

**ENHANCING USER-STORIES PRIORITIZATION
PROCESS IN AGILE ENVIRONMENT**

Dissertation submitted in fulfilment of the requirements for the Degree of

**MASTER OF TECHNOLOGY
in
COMPUTER SCIENCE AND ENGINEERING**

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PAC Form



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ABSTRACT

Agile software development life cycle is mostly being used in the organizations to develop a high quality software system and it provides rapid delivery of the product to customer. In Agile environment, the requirements or features to be deliver are taken in the form of user-stories. The user-stories are to be prioritized for better quality and maintaining business value of the software in the market. The user-stories prioritization depends upon various factors like cost, time and resources etc. There are some methods that are used to prioritize user user-stories but these methods are not efficient as per the literature review done. In this research work, some factors are considered on the basis of which the agile user-stories are prioritized in agile environment. The proposed research work will help software organizations to enhance user-stories prioritization process.

DECLARATION STATEMENT

I hereby declare that the research work reported in the dissertation entitled "ENHANCING USER-STORIES PRIORITIZATION PROCESS IN AGILE ENVIRONMENT" in partial fulfilment of the requirement for the award of Degree for Master of Technology in Computer Science and Engineering at Lovely Professional University, Phagwara, Punjab is an authentic work carried out under supervision of my research supervisor Ms. Gurpreet Kour. I have not submitted this work elsewhere for any degree or diploma.

I understand that the work presented herewith is in direct compliance with Lovely Professional University's Policy on plagiarism, intellectual property rights, and highest standards of moral and ethical conduct. Therefore, to the best of my knowledge, the content of this dissertation represents authentic and honest research effort conducted, in its entirety, by me. I am fully responsible for the contents of my dissertation work.

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SUPERVISOR’S CERTIFICATE

This is to certify that the work reported in the M.Tech Dissertation entitled **“ENHANCING USER-STORIES PRIORITIZATION PROCESS IN AGILE ENVIRONMENT”**, submitted by **Heera** at **Lovely Professional University, Phagwara, India** is a bonafide record of his original work carried out under my supervision. This work has not been submitted elsewhere for any other degree.

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CHAPTER 1

INTRODUCTION

In present day, Agile Software Development Methodologies (ASDM) are mostly being used by organizations to develop a better quality software in the competing market. Agile software development life cycle methodologies are more popular as compare to traditional software development life cycle (SDLC) models. The agile methodologies have many advantages over traditional approaches like quality of software, efficient utilization of resources, and rapid delivery of software.

1.1 Introduction

In agile environment, the requirement prioritization is a very first step after the user-stories are gathered. The user requirements in agile are treated as user-stories. User-stories are developed the clients as per their requirements and these user-stories are prioritized by the product owner by discussing them with project manager and other stakeholders. There are some traditional techniques used for prioritizing these user-stories like MoSCoW (Must Should Could Won't) method, walking skeleton and validate learning methods [1].

The user-stories prioritization process starts with the planning phase and it remains throughout the project duration. The product owner takes user-stories from clients and put these user-stories in product backlog. The product backlog contains prioritized user-stories and priority is managed for the successful delivery of the product to the clients. The user-stories that have high priority are implemented at earlier stages whereas the low priority user-stories are implemented in later stages and there may be the cases where the lower priority user-stories are removed from the product backlog. The prioritization of user-stories depends upon many factors like cost, time, resources, complexity, usability, risk etc. So these factors are needed to be considered during the prioritization of user-stories. Some factors are considered by client and some are considered by developers. The client side factors can be business value and importance of feature whereas developer side factors can be cost, risk, duration and effort [2].

1.1.2 Where to Use Agile Methodologies

- When the requirements are uncertain. The changes in the requirements are always welcome in agile.
- Iterative and incremental approach is needed.
- Clients are also involved in the software development process.
- Quality product is required by the customer.
- Rapid delivery of the product is needed by the customer.
- Each stakeholder is active participant and their idea or input is welcome.

