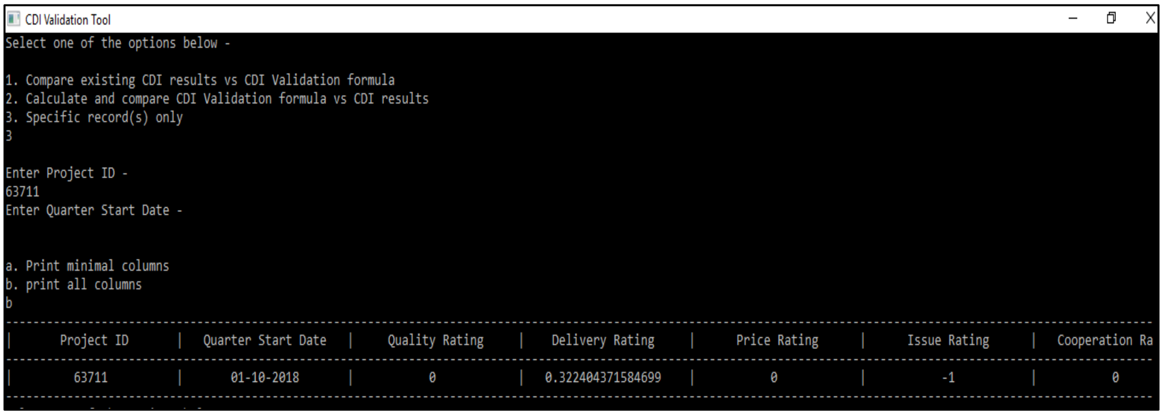
Option 3 - Specific record(s) only:

This option is extremely useful when the user knows the project and/or for which quarter he/she needs to view the data. Simply, the user should enter the project id and/or quarter start date to view the relevant details. User also have capability to enter only the quarter start date and view all the details relevant to the quarter. Users also have an option to view only the CDI and Composite Customer Satisfaction Rating for each of the project respect to each financial quarter wise.



```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
3

Enter Project ID -
63711
Enter Quarter Start Date -


a. Print minimal columns
b. print all columns
a
------------------------------------------------------------------------------------------------------------------------------------------------------------
|                 Project ID                |               Quarter Start Date              |                    CDI                    |
------------------------------------------------------------------------------------------------------------------------------------------------------------
|                   63711                   |                   01-10-2018                  |                    9.5                    |                   4
------------------------------------------------------------------------------------------------------------------------------------------------------------
```

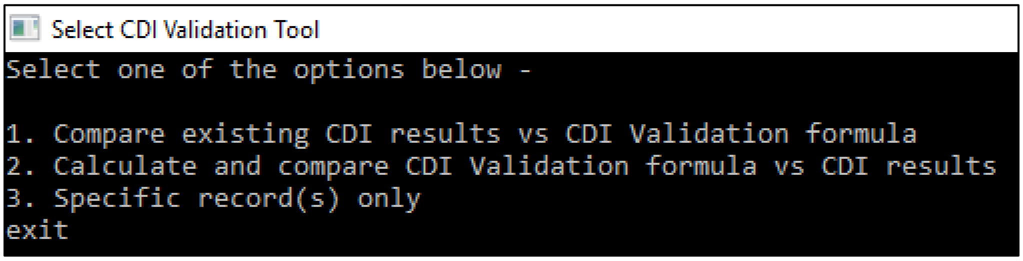
Figure 4-19 : Option 3 - print minimal columns



```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
3

Enter Project ID -
63711
Enter Quarter Start Date -


a. Print minimal columns
b. print all columns
b
---------------------------------------------------------------------------------------------------------------------------------------------
|      Project ID      |  Quarter Start Date  |    Quality Rating    |   Delivery Rating    |     Price Rating     |     Issue Rating     |  Cooperation Ra
---------------------------------------------------------------------------------------------------------------------------------------------
|        63711         |      01-10-2018      |          0           |  0.322404371584699   |          0           |          -1          |          0
---------------------------------------------------------------------------------------------------------------------------------------------
```

Figure 4-20 : Option 3 - print all columns

Users can exit the tool by entering “exit” in the console followed by pressing any button or pressing “CTRL” and “C”.



```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
exit
```

Figure 4-21 : Exit option

4.2.2 Business Layer

Business layer is responsible for all the business logics of the CDI Validation tool. For the Option 1 – ‘Compare existing CDI results vs CDI Validation formula’, the business layer gets the data from the data layer and calculates the Composite Customer Satisfaction Rating (CCSR) and comments for the calculated CCSR and pass it to the service/presentation layer. For the Option 2 – ‘Calculate and compare CDI Validation formula vs CDI results’, the business layer gets the data from the Excel sheet by reading the values from Excel sheet and calculates the Composite Customer Satisfaction Rating and comments for the calculated CCSR and present it to the service/presentation layer. Since the weightages of individual contributing components (Quality Rating, Delivery Rating, Price Rating, Issue Rating, Cooperation Rating) may vary from organization to organization and/or customer to customer, the weightages are specified in a configuration file so that it can be edited in any moment without a need for editing the source code.

4.2.3 Data Layer

Data layer is accountable for the interaction between the database and the business logics of the CDI validation tool. When the business layer request for a data, based on the user input, the data layer connects to the database and request the data by executing the relevant stored procedure and processing it, so that the business layer can understand the data. Since the database connection may vary from organization to organization, the database connection is specified in a configuration file so that different organization can configure their database without a hassle of modifying the source code. Constants and store procedure names are stored separately so that there is no need to bother of creating different names for constants and creating stored procedures with different names. Across different organizations, the constants and stored procedure names and the business logics will be same for CDI Validation Tool.

4.2.4 Common Component

Common component is used mainly for defining the Data Transfer Objects (DTO) of the CDI Validation Tool. The DTO's are widely used by all the three layers such as service/presentation layer, business layer and data layer.

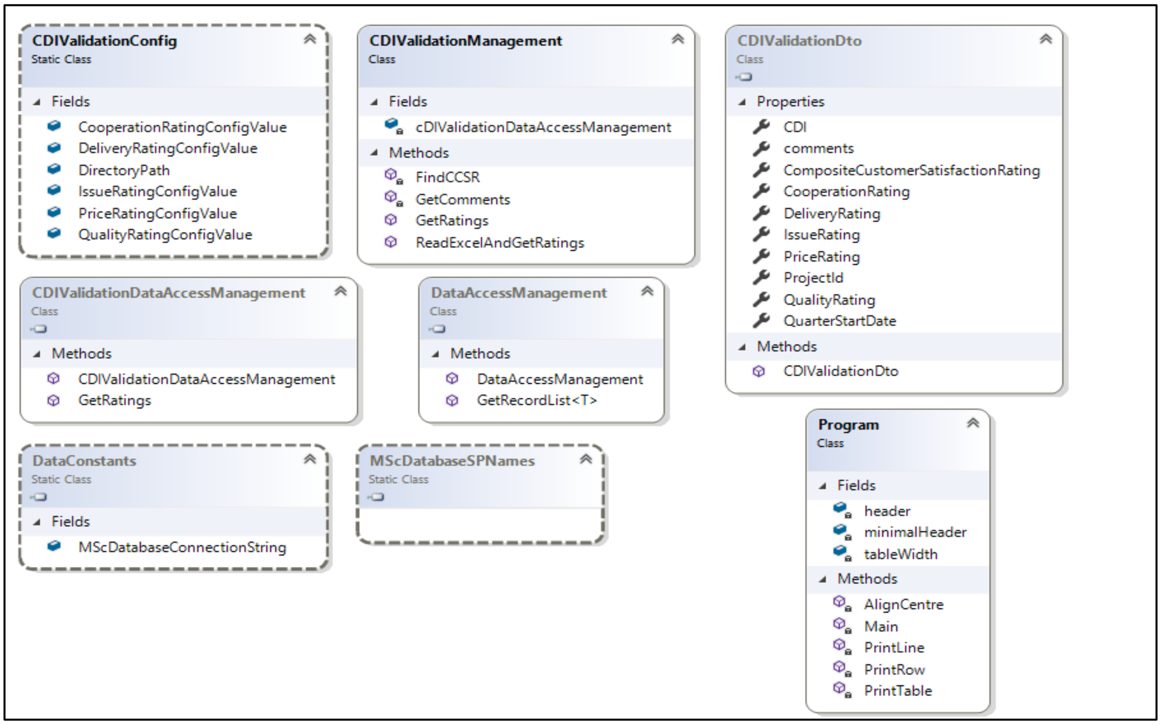


Figure 4-22 : Class Diagram of the CDI Validation Tool

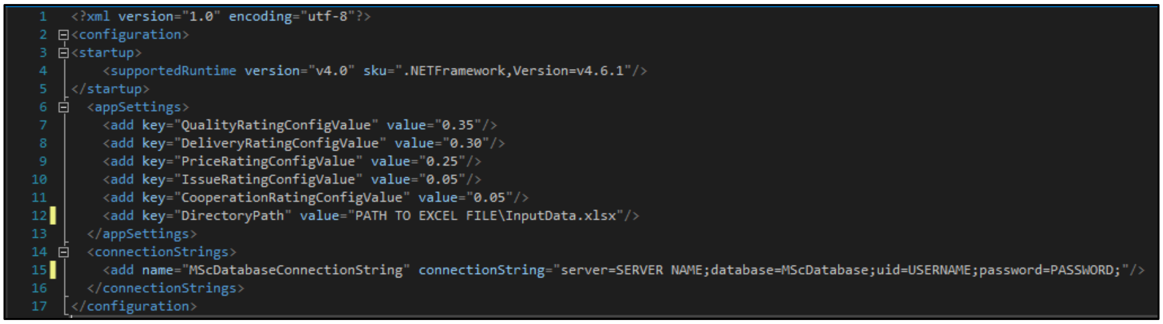
4.3 Features of CDI Validation Tool

- Easy to understand

  The service/presentation layer is designed in a way that the output is understandable by the end user even though it is a console output. As shown from Figure 4-13 to Figure 4-21, the console is presented with meaningful and understandable manner to the user. The given options are easy to understand and a table in presented to validate the values. Users are given options so that they can view all the information in the table or opt-out relevant information only in the table.

- Configurable

  Most of the features are given as configurable so that there is no/less modification will be needed for the source code to cater different organizations. Weightages for CCSR are given in the configuration file so that the values can be configuration at a given moment. Also, the database connection is configurable so that the different organizations can use different databases of their own. Users do not have to provide the path to excel file in the console since path to excel file is given in the configuration file which makes the users to concentrate only in the output.

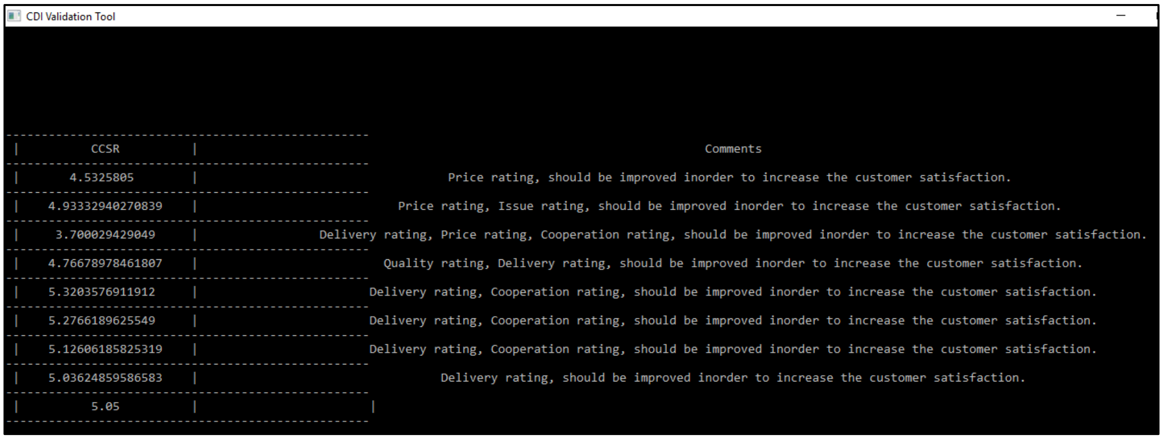


```
<?xml version="1.0" encoding="utf-8"?>
<configuration>
<startup>
    <supportedRuntime version="v4.0" sku=".NETFramework,Version=v4.6.1"/>
</startup>
  <appSettings>
    <add key="QualityRatingConfigValue" value="0.35"/>
    <add key="DeliveryRatingConfigValue" value="0.30"/>
    <add key="PriceRatingConfigValue" value="0.25"/>
    <add key="IssueRatingConfigValue" value="0.05"/>
    <add key="CooperationRatingConfigValue" value="0.05"/>
    <add key="DirectoryPath" value="PATH TO EXCEL FILE\InputData.xlsx"/>
  </appSettings>
  <connectionStrings>
    <add name="MScDatabaseConnectionString" connectionString="server=SERVER NAME;database=MScDatabase;uid=USERNAME;password=PASSWORD;"/>
  </connectionStrings>
</configuration>
```

Figure 4-23 : Configuration file

- Suggestions

  The CDI Validation Tool does not only calculate the CCSR and compare it with the CDI but it also gives the suggestions on the areas which needs to be improved. This will help decision makers, so that at a glance they will identify which area(s) needs to be improved and they can concentrate only at them without worrying about rest of the areas.



```
---------------------------------------------------
|          CCSR          |                                                     Comments
---------------------------------------------------
|       4.5325805        |                         Price rating, should be improved inorder to increase the customer satisfaction.
---------------------------------------------------
|    4.93332940270839    |                  Price rating, Issue rating, should be improved inorder to increase the customer satisfaction.
---------------------------------------------------
|     3.700029429049     |             Delivery rating, Price rating, Cooperation rating, should be improved inorder to increase the customer satisfaction.
---------------------------------------------------
|    4.76678978461807    |                 Quality rating, Delivery rating, should be improved inorder to increase the customer satisfaction.
---------------------------------------------------
|    5.3203576911912     |               Delivery rating, Cooperation rating, should be improved inorder to increase the customer satisfaction.
---------------------------------------------------
|    5.2766189625549     |               Delivery rating, Cooperation rating, should be improved inorder to increase the customer satisfaction.
---------------------------------------------------
|    5.12606185825319    |               Delivery rating, Cooperation rating, should be improved inorder to increase the customer satisfaction.
---------------------------------------------------
|    5.03624859586583    |                     Delivery rating, should be improved inorder to increase the customer satisfaction.
---------------------------------------------------
|          5.05          |                        |
---------------------------------------------------
```

Figure 4-24 : Suggestions provided by CDI Validation Tool

Chapter 4 summarizes the architectural reasoning behind the selection of database and application choices and individual components of the database and application architecture is explained in detail. The screenshots of the CDI Validation Tool is added to ensure that the functionality is same as the expected and as described in chapter 3.

Chapter 5
Evaluation

The CDI Validation Tool is developed to prove the concept, that there exists a relationship between actual customer satisfaction/index and the software project metrics and Composite Customer Satisfaction Rating can be derived based on the available software project metrics. Based on the literature review done in Chapter 2, using the methodology stated in Chapter 3 and solution (CDI Validation Tool) stated in Chapter 4 is developed. The evaluation of the CDI Validation Tool will validate the applicability of the methodology described in Chapter 3, in a real-world example and affinity of the solution to the problem the thesis addressing in explained in Chapter 5.

The evaluation phase of the CDI Validation Tool is consisting of two phases.

- Empirical evaluation
- Performance evaluation

5.1 Empirical Evaluation

Fundamental flow of the CDI Validation Tool is shown in Figure 5-1.

- Extract data from source systems and preprocess and produce information.
- Find the relation between the information produced and software project metrics.
- Calculate the Composite Customer Satisfaction Rating based on the available information.
- Suggest improvement/suggestions that can be made to project to achieve high customer appreciation and grow in fortune.

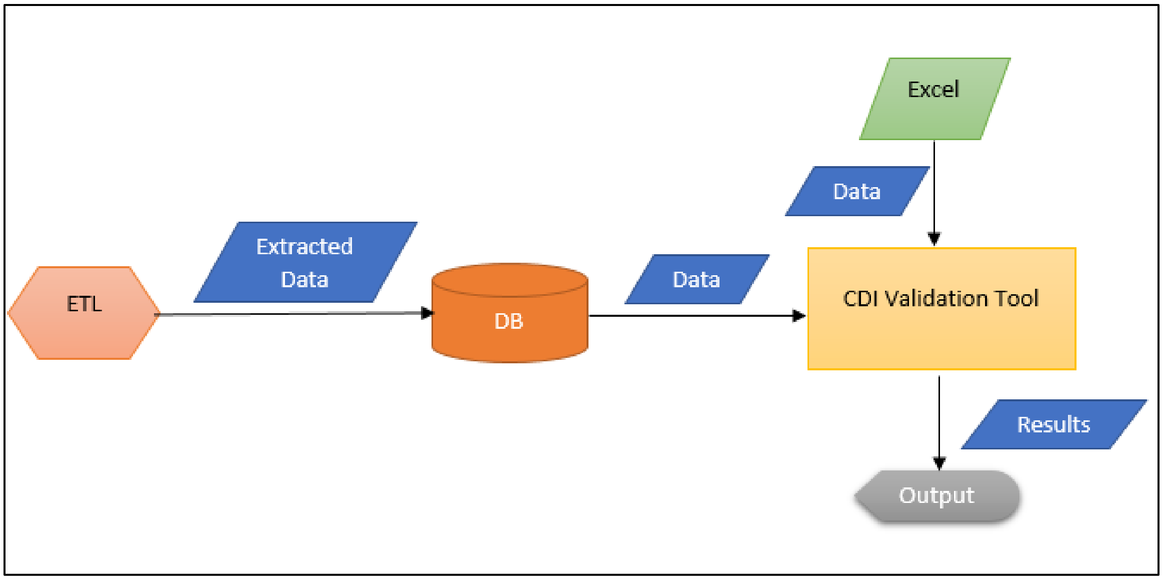


Figure 5-1 : Fundamental flow of CDI Validation Tool

From literature review in Chapter 2, author identified that the Composite Customer Satisfaction Rating depends on the ratings (Quality Rating, Delivery Rating, Price Rating, Issue Rating and Cooperation Rating) that have been calculated. Since the Composite Customer Satisfaction Rating is a 5-point scale rating, if the Composite Customer Satisfaction Rating equal or greater than 5 means that the customer expectations are highly achieved. If the Composite Customer Satisfaction Rating is less than 5 determines that the customer satisfaction is not met.

In the motivation section in Chapter 1, the customer satisfaction score/index is a 10-point scale which is given by the customers for the respective projects. Based on that, the customers are categorized into two categories.

- Promoter
- Distracter

After collection of each customer satisfaction score/index, the customer will be categorized into below categories. Because during customer satisfaction survey period, the customer satisfaction/index may differ from previous customer satisfaction score/index depending on the progress of the project during the customer satisfaction survey period. Therefore, we need to identify the delight of the customer every time during the customer satisfaction survey period.

Promoter:

A promoter is a non-other than a customer who is happy with the services and products of Virtusa Corporation. A customer is categorized as a promoter if the customer satisfaction score/index of the customer for the given customer satisfaction survey period is equal or greater than 8. Goal of the software endeavor is to maintain all their customers as promoters throughout their business operation.

Distractor:

A distractor is opposite of the promoter. A Distracter is a non-other than a customer who is unhappy with the products and services offered by the Virtusa Corporation. A distracter is a customer who have provided customer satisfaction score/index less than 8 in the 10-point scale. Having a customer as distractor will be the worst nightmare of a software enterprise, since it may result in cancellation of the deal or ending the contract by the customer. A software company will never like to see a customer in the distractor category.

5.1.1 Strategy

The strategy to compare the customer satisfaction score/index and Composite Customer Satisfaction Score will be, if the customer satisfaction score/index is greater than or equal to 8 (Promoter) then it will equal or compared with Composite Customer Satisfaction Score which is having greater than or equal to 5. In contrast, if the customer satisfaction score/index is less than 8 (Distractor) then it will equal or compare to the Composite Customer Satisfaction Score which is less than 5. Dedicated test suite is developed for all the scenario's including all the success and failure paths so that the results are validated with the expected output. Following sections describes the main test scenarios and individual test cases are explained in the section.

5.1.2 Main Flow 1 - Compare existing CDI results vs CDI Validation formula

From the ETL process, data is extracted from source system and stored in the database. CDI Validation Tool will request the CDI results and individual ratings (Quality Rating, Delivery Rating, Issue Rating, Price Rating, Cooperation Rating) for a given project and given quarter (Customer satisfaction survey period) from the database. Stored procedure will retrieve the CDI values, individual ratings (Quality Rating, Delivery Rating, Price Rating, Issue Rating and Cooperation Rating) and return it to CDI Validation Tool. CDI Validation Tool will calculate Composite Customer Satisfaction Rating and comments for each Composite Customer Satisfaction Rating. Following experiment is done to demonstrate that there exists a relationship between customer satisfaction score/index and calculated Composite Customer Satisfaction Rating based on the strategy stated in 5.1.1 and the observations from the output is given below.

Table 5-1 : Empirical result of the CDI Validation Tool

Category	Value
Total	6816
CDI >= 8	5386
CDI < 8	1430
CCSR >= 5	6556
CCSR < 5	260
CDI >= 8 and CCSR >= 5	5190
CDI >= 8 and CCSR < 5	196
CDI < 8 and CCSR >= 5	1366
CDI < 8 and CCSR < 5	64

Totally, there were 6816 records for each project for each quarter wise. Among those 6816 records, 5386 records were having customer satisfaction score/index greater than or equal to 8 in 10-point scale and 1430 records were having customer satisfaction score/index less than 8 in 10-point scale. Therefore, there were 5386 promoter records and 1430 distractor records. Amid 6816 records, 6556 records were having Composite Customer Satisfaction Rating greater than or equal to 5 in 5-point scale and 260 records were having Composite Customer Satisfaction Rating less than 5 in 5-point scale. Which implies that there were 6556 highly satisfied customer records and there were 260 customer expectations not achieved records.

From the 6816 records, there are 5190 records which are having customer satisfaction score/index greater or equal to 8 and Composite Customer Satisfaction Score greater or equal to 5. There are 64 records which are having customer satisfaction score/index less than 8 and Composite Customer Satisfaction Score less than 5. There were anomalies of 196 which is having customer satisfaction score/index greater than or equal to 8 but Composite Customer Satisfaction Rating less than 5. By analyzing the data, it is found out that the actual customer satisfaction score/index should have been less than 8 based on the Composite Customer Satisfaction Rating calculated and leads to the question how the customer satisfaction score/index was greater than or equal to 8. The discussion with Process Team of Virtusa Corporation brought out the fact that, for those 196 records the actual customer satisfaction score/index was less than 8 and the project management has requested for better customer satisfaction score/index from the customer and removing the lower customer satisfaction score/index (with the approval of customer and process team) from the system since that will imply a bad picture of the project, team and the project management. From the 6816 records 76% of the records are matching the strategy stated and rest of them are data issues due to no sufficient individual ratings are available. This implies that the Composite Customer Satisfaction Rating formula stated in Chapter 3 can be applied in real world scenarios based on the strategy stated in the previous sub section. Figure 5-2 gives a graphical representation of the empirical result of the CDI Validation Tool by means of a Venn diagram.

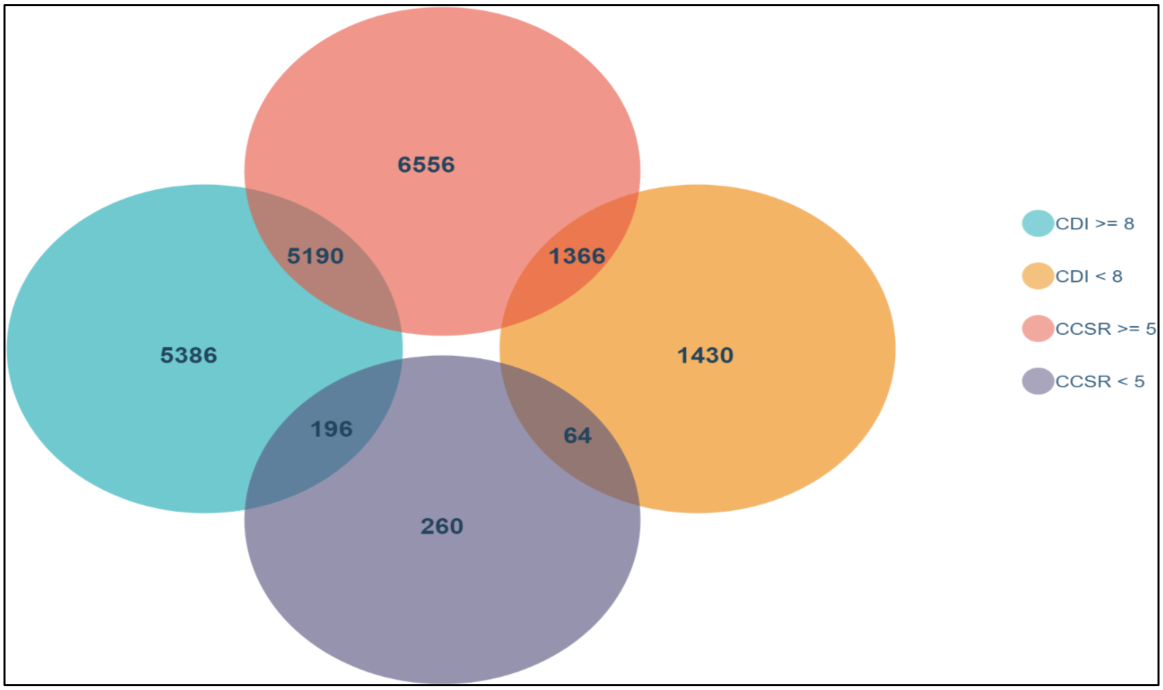
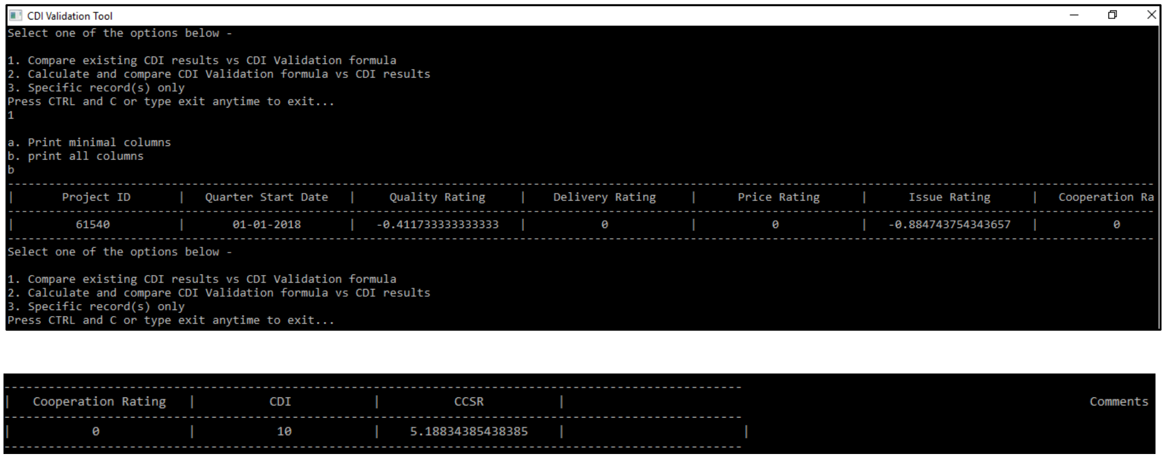


Figure 5-2 : Venn Diagram of the observation

5.1.2.1 Evaluation of Success Path of Main Flow 1

Success path of the main flow 1 – ‘Compare existing CDI results vs CDI Validation formula’ will be the customer satisfaction score/index is equal or greater than 8 and the Composite Customer Satisfaction Rating is equal or greater than 5 based on the strategy stated. The actual output of the success path of the main flow 1 is given below. From the Figure 5-3 it is evident that the Composite Customer Satisfaction Rating (~5.18) equal or greater than 5 is having customer satisfaction score/index (10) equal or greater than 8. Therefore, the test case for the Success path of the main flow 1 is declared passed.



```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
1

a. Print minimal columns
b. print all columns
b
------------------------------------------------------------------------------------------------------------------------------------------------------------
|      Project ID       |   Quarter Start Date   |     Quality Rating     |    Delivery Rating     |      Price Rating      |      Issue Rating      |   Cooperation Ra
------------------------------------------------------------------------------------------------------------------------------------------------------------
|        61540          |       01-01-2018       |  -0.411733333333333    |           0            |           0            |  -0.884743754343657    |          0
------------------------------------------------------------------------------------------------------------------------------------------------------------
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
```

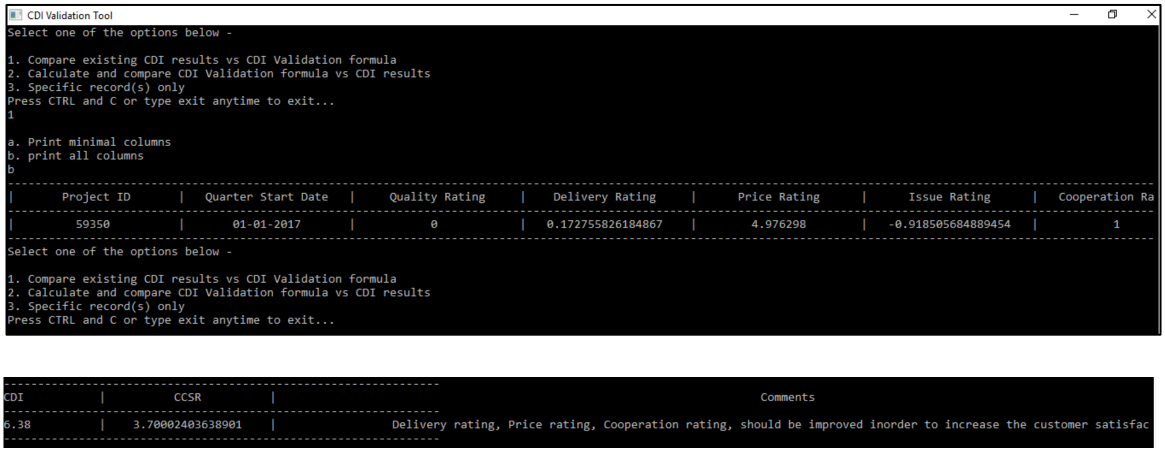
```
--------------------------------------------------------------------------------------------------
|  Cooperation Rating  |          CDI          |          CCSR          |                                          Comments
--------------------------------------------------------------------------------------------------
|          0           |          10           |    5.18834385438385    |                          |
--------------------------------------------------------------------------------------------------
```

Figure 5-3 : Success path of Main Flow 1 - output

5.1.2.2 Evaluation of Failure Path of Main Flow 1

Based on the strategy stated, if the customer satisfaction score/index is less than 8 and Composite Customer Satisfaction Rating is less than 5 then it is considered as the failure path of Main Flow 1 – ‘Compare existing CDI results vs CDI Validation formula’. The result of the failure path is given below. Figure 5-4 shows that a record having a Composite

Customer Satisfaction Rating (3.7) is less than 5 also having a customer satisfaction score/index (6.38) less than 8. Based on the observation the result of the failure path of Main Flow 1 indicates during the test it follows the strategy and it is marked as passed.



```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
1

a. Print minimal columns
b. print all columns
b
--------------------------------------------------------------------------------------------------------------------------------------------------------------
|      Project ID       |  Quarter Start Date  |    Quality Rating    |   Delivery Rating    |     Price Rating     |     Issue Rating     |  Cooperation Ra
--------------------------------------------------------------------------------------------------------------------------------------------------------------
|        59350          |      01-01-2017      |          0           |  0.172755826184867   |       4.976298       |  -0.918505684889454  |          1
--------------------------------------------------------------------------------------------------------------------------------------------------------------
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
```

```
----------------------------------------------------------------
CDI            |       CCSR         |                                            Comments
----------------------------------------------------------------
6.38           |   3.70002403638901  |               Delivery rating, Price rating, Cooperation rating, should be improved inorder to increase the customer satisfac
----------------------------------------------------------------
```

Figure 5-4 : Failure path of Main Flow 1 – output

5.1.2.3 Evaluation of Other Test Cases of Main Flow 1

There are other test scenarios and test cases to prove that the CDI Validation Tool is performing as expected for the all the given scenarios. Test scenarios and test cases includes both the success and failure scenarios of different situations such as displaying correct options, validating user inputs, database connection, calculation of Composite Customer Satisfaction Rating, generating comments for Composite Customer Satisfaction Rating etc. Following Table 5-2 summarizes the test scenario, expected output and actual output. During the testing, the CDI Validation Tool was performed as expected.