1.1.3 Advantages of Agile Development Process

The advantages of agile software development process are given as below:

- **Rapid Delivery:** Agile software development process is a fast software process than traditional software development approaches.
- **Quality Product:** It enhances the quality of the deliverables because development team is self-organized, motivated and skilled.
- **Better Utilization:** Agile development process efficiently uses the available resources.
- **Working Software:** Customer gets early benefits from the deliverables in the form of increments.
- **Customer Collaboration:** Agile development process involves the customer during the software development that leads to customer satisfaction.
- **Adaptive to Change:** Sometimes the requirements from the customer are changed to achieve the business value. So, the agile teams are always welcome to change in the requirements.

1.1.4 Disadvantages of Agile Development Process

The disadvantages of agile software development process are given as below:

- **Require Skilled and Self-Motivated Individuals:** Agile methodologies require highly motivated and skilled individuals who may not always be available.

- **Not Suitable for Large Development Team:** Agile development process works well for small to medium software development teams.
- **Require Active Participants:** In Agile, the active participation from individuals is demanded throughout the development process.

1.2 Agile Manifesto

In 2001, a group of people met to discuss the failings of traditional software development methodologies and how they can make the software development process better. After discussion they came up a new idea that is agile manifesto. The agile manifesto includes four values, which are discussed in below [32]:

- **Individuals and interactions over processes and tools**

In agile software development, the more values are given to the people than processes and tools because it is the people who respond to the customer needs and develop software product.

- **Working software over comprehensive documentation**

In traditional methodologies more amount of time is spent on documentation of the software for its development and delivery of the. Agile methodologies do not eliminate documentation process, it is performed less. Agile documents user requirements as user-stories which are necessary for the development team to start the task of building new features.

- **Customer collaboration over contract negotiation**

In agile customer is involved throughout the development of the software product so, there is no prior contract negotiation is needed so start with the development process.

- **Responding to change over following a plan**

In agile, the software development team is adaptive to change. The change in the software user-stories are always welcome than following a plan. Customer has flexibility to add more features in the product backlog to achieve the business value.

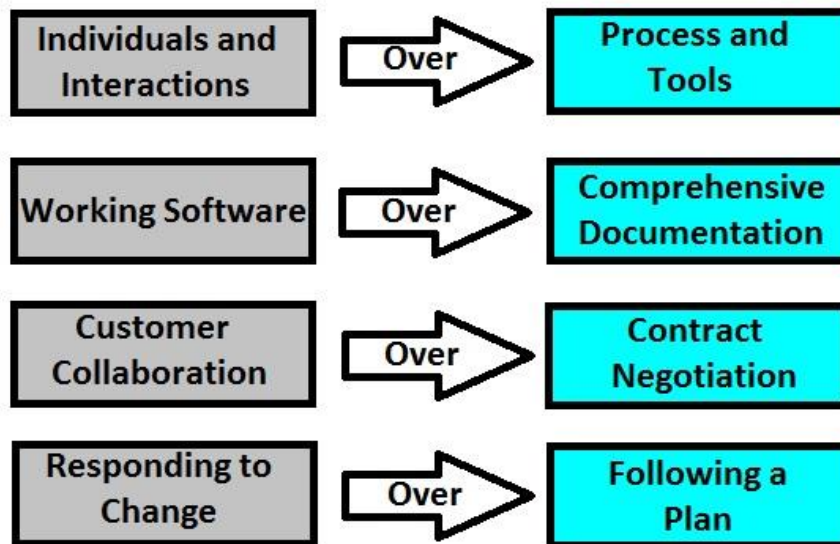


Figure 1.1: Agile Manifesto [32]

1.3 Agile Manifesto Principles

The twelve principles acts as guiding concepts for the agile software development methodologies. The twelve principles of agile software development include [32]:

- **Customer satisfaction through early and continuous software delivery**

Customers are more satisfied to get the product in increments and iterative way than the entire product after the long development process.

- **Accommodate changing requirements during the development process**

The ability to avoid delays when the customer requirements are changed during the development of the software product.

- **Frequent delivery of working software**

Agile assures the frequent and rapid delivery of the software increments. In scrum software is developed in sprints and each sprints ends with a working software.