Table 5-2 : Other test scenarios evaluation of Main Flow 1

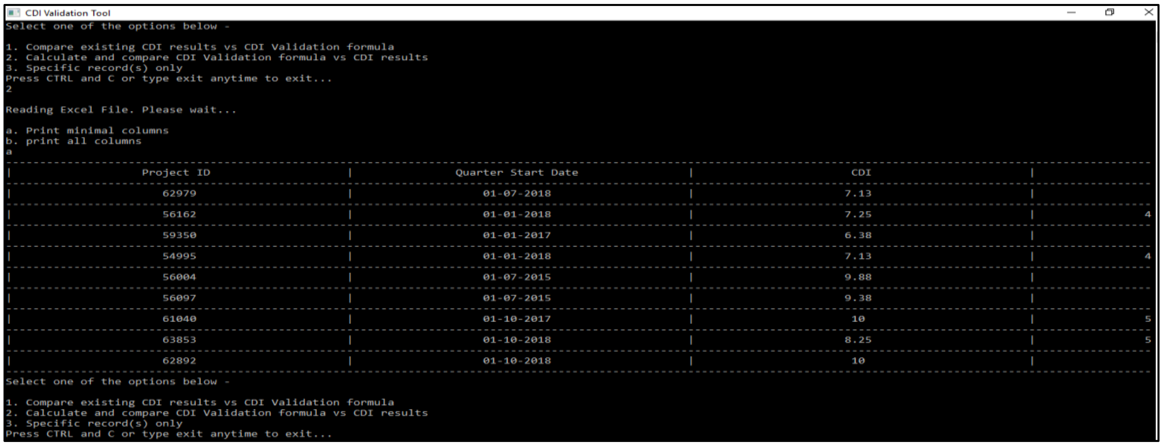
Test Scenario	**Expected Output**	**Actual Output**	**Overall Status**
Set “CDI Validation Tool” as console title	“CDI Validation Tool” string should be set in the title bar of console	“CDI Validation Tool” string is set as the title of the console	Passed
Display options to the user	Message with relevant details with options that should be entered should be visible in the console	Message with options was displayed in the console	Passed
Validating the input from user for main flow – input is correct	Show relevant main flow	Relevant main flow options were displayed in the console	Passed
Validating the input from user for main flow – input is incorrect	An error message should display	Error message “Please select a valid input.” was displayed in the console.	Passed
Database connection success – Data is available	Retrieve the data from database and display the options to choose in console	Data retrieved from database and options were displayed in the console to choose	Passed
Database connection success – Data is available, print minimal columns	Retrieve data from database and display in the console with minimal columns	Data retrieved from database and displayed in the console as a table with minimal columns	Passed
Database connection success – Data is	Retrieve data from database and display in	Data retrieved from database and displayed	Passed

available, print all columns	the console with all columns	in the console as a table with all columns	
Data length is greater than table width	Display ‘…’ at the end of the line	‘…’ was appended with the data by replacing the overflowing data	Passed
Database connection success – Data is not available	An error message should display	Error message “There is no data to display! Please try other options.” was displayed in the console.	Passed
Configuration file is missing	An error message should display with missing configuration file message	An error message with missing configuration file message was displayed in console	Passed
Database connection failure - timeout	An error message should be displayed with relevant timeout error details	Exception with timeout error details was displayed in the console	Passed
Database connection failure – database not exist	An error message should be displayed with relevant database not exist error message	Exception with database not exist error message was displayed in the console	Passed
Database connection failure – wrong username	An error message should be displayed with relevant wrong username error message	Exception with wrong username error message was displayed in the console	Passed

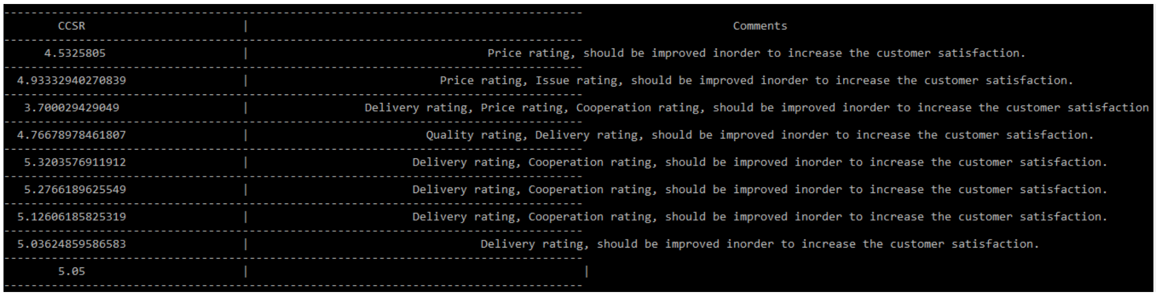
Database connection failure – wrong password	An error message should be displayed with relevant wrong password error message	Exception with wrong password error message was displayed in the console	Passed
Stored procedure not found	An error message should be displayed stating stored procedure not found	An error message is displayed stating that relevant stored procedure is not found	Passed
Failed to calculate CCSR – one to multiple records, not all records	Errored records should get skip	Errored records skipped and successfully calculate values were displayed in the console as a table	Passed
Failed to calculate CCSR – all records	All errored records should get skip	All errored records skipped and empty table was displayed in the console	Passed
Failed to calculate comment – one to multiple records, not all records	Errored records should get skip	Errored records skipped and successfully calculate values were displayed in the console as a table	Passed
Failed to calculate comment – all records	All errored records should get skip	All errored records skipped and empty table was displayed in the console	Passed

5.1.3 Main Flow 2 - Calculate and compare CDI Validation formula vs CDI results

“Calculate and compare CDI Validation formula vs CDI results” option is given so that users can enter the CDI and individual ratings (Quality, Delivery, Price, Issue and Cooperation) for given project and quarter and find the Composite Customer Satisfaction Rating with comments. Users should provide the excel sheet as shown in Figure 4-18. Success path of the Main Flow 2 will be reading the data from excel file, processing it and displaying the Composite Customer Satisfaction Rating and comments in the display because the option is given to calculate the Composite Customer Satisfaction Rating from user’s input and display it to the user. Result of Success path of Main Flow 2 is given below. Overall status of the success path of the Main Flow 2 is marked as success since CDI Validation Tool successfully extracted the values from the excel file, calculated the Composite Customer Satisfaction Rating based on the formula, generated comments for the corresponding Composite Customer Satisfaction Rating.



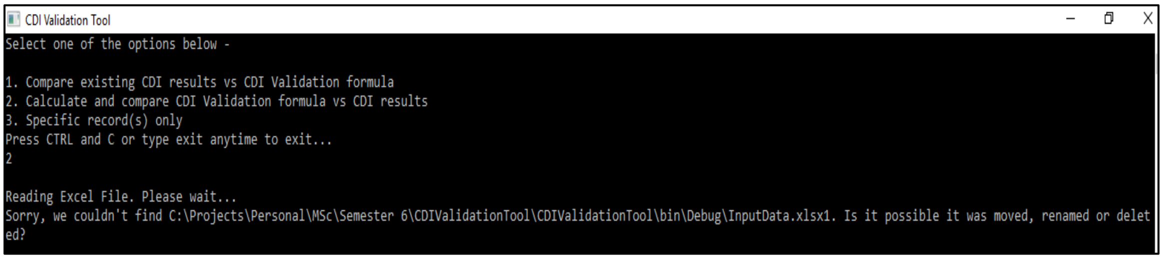
```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
2

Reading Excel File. Please wait...

a. Print minimal columns
b. print all columns
a
--------------------------------------------------------------------------------------------------------------------
|              Project ID              |          Quarter Start Date          |                 CDI                  |
--------------------------------------------------------------------------------------------------------------------
|                62979                 |              01-07-2018              |                 7.13                 |
--------------------------------------------------------------------------------------------------------------------
|                56162                 |              01-01-2018              |                 7.25                 |          4
--------------------------------------------------------------------------------------------------------------------
|                59350                 |              01-01-2017              |                 6.38                 |
--------------------------------------------------------------------------------------------------------------------
|                54995                 |              01-01-2018              |                 7.13                 |          4
--------------------------------------------------------------------------------------------------------------------
|                56004                 |              01-07-2015              |                 9.88                 |
--------------------------------------------------------------------------------------------------------------------
|                56097                 |              01-07-2015              |                 9.38                 |
--------------------------------------------------------------------------------------------------------------------
|                61040                 |              01-10-2017              |                  10                  |          5
--------------------------------------------------------------------------------------------------------------------
|                63853                 |              01-10-2018              |                 8.25                 |          5
--------------------------------------------------------------------------------------------------------------------
|                62892                 |              01-10-2018              |                  10                  |
--------------------------------------------------------------------------------------------------------------------
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
```



```
----------------------------------------------------------------------------------------
       CCSR                     |                                  Comments
----------------------------------------------------------------------------------------
     4.5325805                  |                  Price rating, should be improved inorder to increase the customer satisfaction.
----------------------------------------------------------------------------------------
 4.93332940270839               |              Price rating, Issue rating, should be improved inorder to increase the customer satisfaction.
----------------------------------------------------------------------------------------
  3.700029429049                |       Delivery rating, Price rating, Cooperation rating, should be improved inorder to increase the customer satisfaction
----------------------------------------------------------------------------------------
 4.76678978461807               |             Quality rating, Delivery rating, should be improved inorder to increase the customer satisfaction.
----------------------------------------------------------------------------------------
  5.3203576911912               |            Delivery rating, Cooperation rating, should be improved inorder to increase the customer satisfaction.
----------------------------------------------------------------------------------------
  5.2766189625549               |            Delivery rating, Cooperation rating, should be improved inorder to increase the customer satisfaction.
----------------------------------------------------------------------------------------
 5.12606185825319               |            Delivery rating, Cooperation rating, should be improved inorder to increase the customer satisfaction.
----------------------------------------------------------------------------------------
 5.03624859586583               |                 Delivery rating, should be improved inorder to increase the customer satisfaction.
----------------------------------------------------------------------------------------
       5.05                     |                                        |
----------------------------------------------------------------------------------------
```

Figure 5-5 : Success path of Main Flow 2 - output

Contradict to the success path of the Main Flow 2, the overall status of the failure path of Main Flow 2 – 'Calculate and compare CDI Validation formula vs CDI results' will be determined by the failure of reading the excel file and displaying an error message. Result of failure path of Main Flow 2 is given below. Overall status is marked as passed considering the below output given that it shows error message when the excel file is not there (excel file read failure).



```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
2

Reading Excel File. Please wait...
Sorry, we couldn't find C:\Projects\Personal\MSc\Semester 6\CDIValidationTool\CDIValidationTool\bin\Debug\InputData.xlsx1. Is it possible it was moved, renamed or delet
ed?
```

Figure 5-6 : Failure path of Main Flow 2 - output

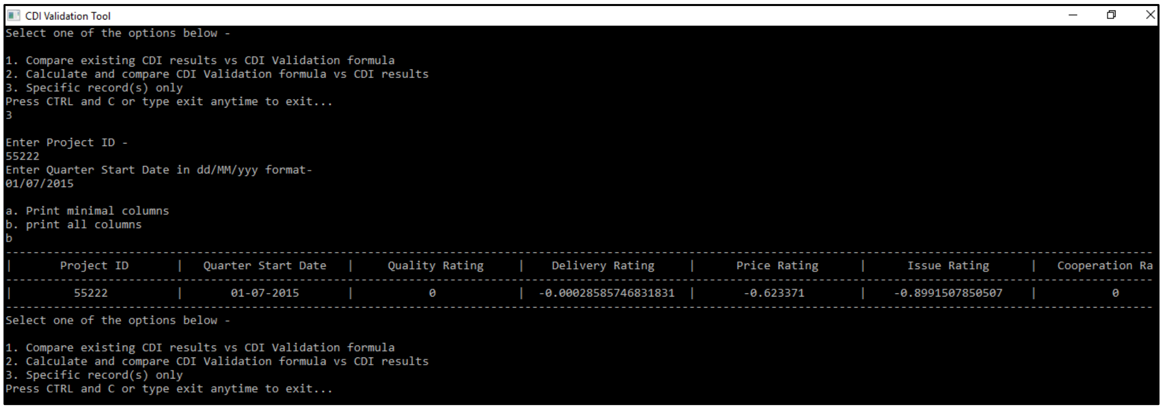
Points to consider from both success and failure path of Main Flow 2 is that the Composite Customer Satisfaction Rating calculated and customer satisfaction score/index follows the strategy mentioned and proves the formula is working in Main Flow 2. The test scenarios and test cases explained in Table 5-2 is valid for Main Flow 2 and addition to that, Table 5-3 consists of test scenarios and test cases for validating Main Flow 2 correctness. Based on the actual outputs, CDI Validation Tool working as expected for Main Flow 2.

Table 5-3 : Other test scenarios evaluation of Main Flow 2

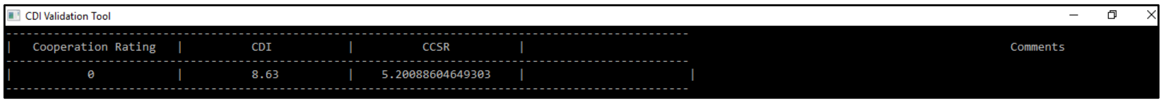
Test Scenario	Expected Output	Actual Output	Overall Status
Failed to read from excel file – one to multiple records, not all records	Errored records should get skip	Errored records skipped and successfully calculated values were displayed in the console as a table	Passed
Failed to read from excel file–all records	An error message should display	Error message "There is no data to display! Please try other options." was displayed in the console.	Passed

5.1.4 Main Flow 3 - Specific record(s) only

Option 3 – 'Specific records(s) only' is extremely helpful if the user wants to know about the Composite Customer Satisfaction Rating and comments for a given project during a given quarter. Therefore, success path of the Main Flow 3 will be reading the input from user, processing it, get the relevant data from database and displaying the Composite Customer Satisfaction Rating and comments in the display. Result of Success path of Main Flow 3 is given below. Output shows that when the user is given a valid project id and/or a valid quarter, the CDI Validation Tool displays the Composite Customer Satisfaction Rating (~5.2) which is greater than 5 and customer satisfaction score/index (8.63) which is greater than 8 determine that during success path of Main Flow 3, it is following the strategy and the overall status of the test is marked as passed.



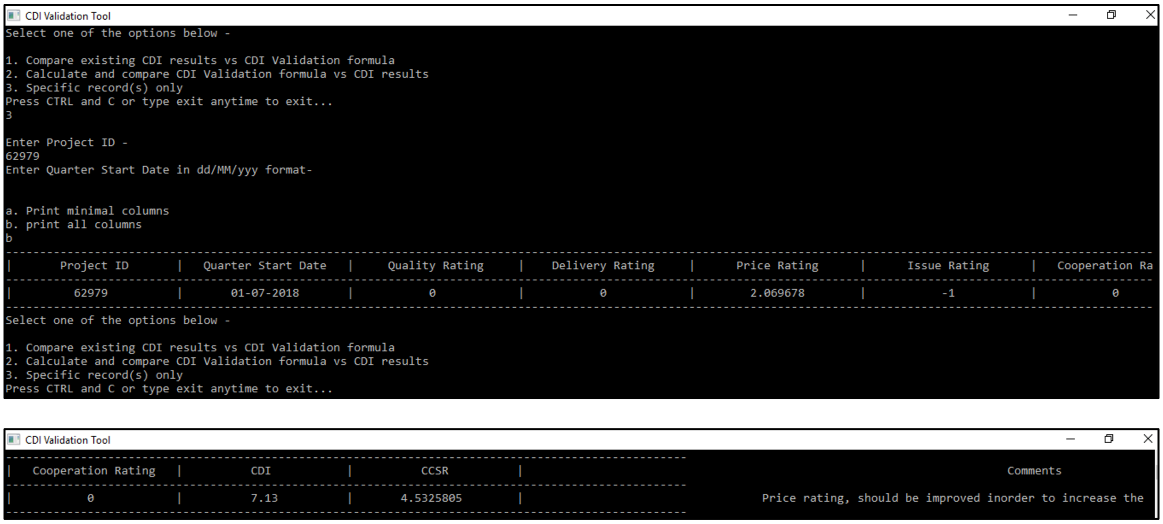
```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
3

Enter Project ID -
55222
Enter Quarter Start Date in dd/MM/yyy format-
01/07/2015

a. Print minimal columns
b. print all columns
b
------------------------------------------------------------------------------------------------------------------------------------------------------------------------
|      Project ID       |  Quarter Start Date   |    Quality Rating     |    Delivery Rating    |     Price Rating      |     Issue Rating      |  Cooperation Ra
------------------------------------------------------------------------------------------------------------------------------------------------------------------------
|        55222          |      01-07-2015       |           0           | -0.00028585746831831  |      -0.623371        |   -0.8991507850507    |          0
------------------------------------------------------------------------------------------------------------------------------------------------------------------------
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
```



```
-----------------------------------------------------------------------------------------------------
|  Cooperation Rating   |          CDI          |         CCSR          |                                                 Comments
-----------------------------------------------------------------------------------------------------
|          0            |         8.63          |   5.20088604649303    |                       |
-----------------------------------------------------------------------------------------------------
```

Figure 5-7 : Success path of Main Flow 3 – output

The failure path of Main Flow 3 – ‘Specific record(s) only’ will be, the CDI Validation Tool generates Composite Customer Satisfaction Score according to the strategy for the given user input. Result of failure path of Main Flow 3 is given below. Output shows that when the user is given a valid project id and/or a valid quarter, the CDI Validation Tool displays the Composite Customer Satisfaction Rating (~4.5) which is less than 5 and customer satisfaction score/index (7.13) which is less than 8 determines that during failure path of Main Flow 3 is following the strategy and the overall status of the test is marked as passed.



```
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
3

Enter Project ID -
62979
Enter Quarter Start Date in dd/MM/yyy format-


a. Print minimal columns
b. print all columns
b
---------------------------------------------------------------------------------------------------------------------------------------------
|      Project ID      |  Quarter Start Date  |    Quality Rating    |    Delivery Rating   |     Price Rating     |     Issue Rating     |  Cooperation Ra
---------------------------------------------------------------------------------------------------------------------------------------------
|        62979         |      01-07-2018      |          0           |          0           |       2.069678       |          -1          |          0
---------------------------------------------------------------------------------------------------------------------------------------------
Select one of the options below -

1. Compare existing CDI results vs CDI Validation formula
2. Calculate and compare CDI Validation formula vs CDI results
3. Specific record(s) only
Press CTRL and C or type exit anytime to exit...
```

```
--------------------------------------------------------------------------------
|  Cooperation Rating  |         CDI          |         CCSR         |                                                 Comments
--------------------------------------------------------------------------------
|          0           |         7.13         |      4.5325805       |                    Price rating, should be improved inorder to increase the
--------------------------------------------------------------------------------
```

Figure 5-8 : Failure path of Main Flow 3 - output

Apart from test scenarios and test cases explained in Table 5-2, following table summarizes the test scenarios and test cases for validating Main Flow 3 accuracy.

Table 5-4 : Other test scenarios evaluation of Main Flow 3

Test Scenario	**Expected Output**	**Actual Output**	**Overall Status**
Empty project id and empty quarter start end	An error message should display	Error message “Please enter a valid project id/ Quarter start date.” was displayed in the console.	Passed
Given user input does not match record in the database	An error message should display	Error message “There is no data to display! Please try other options.” was display in the console.	Passed

5.2 Performance Evaluation

It is required that CDI Validation Tool performs with optimum performance for better user experience. The workload factors were decided based on the article [35]. Following are the hardware properties of the machine where CDI Validation Tool underwent performance testing.

Processor	: Intel® Core™ i5-5200U CPU @ 2.20GHz
Random Access Memory	: 8.00 GB
System Type	: 64-bit Operating System
Operating System	: Windows 10

5.2.1 Performance Evaluation of Main Flow 1

Without changing other factors, the number of records returned for the Main Flow 1 is changed. The complexity and the performance of the CDI Validation Tool depends on the number of records it is processing and the time take to render it in the console. Following table describes number of records processed versus the average execution time taken by CDI Validation Tool.

Table 5-5 : Average execution time with regards to number of records processed – Main Flow 1

Number of Records Processed	Average Execution Time (seconds)
250	8.8
500	8.8
1000	10.9
2500	16.6
3500	20.9

5500	27.2

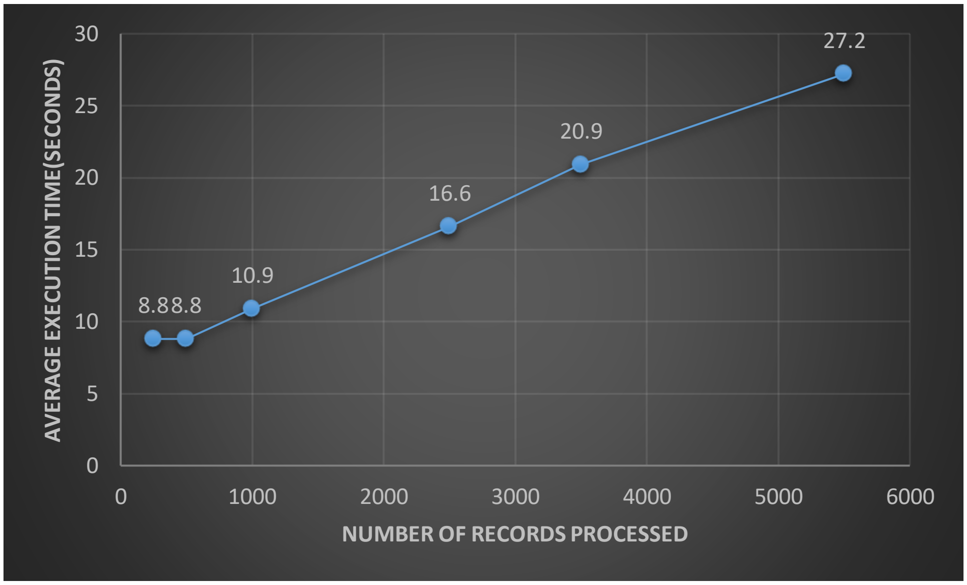


Figure 5-9 : Average execution time with regards to number of records processed graph – Main Flow 1

From the graph, we can identify even though the execution is more or less same up to 500 records, there is a gradual increase in the trend. Therefore, when the number of records to be processed increases then the execution time increases which is expected that if number of records increases then the execution time also should get increased. This is due to a table is rendered in the console. The time taken to retrieve the records and process the records took almost similar duration during all the performance tests.

5.2.2 Performance Evaluation of Main Flow 2

Main Flow 2 includes an excel file reading with the records that should be processed by the CDI Validation Tool. In this case, the complexity and the performance of the CDI Validation Tool depends on the time taken to read the excel file and it plays the major role apart from processing, calculating the Composite Customer Satisfaction Rating and comments and displaying the output. Execution time of CDI Validation Tool with regards to excel file reading and processing of records are shown in below table.

Table 5-6 : Average execution time with regards to number of records processed – Main Flow 2

Number of Records Processed	**Average Execution Time (minutes)**
250	0.6
500	1.22
1000	2.08
2500	4.34
3500	7.48
5500	9.21

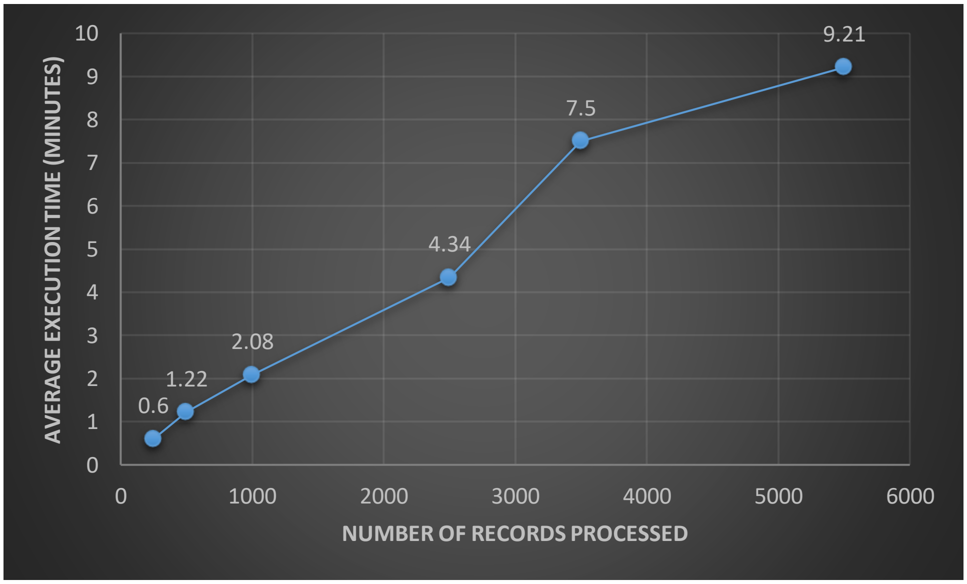


Figure 5-10 : Average execution time with regards to number of records processed graph – Main Flow 2

Compared to Table 5-5, in Table 5-6 the average executive time has changed from seconds to minutes. This is because of excel file reading. It is taking constant time to get the excel object in the all the test cases and the execution time to print the values are equal to average execution time taken during the Main Flow 1 performance testing. But reading of excel values impacting the average execution time. Graph shows a gradual increase in the average execution time with regards to number of records processed though there is an anomaly for reading of 3500 records due to data issues.

5.2.3 Performance Evaluation of Main Flow 3

Main Flow 3 takes 2 parameters from the user. Therefore, there will be 3 performance testing conducted separately. a) By keeping other factors constant and changing the number of records processed for a given project, b) changing the number of records processed for a given quarter by keeping all other factors constant and c) having the combination of project id and quarter as changing factor and keeping other factors as constant will be the 3 test scenarios. But for 3rd scenario, always there will be one record because for a quarter, there can't be multiple calculation for a given project. Thus, finding the average execution time for one record is omitted. Following table shows how the CDI Validation Tool performed for number of records processed for a given project.

Table 5-7 : Average execution time with regards to number of records processed per project– Main Flow 3

Number of Records Processed per Project	Average Execution Time (seconds)
4	3.2
8	3.3
12	3.5
16	3.6
20	3.8

24	3.9

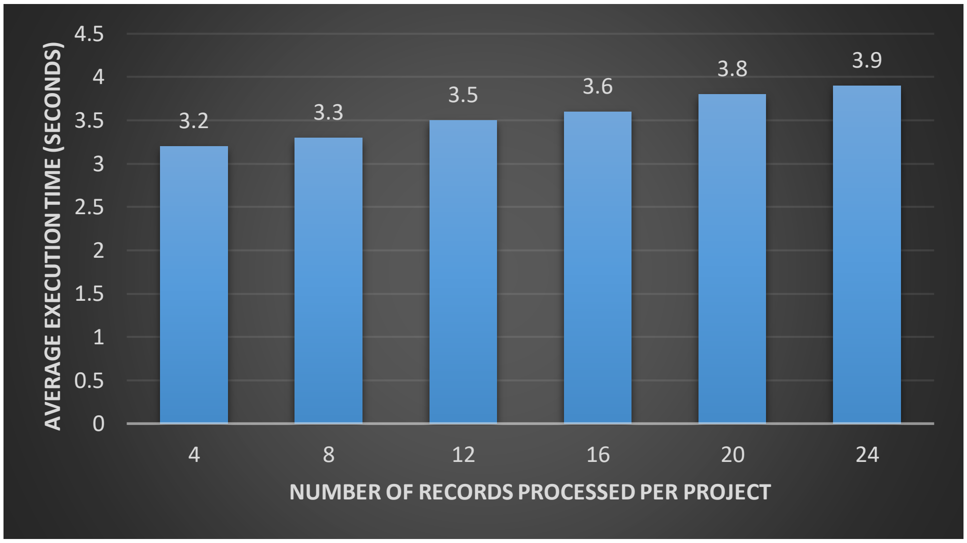


Figure 5-11 : Average execution time with regards to number of records processed per project graph – Main Flow 3

The performance of the CDI Validation Tool is almost same in all the scenarios for Main Flow 3. This depicts that the calculation logic is performing equally. Since the reading the data from database and calculation logic takes similar timing for execution, the deciding factor for the execution time is rendering the result in the console (without considering latency of the user to input data). Following table shows how the CDI Validation Tool performed for number of records processed for a given quarter.