- **Collaboration between the business people and developers throughout the project**

In agile, the decisions are taken by business team and the development team collaboratively.

- **Support and motivate the people involved in development**

Supportive and motivated teams are more likely to deliver their best work and the quality product.

- **Face-to-face interactions are good for successful project**

Face to face communication is more successful when development teams are working together.

- **Working software acts as measure of progress**

The working software at the end of each sprint in scrum easily measures the progress of the development process.

- **Agile processes to support a consistent development pace**

Agile teams repeat and maintain development process to deliver working software, and they repeat it during each sprint.

- **Continuous attention to technical detail and design enhances agility**

The technical skills and good design ensures that the team can improve the software product.

- **Simplicity**

The simplicity always maximizes the productivity and make the development team to develop software rapidly.

- **Self-organizing teams encourage better architectures, requirements, and designs**

Skilled, self-organizing and motivated team members who have the ability to take decision, communicate daily with team members and discuss new ideas leads to quality products.

- **Regular reflections on how to become more effective**

Regular self-improvement, advancing skills, and new development tools knowledge help the development team to in an efficient way.

1.4 Agile Software Development Methodology

Agile software development methodology is the one of the most commonly used methodology for the development of the software. The main focus of the agile is on the satisfaction of customer, quality of the software product. Agile methodologies are incremental and iterative in nature, which deliver the product into increments. Each increment of software product is developed in a time boxed duration of time. At the end of time boxed duration called sprint, product increment is delivered to the customer to take feedback from the customer. So, it is helpful for the development team to enhance the product quality. In agile development process, the gathered user-stories are divided into set of backlogs. Furthermore, the user-stories in a backlog are prioritized, implemented and delivered to the client in the form of deliverable. The deliverable is the working software that is executable in nature.

In agile, there are family of methods that can be used for the quality development of the product. These methods include Extreme programming, Dynamic System Development, Scrum, Adaptive Software Development, Feature-Driven Development (FDD), Crystal Method and Kanban. Scrum and Extreme Programming methods are the most used agile technologies for the development of software product. These methods focus on how to increase the productivity and quality of the product under the considerations of constraints like time, money and resources.

Agile methodologies have gained more popularity because this software development methodology is based on changes in user requirements based upon the feedback from the user. Agile development team always welcome the changes in user requirements desired by customer.

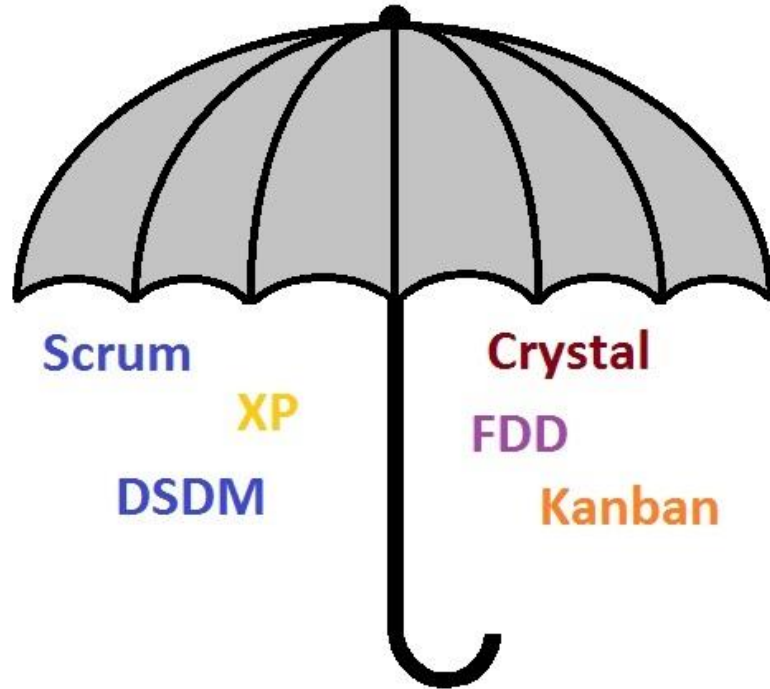


Figure 1.2: Agile Umbrella [31]

i. Scrum

Scrum is an iterative and incremental agile approach. Scrum uses sprints for the development of software in increments. Each sprint is a time boxed and is of two to four weeks duration.