Table 5-8 : Average execution time with regards to number of records processed per quarter – Main Flow 3

Number of Records Processed per Quarter	**Average Execution Time (seconds)**
01-04-2013	3.4
01-10-2012	3.6
01-07-2016	3.8
01-10-2015	4.2

01-01-2018	5
01-10-2018	5.4

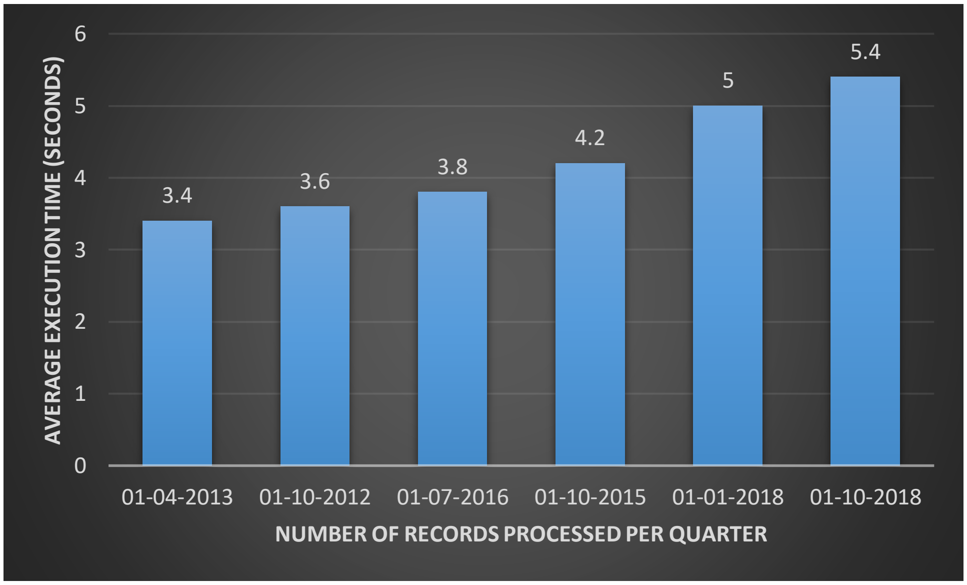


Figure 5-12 : Average execution time with regards to number of records processed per quarter graph – Main Flow 3

There were 28 records for April-June 2013 and it took 3.4 seconds to process. During Oct-Dec 2012, there were 106 records to be processed and it took 3.6 seconds to process. 222 records were processed in 3.8 seconds for Jul-Sep 2016. Average execution time was 4.2 for records 304 during Oct-Dec 2015. There were 373 records for Jan-Mar 2018 and it took 5 seconds to process. During Oct-Dec 2018, there were 379 records to be processed and it took 5.4 seconds. Like previous results, reading the data from database and calculation logic takes similar timing for execution, the deciding factor for the execution time is rendering the result in the console (without considering latency of the user to input data).

Chapter 5 demonstrated the empirical and performance evaluation of the CDI Validation Tool and it is recorded that tool performs and expected during all the scenarios.

Chapter 6

Conclusion

The outline of the thesis is to derive and discover the relationship between the client satisfaction, overview comes about the extend measurements and construct a system/framework so that management or venture administration can act in like manner. The output of the thesis was applied as a pilot run in the motivation example stated in Chapter 1 and results are recorded accordingly. Some of the common topics related to customer satisfaction which are not directly related to software industry also discussed in the thesis. To date, there is no proper research has been done in customer satisfaction in software industry and there is no framework is developed to map the customer satisfaction feedback and software project metrics. The thesis attempts to lay off a foundation for the Client Delight Process of Virtusa Corporation and extend the framework so that other software ventures also can benefit from it.

6.1 Research Contribution

As stated in section 1.4, the focus of this thesis is to find the relationship between the actual customer satisfaction score/index and the software project metrics and to develop a system/framework out of it so that the software ventures can predict the customer satisfaction score/index before requesting the customer satisfaction score/index or before sending out customer satisfaction survey. CDI Validation Tool was developed as proof of concept and Composite Customer Satisfaction Rating was calculated based on the available software project metrics. If the predicted Composite Customer Satisfaction Rating value is lesser than 5 in the 5-point scale then the management or venture administration should focus on improving the relevant area(s) to meet higher customer satisfaction to retain the customer. Now decision makers can make decisions beforehand to eliminate the factors which affects the customer satisfaction based on the output given by the Composite Customer Satisfaction Rating. The system/framework also suggests the area(s) that need to be improved (even though the Composite Customer Satisfaction Rating is equal or greater than 5). This will be beneficial for the project management since it will enhance the satisfactory level of software they deliver and they can retain customers and gain profit via them.

Empirical and performance evaluation is conducted for all three main flows of the CDI Validation Tool and results from empirical evaluation mentions that the methodology and strategy stated in literature review can be applied in real world situations and it can be extended to other software companies as well. Performance evaluation results shows that the CDI Validation Tool performs well as expected in most of the scenarios.

6.2 Limitations

There are some limitations of this research that, currently the CDI Validation Tool can be only used to calculate the Composite Customer Satisfaction Rating and comments of the past and current individual ratings (Quality, Delivery, Price, Issue and Cooperation). To validate the results and to prove the concept will work, it required much data. This cannot be applied to new projects unless similar kind of project is executed before and the Composite Customer Satisfaction Rating is calculated for the same. For this research, Microsoft programming language C# is used since it is widely used and 74.44% of desktop operating system is running Windows which is developed by Microsoft [36]. Even though making this factor as beneficial as it can reach out to most desktop machines, it also makes that the methodology to be bound to the resources and tools available in the respective platforms. Currently it only supports console version. Reading of records from the excel sheet consumes considerable amount of time and it vastly affects the execution time of the CDI Validation Tool.

6.3 Future Work

As the research and thesis output, a tool called CDI Validation tool is developed to prove the concept will work. It’s a basic console application with much features. But this can be intensified with more features. An User Interface (UI) based tool will be user friendly and easy to use for the user. Tool can be extended to predict the future trends of the customer satisfaction score/index or Composite Customer Satisfaction Rating based on the current customer satisfaction/score or Composite Customer Satisfaction Rating. To do this, data mining should be used and extensive amount of data is needed to train the model and get the high accuracy output.

Currently the tool cannot be applied to new projects. But after implementing data mining and based on similar project(s) execution, (based on nature of the software, team size, experience of the team, past customer satisfaction score/index, past Composite Customer Satisfaction Rating) we can apply this for new projects just after couple of weeks after the project kick-off (To compare and predict, actual individual ratings are needed). Reading the excel sheet using Component Object Model (COM) objects is extremely slow since it acquires operating system level privileges. Alternative and speedier approach should be adapted to get the input from the user and calculate the Composite Customer Satisfaction Rating. Solution can be extended among software companies by having a data lake [37], [38] of different software companies and by using machine learning, artificial intelligence and data mining, we can predict the customer satisfaction of similar projects of different ventures and everyone can benefit from it. By creating the framework/platform, will enable the users to access the information where ever from the world using mobile or web. I believe, in future anyone interested could also contribute to the project and devote to customer satisfaction in software industry to make the industry as industry with high customer satisfaction.

References

[1] V. Osetskyi, Medium.com, 30 November 2018. [Online]. Available: https://medium.com/existek/types-of-it-outsourcing-and-types-of-contracts-in-outsourced-software-projects-management-c7b18d7d63ea. [Accessed 06 April 2019].

[2] X. Luo and C. Homburg, "Neglected Outcomes of Customer Satisfaction," *Journal of Marketing,* vol. 71, no. 2, pp. 133-149, 2007.

[3] A. Bhatia, Forester.com, 22 November 2017. [Online]. Available: https://go.forrester.com/blogs/customer-experience-index-india-2017-results/. [Accessed 07 April 2019].

[4] helpscout.com, [Online]. Available: https://www.helpscout.com/75-customer-service-facts-quotes-statistics/. [Accessed 08 April 2019].

[5] J. Rivera, Gartner.com, 19 June 2015. [Online]. Available: https://www.gartner.com/en/newsroom/press-releases/2015-06-09-gartner-says-organizations-are-changing-their-customer-experience-priorities. [Accessed 09 April 2019].

[6] N. Karten, "The Psychology of Customer Satisfaction," boston-spin and ASQ, 2007.

[7] S. Phadnis and R. Ayyar, Indiatimes.com, 31 October 2017. [Online]. Available: https://timesofindia.indiatimes.com/business/india-business/technology-giants-prepare-for-layoffs/articleshow/58585806.cms. [Accessed 09 April 2019].

[8] C. Homburg, N. Koschate and W. D. Hoyer, "Do Satisfied Customers Really Pay More? A Study of the Relationship between Customer Satisfaction and Willingness to Pay," *Journal of Marketing,* vol. 69, no. 2, pp. 84-96, 2005.

[9] T. Hennig-Thurau and A. Klee, "The Impact of Customer Satisfaction and Relationship Quality on Customer Retention: A Critical Reassessment and Model Development," *Psychology & Marketing,* vol. 14, no. 18, p. 737–764, 1997.

[10] J. Kujala and T. Ahola, "The Value of Customer Satisfaction Surveys for Project-based Organizations: Symbolic, Technical, or None," *International Journal of Project Management,* vol. 23, no. 5, p. 04–409, 2005.

[11] W. R. Loomis, "QS-9000 Customer Satisfaction Monitoring Isn't Working," *Quality Progress,* vol. 32, no. 7, pp. 54-59, 1999.

[12] O. Zwikael, "A Road Map towards Customer Satisfaction," *Innovative Marketing,* vol. 2, no. 1, pp. 37-44, 2006.

[13] G. A. Churchill Jr and C. Surprenant, "An Investigation into the Determinants of Customer Satisfaction," *JMR, Journal of Marketing Research,* vol. 19, no. 4, pp. 491-504, 1982.

[14] C. Fornell, M. D. Johnson, E. W. Anderson, J. Cha and B. E. Bryant, "The American Customer Satisfaction Index: Nature, Purpose, and Findings," *Journal of Marketing,* vol. 60, no. 4, pp. 7-18, 1996.

[15] A. A. Jahanshahi, M. A. H. Gashti, S. A. Mirdamadi, K. Nawaser and S. M. S. Khaksar, "Study the Effects of Customer Service and Product Quality on Customer Satisfaction and Loyalty," *International Journal of Humanities and Social Science,* vol. 1, no. 7, pp. 253-260, 2011.

[16] R. Hallowell, "The Relationships of Customer Satisfaction, Customer Loyalty, and Profitability: An Empirical Study," *International Journal of Service Industry Management,* vol. 7, no. 4, pp. 27-42, 1996.

[17] M. R. Rahman and P. K. Safeena, "Customer Needs and Customer Satisfaction," in *Theeranaipunya - Equipping Fisherwomen Youth for Future*, Kochi, ICAR-Central Marine Fisheries Research Institute, 2016, pp. 259-262.

[18] F. A. M. Matog and D. R. Baduu, "Customer Satisfaction in Software Industry," *Global Journal of Advanced Engineering Technologies,* vol. 3, no. 3, pp. 339-344, 2014.

[19] G. Succi, L. Benedicenti and T. Vernazza, "Analysis of The Effects of Software Reuse on Customer Satisfaction In An RPG Environment," *IEEE Transactions on Software Engineering,* vol. 27, no. 5, pp. 473 - 479, 2001.

[20] S. Kekre, M. S. Krishnan and K. Srinivasan, "Drivers of Customer Satisfaction for Software Products: Implications for Design and Service Support," *Management Science,* vol. 41, no. 9, pp. 1456-1470, 1995.

[21] A. Shahin, A. A. Abandi and M. H. M. Javadi, "Analyzing the Relationship between Customer Satisfaction and Loyalty in the Software Industry - With a Case Study in Isfahan System Group," *International Journal of Business and Social Science,* vol. 2, no. 23, pp. 129-136, 2011.

[22] J. W. Whitaker, M. S. Krishnan and C. Fornell, "Does Offshoring Impact Customer Satisfaction?," in *Americas Conference on Information Systems*, Acapulco, 2006.

[23] M. Hanif, S. Hafeez and A. Riaz, "Factors Affecting Customer Satisfaction," *International Research Journal of Finance and Economics,* no. 60, pp. 44-52, 2010.

[24] N. Gautham, ameyo.com, 19 July 2017. [Online]. Available: https://www.ameyo.com/blog/50-important-customer-experience-cx-statistics-you-need-to-know. [Accessed 10 April 2019].

[25] E. W. Anderson, "Customer Satisfaction and Word of Mouth," *Journal of Service Research,* vol. 1, no. 1, pp. 5-17, 1998.

[26] S. Bhatia, J. Li, W. Peng and T. Sun, "Monitoring and Analyzing Customer Feedback Through Social Media Platforms for Identifying and Remedying Customer Problems," *2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining,* pp. 1147-1154, 25-28 August 2013.

[27] N. Hill and J. Brierley, How to Measure Customer Satisfaction, London: Routledge, 2003.

[28] C. Tucker and H. M. Kim, "Predicting Emerging Product Design Trend By Mining Publicly Available Customer Review Data," *International Conference on Engineering Design,* vol. 6, pp. 43-52, 2011.

[29] B. L. B. Anders P. Fundin, "Exploring the Customer Feedback Process," *Measuring Business Excellence,* vol. 7, no. 2, pp. 55-65, 2003.

[30] B. Randall, Slideplayer.com, 2015. [Online]. Available: http://slideplayer.com/slide/6302137/. [Accessed 10 April 2019].

[31] S. E. DeFranzo, snapsurveys.com, 11 June 2014. [Online]. Available: https://www.snapsurveys.com/blog/7-common-mistakes-customer-feedback-3-one-channel/. [Accessed 11 April 2019].

[32] D. C. Swaddling and C. Miller, "Don't Measure Customer Satisfaction - Customer Perceived Value is a Better Alternative to Traditional Customer Satisfaction Measurements," *Quality Progress,* pp. 62-67, 2002.

[33] L. Barbier, "How to Measure Customer Satisfaction, and Why It's So Important," aircall.io, [Online]. Available: https://aircall.io/blog/customer-happiness/how-to-measure-customer-satisfaction/. [Accessed 12 April 2019].

[34] M. Chemuturi, "How to Measure Customer Satisfaction," Chemuturi Consultants, 2007.

[35] E. J. Weyuker and F. I. Vokolos, "Experience with Performance Testing of Software Systems: Issues, an Approach, and Case Study," *IEEE Transactions on Software Engineering,* vol. 26, no. 12, pp. 1147-1156, 2000.

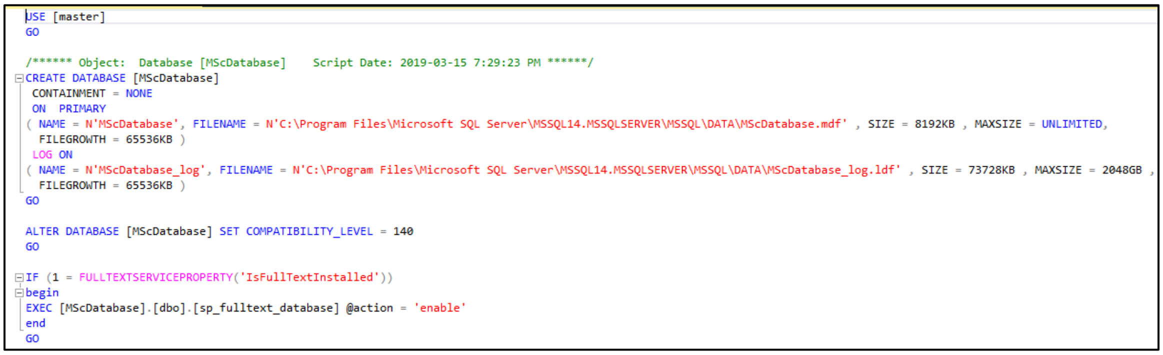
[36] statcounter.com, [Online]. Available: http://gs.statcounter.com/os-market-share/desktop/worldwide/. [Accessed 12 April 2019].

[37] Digite, Digite.com, 06 March 2019. [Online]. Available: https://www.digite.com/news/the-worlds-first-xai-explainable-ai-product-for-enterprise-project-intelligence/. [Accessed 12 April 2019].

[38] A. A. Swarup, Digite.com, 11 March 2019. [Online]. Available: https://www.digite.com/blog/xai-explainable-ai-contextual-introduction/. [Accessed 12 April 2019].

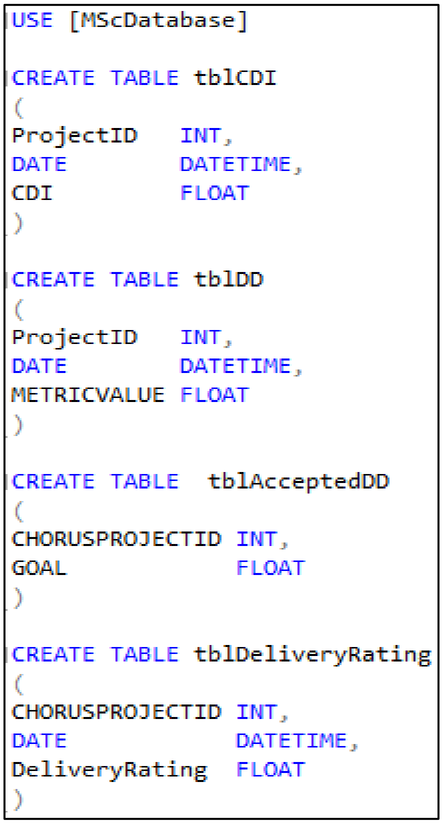
Appendices

Appendix A – SQL Queries used for Data Extraction



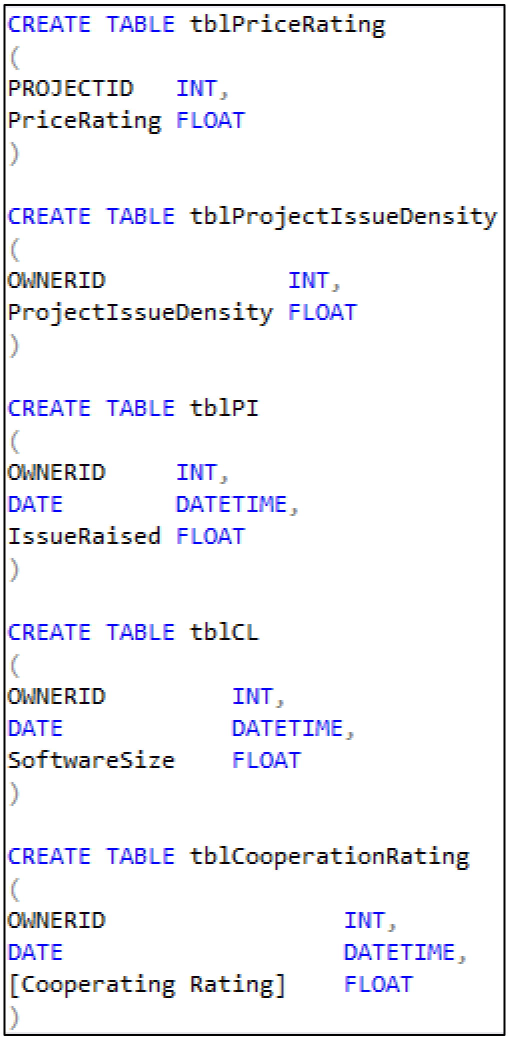
```
USE [master]
GO

/****** Object:  Database [MScDatabase]    Script Date: 2019-03-15 7:29:23 PM ******/
CREATE DATABASE [MScDatabase]
 CONTAINMENT = NONE
 ON  PRIMARY
( NAME = N'MScDatabase', FILENAME = N'C:\Program Files\Microsoft SQL Server\MSSQL14.MSSQLSERVER\MSSQL\DATA\MScDatabase.mdf' , SIZE = 8192KB , MAXSIZE = UNLIMITED,
  FILEGROWTH = 65536KB )
 LOG ON
( NAME = N'MScDatabase_log', FILENAME = N'C:\Program Files\Microsoft SQL Server\MSSQL14.MSSQLSERVER\MSSQL\DATA\MScDatabase_log.ldf' , SIZE = 73728KB , MAXSIZE = 2048GB ,
  FILEGROWTH = 65536KB )
GO

ALTER DATABASE [MScDatabase] SET COMPATIBILITY_LEVEL = 140
GO

IF (1 = FULLTEXTSERVICEPROPERTY('IsFullTextInstalled'))
begin
EXEC [MScDatabase].[dbo].[sp_fulltext_database] @action = 'enable'
end
GO
```

Appendix 1 : Queries used to create database



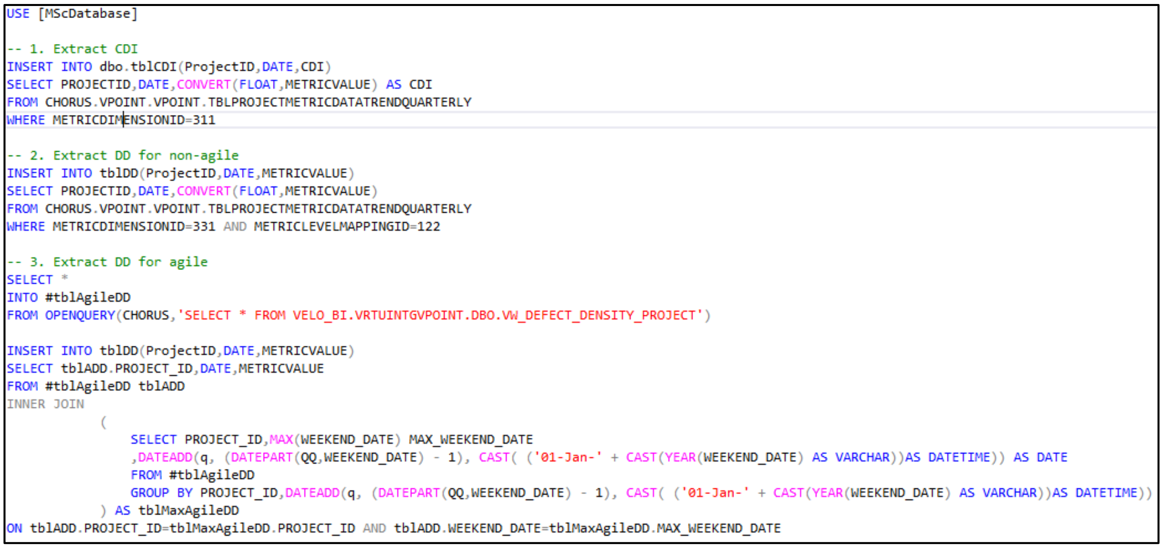
```
USE [MScDatabase]

CREATE TABLE tblCDI
(
ProjectID   INT,
DATE        DATETIME,
CDI         FLOAT
)

CREATE TABLE tblDD
(
ProjectID   INT,
DATE        DATETIME,
METRICVALUE FLOAT
)

CREATE TABLE  tblAcceptedDD
(
CHORUSPROJECTID INT,
GOAL            FLOAT
)

CREATE TABLE tblDeliveryRating
(
CHORUSPROJECTID INT,
DATE            DATETIME,
DeliveryRating  FLOAT
)
```

Appendix 2 : Queries used to create tables 1



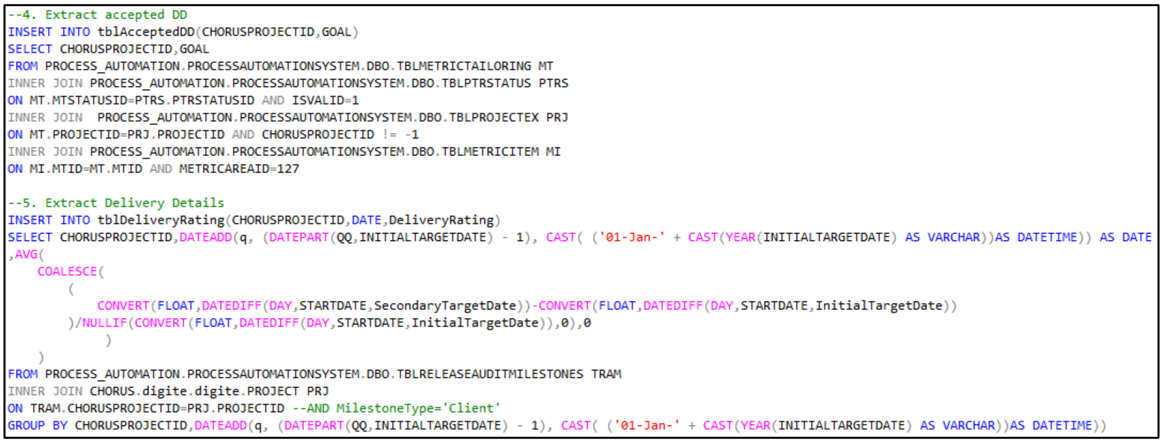
```
CREATE TABLE tblPriceRating
(
PROJECTID   INT,
PriceRating FLOAT
)

CREATE TABLE tblProjectIssueDensity
(
OWNERID             INT,
ProjectIssueDensity FLOAT
)

CREATE TABLE tblPI
(
OWNERID     INT,
DATE        DATETIME,
IssueRaised FLOAT
)

CREATE TABLE tblCL
(
OWNERID         INT,
DATE            DATETIME,
SoftwareSize    FLOAT
)

CREATE TABLE tblCooperationRating
(
OWNERID                 INT,
DATE                    DATETIME,
[Cooperating Rating]    FLOAT
)
```

Appendix 3 : Queries used to create tables 2



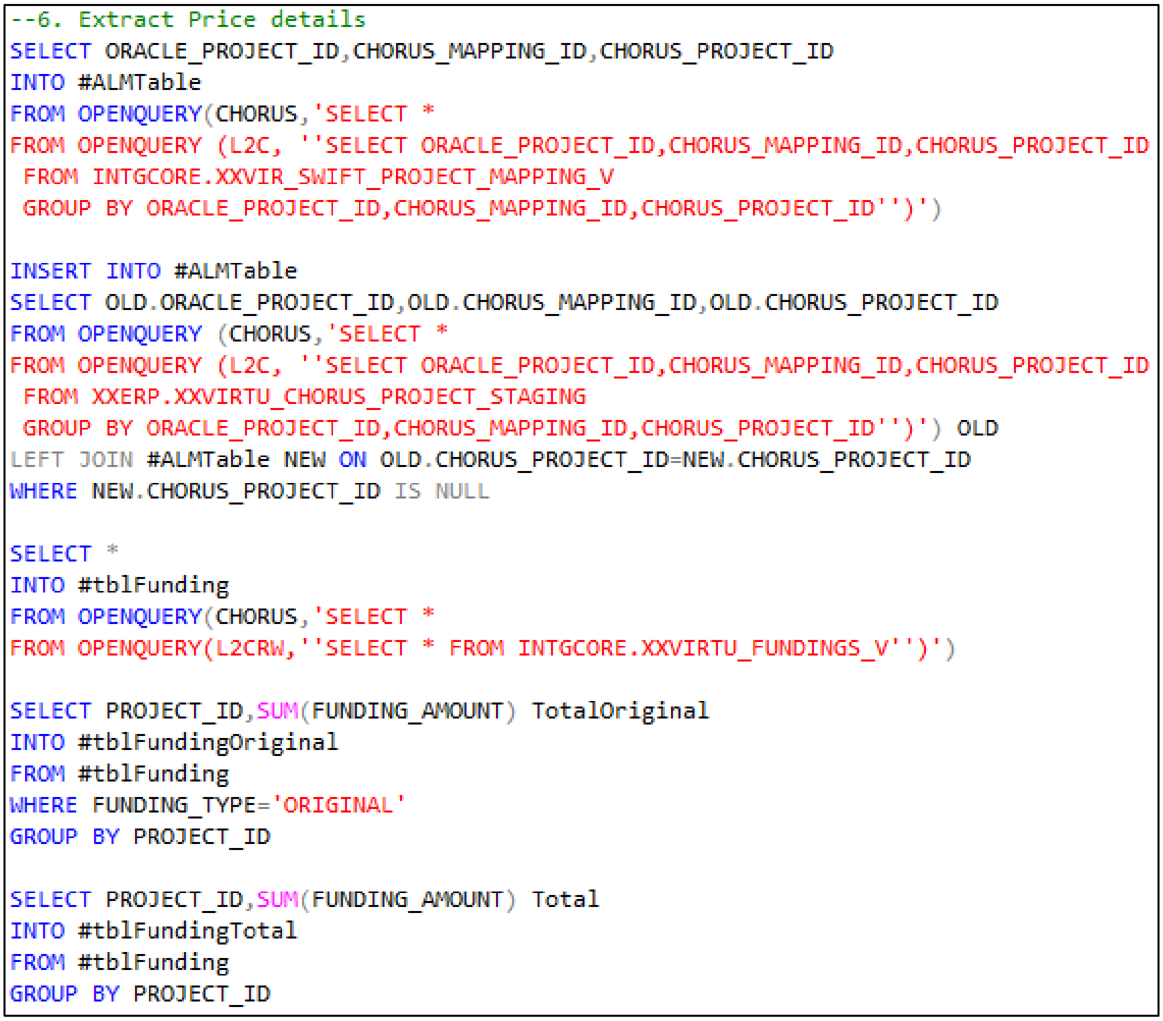
```sql
USE [MScDatabase]

-- 1. Extract CDI
INSERT INTO dbo.tblCDI(ProjectID,DATE,CDI)
SELECT PROJECTID,DATE,CONVERT(FLOAT,METRICVALUE) AS CDI
FROM CHORUS.VPOINT.VPOINT.TBLPROJECTMETRICDATATRENDQUARTERLY
WHERE METRICDIMENSIONID=311

-- 2. Extract DD for non-agile
INSERT INTO tblDD(ProjectID,DATE,METRICVALUE)
SELECT PROJECTID,DATE,CONVERT(FLOAT,METRICVALUE)
FROM CHORUS.VPOINT.VPOINT.TBLPROJECTMETRICDATATRENDQUARTERLY
WHERE METRICDIMENSIONID=331 AND METRICLEVELMAPPINGID=122

-- 3. Extract DD for agile
SELECT *
INTO #tblAgileDD
FROM OPENQUERY(CHORUS,'SELECT * FROM VELO_BI.VRTUINTGVPOINT.DBO.VW_DEFECT_DENSITY_PROJECT')

INSERT INTO tblDD(ProjectID,DATE,METRICVALUE)
SELECT tblADD.PROJECT_ID,DATE,METRICVALUE
FROM #tblAgileDD tblADD
INNER JOIN
            (
                SELECT PROJECT_ID,MAX(WEEKEND_DATE) MAX_WEEKEND_DATE
                ,DATEADD(q, (DATEPART(QQ,WEEKEND_DATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(WEEKEND_DATE) AS VARCHAR))AS DATETIME)) AS DATE
                FROM #tblAgileDD
                GROUP BY PROJECT_ID,DATEADD(q, (DATEPART(QQ,WEEKEND_DATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(WEEKEND_DATE) AS VARCHAR))AS DATETIME))
            ) AS tblMaxAgileDD
ON tblADD.PROJECT_ID=tblMaxAgileDD.PROJECT_ID AND tblADD.WEEKEND_DATE=tblMaxAgileDD.MAX_WEEKEND_DATE
```