At the start of each sprint, sprint planning is performed by the scrum roles to define the work and effort necessary to meet their sprint commitment. After the completion of each sprint a sprint review and sprint retrospective is performed.

In scrum, there are basically three roles that are Product owner, Scrum master and Development team. The product owner is the representative of the client who gather the user-stories and prioritize the user-stories. The scrum master acts as a guide to the development team. The development team is self-organized, self-motivated and cross-functional. Figure 1.3 shows the working model of scrum methodology.

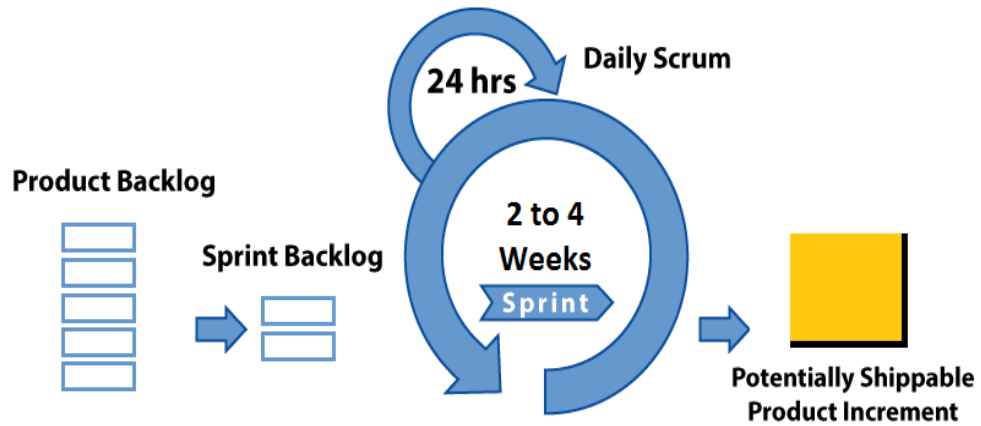


Figure 1.3: Scrum Methodology [31]

ii. Extreme Programming (XP)

Extreme programming is a flexible, lightweight, efficient, predictable, scientific and fun way for the development of software product. It is most widely used methodology like scrum. Extreme programming consists of some values and principles that act as a guide for the development team. Basically, it is based on twelve principles that are described in below:

- **Planning game**

The planning process in extreme programming is called planning game. It is a type of meeting that is performed before the start of each iteration. In this, the scope of next release is estimated using business and technical decisions.

- **Small releases**

The software product is developed into number of smaller releases. Every release should be small to be achievable during the small iteration. Small releases give feedback to the development team.

- **Metaphor**

A metaphor in extreme programming is a practice that is used by the development team to replace the traditional software development lifecycle methodologies. It is

communication about the project in terms that both development team and customers will understand, and it does not require familiarity with the problem domain. The system metaphor guides the members of the project to shape logical architecture for the system.

- **Simple design**

The software should be designed as simple as possible during the development process. The complexity is removed if it is discovered.

- **Testing**

The software developers write the unit test cases continuously during the development process. These test cases must be passed to continue with the development process.

- **Refactoring**

Code refactoring is the process of changing the existing code to simplify and improve the software product. The software developers restructure the software without changing its behavior.

- **Pair programming**

In Pair programming, the software code is written by two developers on one machine with single keyboard and single mouse. While one developer is writing the software code, the other developer reviews the code. Both developers switch roles regularly. This reduces the chances of error during the programming and implementation.

- **Collective ownership**

In extreme programming, the entire team is responsible for the quality of the software product, and all members are having the same ownership.

- **Continuous integration**

In extreme programming, the code is integrated and tested many times in a day. It helps in fixing the errors.

- **40-hour workweek**

Extreme programming team does not work more than forty hours per week. This helps the team to be active and effective.