Appendix 4 : Queries used to extract data 1



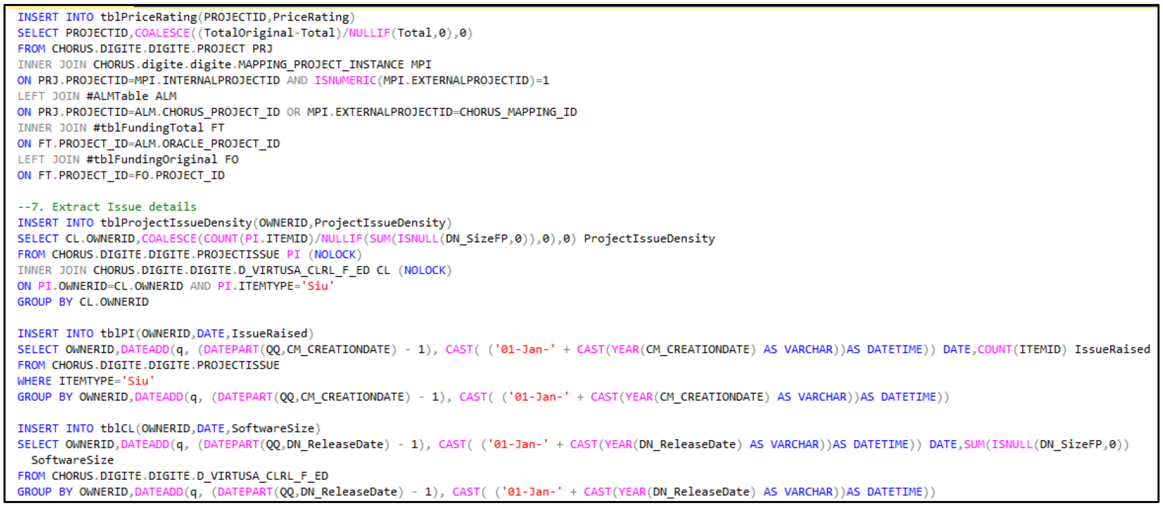
```sql
--4. Extract accepted DD
INSERT INTO tblAcceptedDD(CHORUSPROJECTID,GOAL)
SELECT CHORUSPROJECTID,GOAL
FROM PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLMETRICTAILORING MT
INNER JOIN PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLPTRSTATUS PTRS
ON MT.MTSTATUSID=PTRS.PTRSTATUSID AND ISVALID=1
INNER JOIN  PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLPROJECTEX PRJ
ON MT.PROJECTID=PRJ.PROJECTID AND CHORUSPROJECTID != -1
INNER JOIN PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLMETRICITEM MI
ON MI.MTID=MT.MTID AND METRICAREAID=127

--5. Extract Delivery Details
INSERT INTO tblDeliveryRating(CHORUSPROJECTID,DATE,DeliveryRating)
SELECT CHORUSPROJECTID,DATEADD(q, (DATEPART(QQ,INITIALTARGETDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(INITIALTARGETDATE) AS VARCHAR))AS DATETIME)) AS DATE
,AVG(
    COALESCE(
        (
            CONVERT(FLOAT,DATEDIFF(DAY,STARTDATE,SecondaryTargetDate))-CONVERT(FLOAT,DATEDIFF(DAY,STARTDATE,InitialTargetDate))
        )/NULLIF(CONVERT(FLOAT,DATEDIFF(DAY,STARTDATE,InitialTargetDate)),0),0
             )
    )
FROM PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLRELEASEAUDITMILESTONES TRAM
INNER JOIN CHORUS.digite.digite.PROJECT PRJ
ON TRAM.CHORUSPROJECTID=PRJ.PROJECTID --AND MilestoneType='Client'
GROUP BY CHORUSPROJECTID,DATEADD(q, (DATEPART(QQ,INITIALTARGETDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(INITIALTARGETDATE) AS VARCHAR))AS DATETIME))
```

Appendix 5 : Queries used to extract data 2



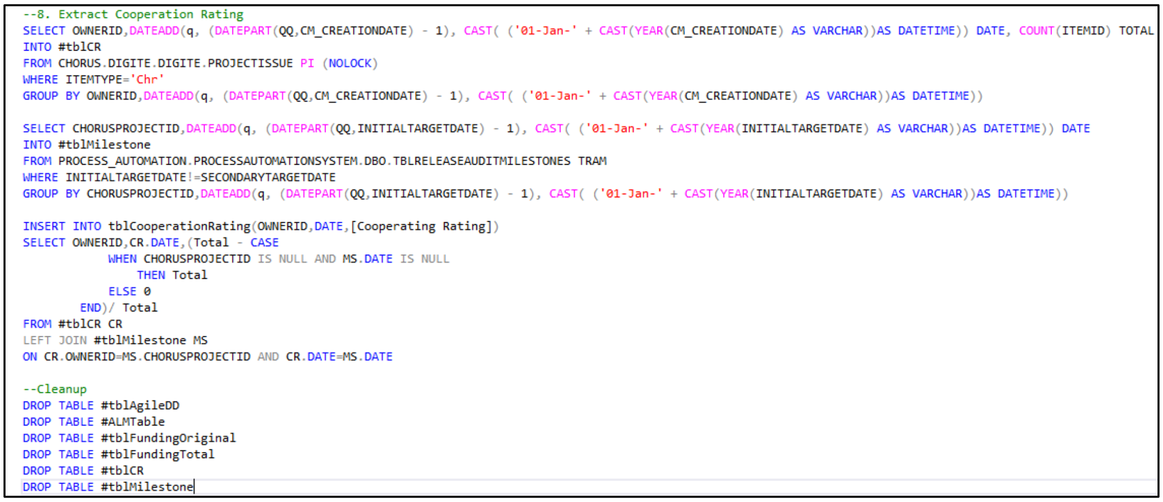
```
--6. Extract Price details
SELECT ORACLE_PROJECT_ID,CHORUS_MAPPING_ID,CHORUS_PROJECT_ID
INTO #ALMTable
FROM OPENQUERY(CHORUS,'SELECT *
FROM OPENQUERY (L2C, ''SELECT ORACLE_PROJECT_ID,CHORUS_MAPPING_ID,CHORUS_PROJECT_ID
 FROM INTGCORE.XXVIR_SWIFT_PROJECT_MAPPING_V
 GROUP BY ORACLE_PROJECT_ID,CHORUS_MAPPING_ID,CHORUS_PROJECT_ID'')')

INSERT INTO #ALMTable
SELECT OLD.ORACLE_PROJECT_ID,OLD.CHORUS_MAPPING_ID,OLD.CHORUS_PROJECT_ID
FROM OPENQUERY (CHORUS,'SELECT *
FROM OPENQUERY (L2C, ''SELECT ORACLE_PROJECT_ID,CHORUS_MAPPING_ID,CHORUS_PROJECT_ID
 FROM XXERP.XXVIRTU_CHORUS_PROJECT_STAGING
 GROUP BY ORACLE_PROJECT_ID,CHORUS_MAPPING_ID,CHORUS_PROJECT_ID'')') OLD
LEFT JOIN #ALMTable NEW ON OLD.CHORUS_PROJECT_ID=NEW.CHORUS_PROJECT_ID
WHERE NEW.CHORUS_PROJECT_ID IS NULL

SELECT *
INTO #tblFunding
FROM OPENQUERY(CHORUS,'SELECT *
FROM OPENQUERY(L2CRW,''SELECT * FROM INTGCORE.XXVIRTU_FUNDINGS_V'')')

SELECT PROJECT_ID,SUM(FUNDING_AMOUNT) TotalOriginal
INTO #tblFundingOriginal
FROM #tblFunding
WHERE FUNDING_TYPE='ORIGINAL'
GROUP BY PROJECT_ID

SELECT PROJECT_ID,SUM(FUNDING_AMOUNT) Total
INTO #tblFundingTotal
FROM #tblFunding
GROUP BY PROJECT_ID
```

Appendix 6 : Queries used to extract data 3



```
INSERT INTO tblPriceRating(PROJECTID,PriceRating)
SELECT PROJECTID,COALESCE((TotalOriginal-Total)/NULLIF(Total,0),0)
FROM CHORUS.DIGITE.DIGITE.PROJECT PRJ
INNER JOIN CHORUS.digite.digite.MAPPING_PROJECT_INSTANCE MPI
ON PRJ.PROJECTID=MPI.INTERNALPROJECTID AND ISNUMERIC(MPI.EXTERNALPROJECTID)=1
LEFT JOIN #ALMTable ALM
ON PRJ.PROJECTID=ALM.CHORUS_PROJECT_ID OR MPI.EXTERNALPROJECTID=CHORUS_MAPPING_ID
INNER JOIN #tblFundingTotal FT
ON FT.PROJECT_ID=ALM.ORACLE_PROJECT_ID
LEFT JOIN #tblFundingOriginal FO
ON FT.PROJECT_ID=FO.PROJECT_ID

--7. Extract Issue details
INSERT INTO tblProjectIssueDensity(OWNERID,ProjectIssueDensity)
SELECT CL.OWNERID,COALESCE(COUNT(PI.ITEMID)/NULLIF(SUM(ISNULL(DN_SizeFP,0)),0),0) ProjectIssueDensity
FROM CHORUS.DIGITE.DIGITE.PROJECTISSUE PI (NOLOCK)
INNER JOIN CHORUS.DIGITE.DIGITE.D_VIRTUSA_CLRL_F_ED CL (NOLOCK)
ON PI.OWNERID=CL.OWNERID AND PI.ITEMTYPE='Siu'
GROUP BY CL.OWNERID

INSERT INTO tblPI(OWNERID,DATE,IssueRaised)
SELECT OWNERID,DATEADD(q, (DATEPART(QQ,CM_CREATIONDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(CM_CREATIONDATE) AS VARCHAR))AS DATETIME)) DATE,COUNT(ITEMID) IssueRaised
FROM CHORUS.DIGITE.DIGITE.PROJECTISSUE
WHERE ITEMTYPE='Siu'
GROUP BY OWNERID,DATEADD(q, (DATEPART(QQ,CM_CREATIONDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(CM_CREATIONDATE) AS VARCHAR))AS DATETIME))

INSERT INTO tblCL(OWNERID,DATE,SoftwareSize)
SELECT OWNERID,DATEADD(q, (DATEPART(QQ,DN_ReleaseDate) - 1), CAST( ('01-Jan-' + CAST(YEAR(DN_ReleaseDate) AS VARCHAR))AS DATETIME)) DATE,SUM(ISNULL(DN_SizeFP,0))
  SoftwareSize
FROM CHORUS.DIGITE.DIGITE.D_VIRTUSA_CLRL_F_ED
GROUP BY OWNERID,DATEADD(q, (DATEPART(QQ,DN_ReleaseDate) - 1), CAST( ('01-Jan-' + CAST(YEAR(DN_ReleaseDate) AS VARCHAR))AS DATETIME))
```

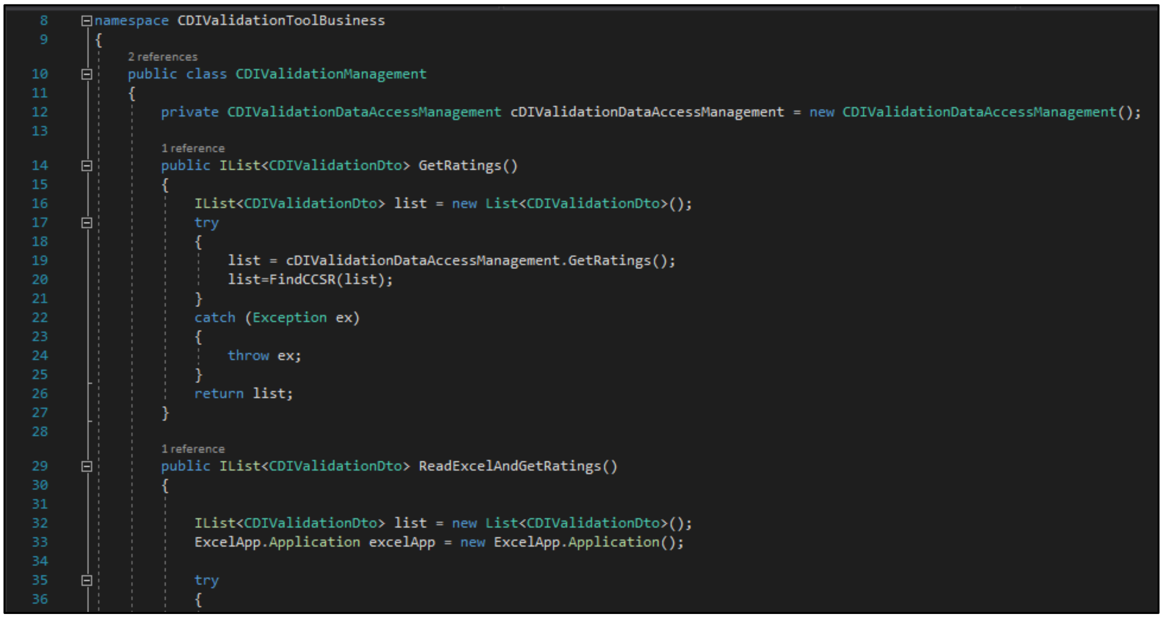
Appendix 7 : Queries used to extract data 4



```
--8. Extract Cooperation Rating
SELECT OWNERID,DATEADD(q, (DATEPART(QQ,CM_CREATIONDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(CM_CREATIONDATE) AS VARCHAR))AS DATETIME)) DATE, COUNT(ITEMID) TOTAL
INTO #tblCR
FROM CHORUS.DIGITE.DIGITE.PROJECTISSUE PI (NOLOCK)
WHERE ITEMTYPE='Chr'
GROUP BY OWNERID,DATEADD(q, (DATEPART(QQ,CM_CREATIONDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(CM_CREATIONDATE) AS VARCHAR))AS DATETIME))

SELECT CHORUSPROJECTID,DATEADD(q, (DATEPART(QQ,INITIALTARGETDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(INITIALTARGETDATE) AS VARCHAR))AS DATETIME)) DATE
INTO #tblMilestone
FROM PROCESS_AUTOMATION.PROCESSAUTOMATIONSYSTEM.DBO.TBLRELEASEAUDITMILESTONES TRAM
WHERE INITIALTARGETDATE!=SECONDARYTARGETDATE
GROUP BY CHORUSPROJECTID,DATEADD(q, (DATEPART(QQ,INITIALTARGETDATE) - 1), CAST( ('01-Jan-' + CAST(YEAR(INITIALTARGETDATE) AS VARCHAR))AS DATETIME))

INSERT INTO tblCooperationRating(OWNERID,DATE,[Cooperating Rating])
SELECT OWNERID,CR.DATE,(Total - CASE
            WHEN CHORUSPROJECTID IS NULL AND MS.DATE IS NULL
                THEN Total
            ELSE 0
        END)/ Total
FROM #tblCR CR
LEFT JOIN #tblMilestone MS
ON CR.OWNERID=MS.CHORUSPROJECTID AND CR.DATE=MS.DATE

--Cleanup
DROP TABLE #tblAgileDD
DROP TABLE #ALMTable
DROP TABLE #tblFundingOriginal
DROP TABLE #tblFundingTotal
DROP TABLE #tblCR
DROP TABLE #tblMilestone
```