- **On-site customer**

In extreme programming, customer is always involved during the development process to answer the questions and determines the features to be developed.

- **Coding standards**

The programmers use same standards within the organization to develop the software project. It ensures the collective ownership of all the developers.

iii. Dynamic System Development Method (DSDM)

DSDM is simple and straight forward technique that uses agile software development lifecycle. It is incremental delivery approach. In DSDM, the development team is empowered to take the decisions and all users are actively involved throughout the development process.

iv. Crystal

Crystal is an agile software development methodology that focuses on people, communication, skills and interactions among them during the software development process. In crystal, the tools and techniques to be used are not fixed.

v. Feature-Driven Development (FDD)

Feature-Driven Development (FDD) is an agile software development methodology used for the development of an enterprise software. It combines the features of scrum, extreme programming, dynamic feature teams and peer reviews. FDD is generally used for large projects within large teams. It consists of five processes that are develop an overall model, build feature list, plan by feature, design by feature and build by feature.

vi. Kanban

Kanban is a visual card system and it was developed by Toyota in 1940s. It is a scheduling system that tells what, when and how much is to produce. It is an effective tool that is used to track the production. It reduces the overproduction that saves the cost and time.

1.5 Agile User-stories

In Agile development process, the user requirements are requirements and features to be developed by the development team. User-stories are taken from the clients as per their requirements and these user-stories are prioritized by the product owner by discussing them with project manager and other stakeholders. The user-stories prioritization is a very first step after the user-stories are gathered. The user user-stories in agile are one of the primary development artifacts. There are many techniques used for prioritizing these user-stories which includes MoSCoW (Must Should Could Won't) method, walking skeleton and validate learning methods [1].

The user-stories prioritization process starts with the planning phase and it remains throughout the project duration. The product owner writes user-stories as per requirements. All the user-stories will be added in the product backlog. The product backlog contains prioritized user-stories and priority is managed for the successful delivery of the product to the clients. The user-stories that have high priority are implemented at earlier stages whereas the low priority user-stories are implemented in later stages and there may be the cases where the lower priority user-stories are removed from the product backlog. The prioritization of user-stories depends upon many factors like cost, time, resources, complexity, usability, risk etc. So, it is important to consider the above mentioned factors during the prioritization of user-stories. Some factors are considered by client and some are considered by developers. The client side factors can be business value and importance of feature whereas developed side factors can be cost, risk, duration and effort [2].

1.5.1 Types of User-Stories

Broadly the user-stories can be categorized as [17]:

i. Functional User-stories

The functional user-stories are implemented to perform some functions associated with software to fulfill user needs. These functions take input from the user and produce the output that is desired by the user of the software product.

For example:

As a student, I want to create profile to increase accessibility.

ii. Non-functional User-stories

The non-functional user-stories focus on the quality of the deliverable as well as end product. These user-stories can be of following types:

- **Security**

Security ensures that authorization and authentication process before accessing the software and it decreases theft of sensitive information and data of software user.

- **Flexibility**

It is the ability of software to add, remove and modify components without affecting overall software product.

- **Accessibility**

It assures that the software product is always available for the use.

- **Reliability**

Reliability feature ensures that software is able to produce the desired output without any occurrence of error in it.

- **Portability**

It means that software product can be transferred from one hardware to another without affecting any functionality.

- **Maintainability**

It assures that software is maintainable in the future.

1.5.2 Qualities of Good User-story

The user-story is known as a good user-story that is easily understandable, not dependent on other user-stories, short in size. A bad user-story is one that is contradictory in nature. The qualities that must be there within a good user-story are given in the below as:

- **Independent:** The user-story should not have dependencies over the other user-stories.
- **Negotiable:** User-story should be able to change and rewrite.
- **Valuable:** User-story must give business value to the customer.
- **Estimable:** Development effort, cost effort for a user-story must be easily estimated.
- **Scalable:** User-story must not be bigger in size.
- **Testable:** User-story must be easily tested.