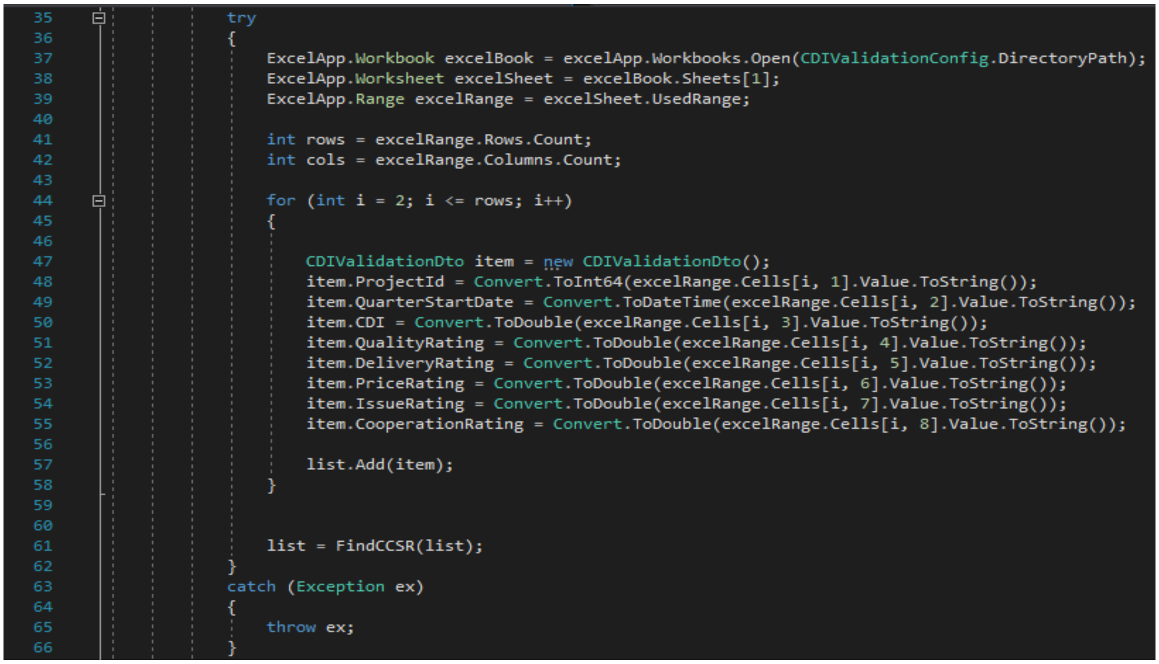
Appendix 8 : Queries used to extract data 5

Appendix B – Classes of Business Layer and Data Layer



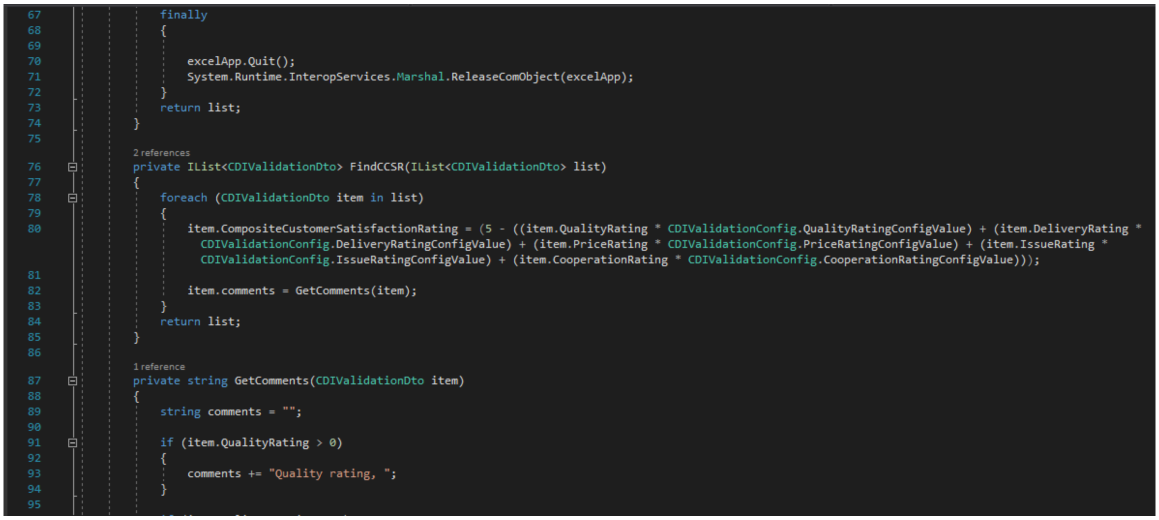
```
namespace CDIValidationToolBusiness
{
    2 references
    public class CDIValidationManagement
    {
        private CDIValidationDataAccessManagement cDIValidationDataAccessManagement = new CDIValidationDataAccessManagement();

        1 reference
        public IList<CDIValidationDto> GetRatings()
        {
            IList<CDIValidationDto> list = new List<CDIValidationDto>();
            try
            {
                list = cDIValidationDataAccessManagement.GetRatings();
                list=FindCCSR(list);
            }
            catch (Exception ex)
            {
                throw ex;
            }
            return list;
        }

        1 reference
        public IList<CDIValidationDto> ReadExcelAndGetRatings()
        {

            IList<CDIValidationDto> list = new List<CDIValidationDto>();
            ExcelApp.Application excelApp = new ExcelApp.Application();

            try
            {
```

Appendix 9 : Business Layer class 1



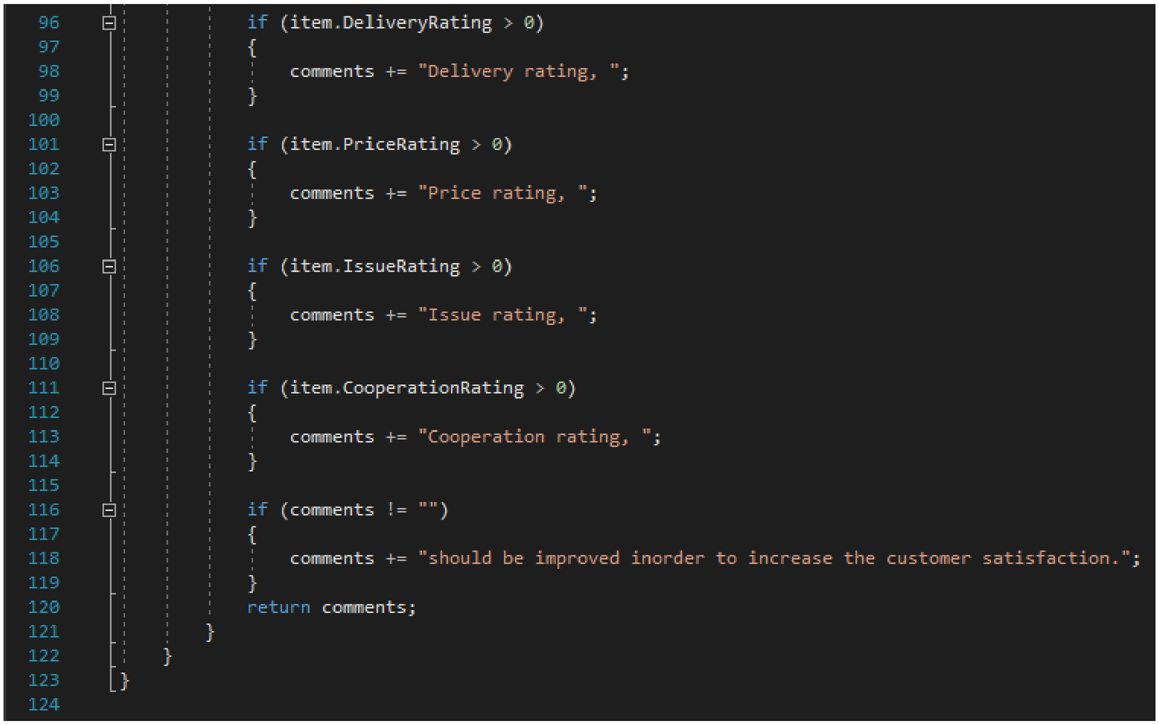
```
            try
            {
                ExcelApp.Workbook excelBook = excelApp.Workbooks.Open(CDIValidationConfig.DirectoryPath);
                ExcelApp.Worksheet excelSheet = excelBook.Sheets[1];
                ExcelApp.Range excelRange = excelSheet.UsedRange;

                int rows = excelRange.Rows.Count;
                int cols = excelRange.Columns.Count;

                for (int i = 2; i <= rows; i++)
                {

                    CDIValidationDto item = new CDIValidationDto();
                    item.ProjectId = Convert.ToInt64(excelRange.Cells[i, 1].Value.ToString());
                    item.QuarterStartDate = Convert.ToDateTime(excelRange.Cells[i, 2].Value.ToString());
                    item.CDI = Convert.ToDouble(excelRange.Cells[i, 3].Value.ToString());
                    item.QualityRating = Convert.ToDouble(excelRange.Cells[i, 4].Value.ToString());
                    item.DeliveryRating = Convert.ToDouble(excelRange.Cells[i, 5].Value.ToString());
                    item.PriceRating = Convert.ToDouble(excelRange.Cells[i, 6].Value.ToString());
                    item.IssueRating = Convert.ToDouble(excelRange.Cells[i, 7].Value.ToString());
                    item.CooperationRating = Convert.ToDouble(excelRange.Cells[i, 8].Value.ToString());

                    list.Add(item);
                }


                list = FindCCSR(list);
            }
            catch (Exception ex)
            {
                throw ex;
            }
```

Appendix 10 : Business Layer class 2



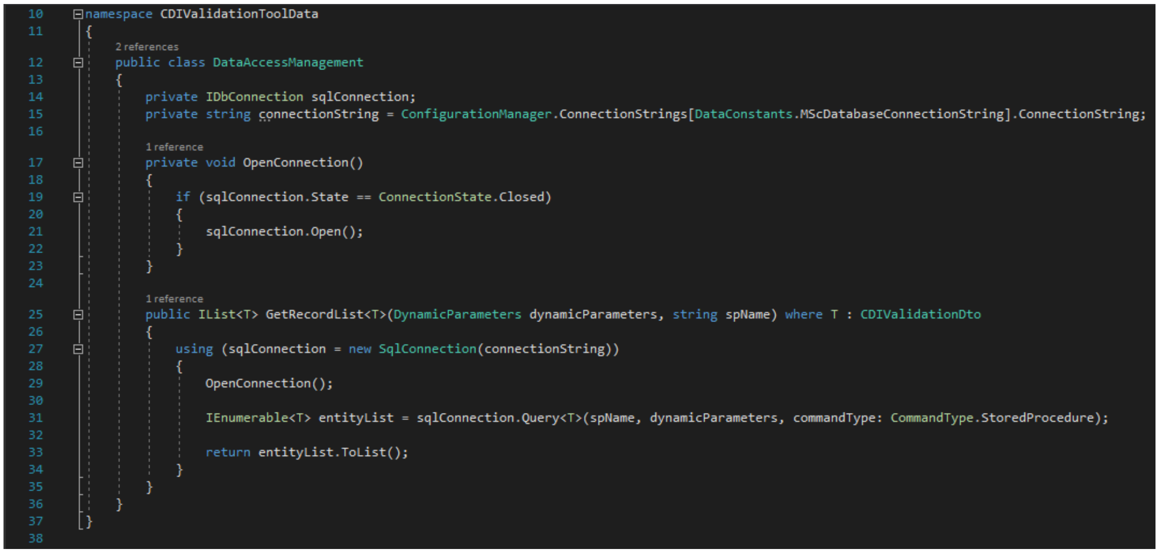
```
            finally
            {

                excelApp.Quit();
                System.Runtime.InteropServices.Marshal.ReleaseComObject(excelApp);
            }
            return list;
        }

        2 references
        private IList<CDIValidationDto> FindCCSR(IList<CDIValidationDto> list)
        {
            foreach (CDIValidationDto item in list)
            {
                item.CompositeCustomerSatisfactionRating = (5 - ((item.QualityRating * CDIValidationConfig.QualityRatingConfigValue) + (item.DeliveryRating *
                  CDIValidationConfig.DeliveryRatingConfigValue) + (item.PriceRating * CDIValidationConfig.PriceRatingConfigValue) + (item.IssueRating *
                  CDIValidationConfig.IssueRatingConfigValue) + (item.CooperationRating * CDIValidationConfig.CooperationRatingConfigValue)));

                item.comments = GetComments(item);
            }
            return list;
        }

        1 reference
        private string GetComments(CDIValidationDto item)
        {
            string comments = "";

            if (item.QualityRating > 0)
            {
                comments += "Quality rating, ";
            }

```

Appendix 11 : Business Layer class 3



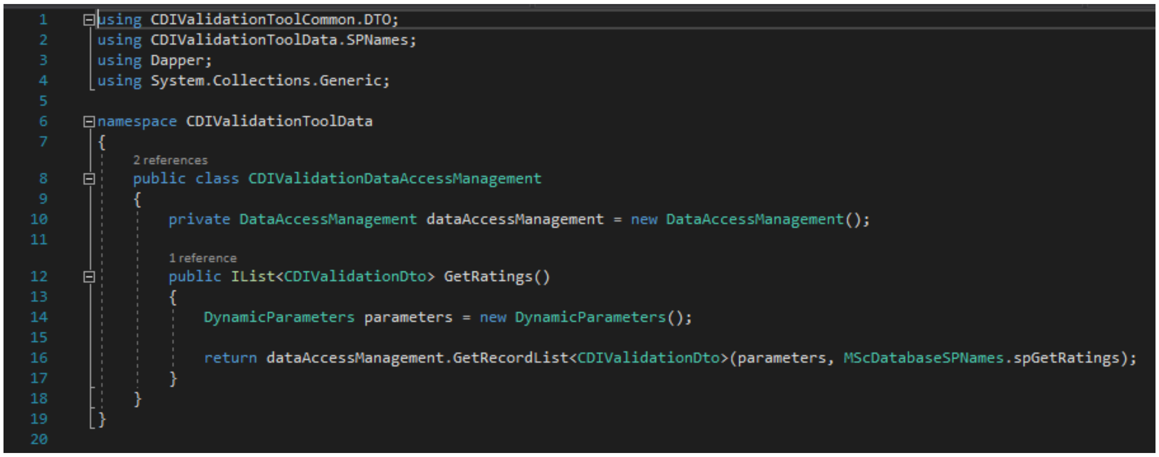
```
            if (item.DeliveryRating > 0)
            {
                comments += "Delivery rating, ";
            }

            if (item.PriceRating > 0)
            {
                comments += "Price rating, ";
            }

            if (item.IssueRating > 0)
            {
                comments += "Issue rating, ";
            }

            if (item.CooperationRating > 0)
            {
                comments += "Cooperation rating, ";
            }

            if (comments != "")
            {
                comments += "should be improved inorder to increase the customer satisfaction.";
            }
            return comments;
        }
    }
}

```

Appendix 12 : Business Layer class 4



```
namespace CDIValidationToolData
{
    2 references
    public class DataAccessManagement
    {
        private IDbConnection sqlConnection;
        private string connectionString = ConfigurationManager.ConnectionStrings[DataConstants.MScDatabaseConnectionString].ConnectionString;

        1 reference
        private void OpenConnection()
        {
            if (sqlConnection.State == ConnectionState.Closed)
            {
                sqlConnection.Open();
            }
        }

        1 reference
        public IList<T> GetRecordList<T>(DynamicParameters dynamicParameters, string spName) where T : CDIValidationDto
        {
            using (sqlConnection = new SqlConnection(connectionString))
            {
                OpenConnection();

                IEnumerable<T> entityList = sqlConnection.Query<T>(spName, dynamicParameters, commandType: CommandType.StoredProcedure);

                return entityList.ToList();
            }
        }
    }
}
```

Appendix 13 : Data Layer class 1



```
using CDIValidationToolCommon.DTO;
using CDIValidationToolData.SPNames;
using Dapper;
using System.Collections.Generic;

namespace CDIValidationToolData
{
    2 references
    public class CDIValidationDataAccessManagement
    {
        private DataAccessManagement dataAccessManagement = new DataAccessManagement();

        1 reference
        public IList<CDIValidationDto> GetRatings()
        {
            DynamicParameters parameters = new DynamicParameters();

            return dataAccessManagement.GetRecordList<CDIValidationDto>(parameters, MScDatabaseSPNames.spGetRatings);
        }
    }
}
```

Appendix 14 : Data Layer class 2