1.6 Agile User-Stories Spectrum for Prioritization

In Agile software requirement engineering process we have a spectrum of user-story specification. The spectrum represent that how much user-stories are well stated and defined during the requirement engineering process in agile environment. The closing parts of this user-story spectrum are Nothing is defined and Everything is defined. Whenever user-stories are well stated and defined then there will be less investigation and if user-stories are not defined then there will be more investigation and discussion. Furthermore the defined user-stories will help in better quality of the software, efficient usage of resources, estimation of cost, estimation of project duration, estimation of risk related to product [1]. The Agile user-stories spectrum is shown in the given Figure 1.4.

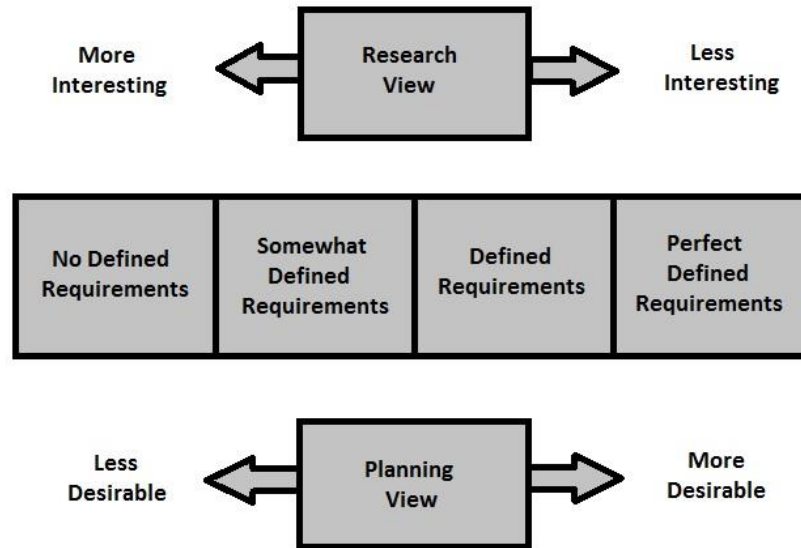


Figure 1.4: Agile User-Stories Spectrum [1]

From planning point of view it is more desirable to have perfectly defined user-stories and from research view it is less interesting if user-stories are defined already [1].

1.7 User-Stories Prioritization Factors

There are various factors that will impact during the prioritizations of user-stories in the agile environment for software development. The user-stories factors are briefly discussed as:

i. Timely Delivery

The time is an important factor that plays an important role in the user-stories prioritization and throughout the whole software development process. Client wants the important user-stories should be delivered earlier, it will lead to the customer satisfaction. If the user-stories are complex then they will require more time whereas the smaller user-stories will take less implementation time. So, the developer must take time factor into consideration during the priority process of user-stories in agile development process [1].

ii. Dependencies

Dependencies of the user-stories play critical role in the agile development process. The dependencies in some of user-stories will impact the user-stories prioritization process of requirement engineering. If two or more user-stories are dependent then they must be implemented together otherwise it will affect the business value or quality of software [1].

iii. Business Value

The business value is the important factor that must be calculated and taken into account by stakeholders during the prioritization of the user-stories in agile environment development. The business value can be calculated by using the return on investment, user value and revenue. If the business value is more, then that user-story should be implemented at earlier stages [1].

iv. Risk Minimization

The user-stories that have high risk associated with them should be implemented during the earlier stages so that the changes that will be applied on the user-stories can be caught during the early implementation. The user-stories that have low risk associated with them should be implemented at later stages in the agile environment [1].

v. Cost Minimization

Every user-story has cost value associated with them so cost should be calculated before the prioritization process of the user-stories in the agile requirement engineering process. The user-stories cost should always be in budget of the customer of the proposed software [1].

vi. Quality Delivery

The project quality includes reliability, maintainability, profitability, efficiency, functionality and usability. The user-stories must possess these quality factors to fulfill the needs of the end user. So, these quality parameters should be considered during the prioritization process of the user-stories in agile engineering development process [1].

vii. Technical Ability

The technical skills are important during the prioritization process of the user-stories in agile environment. If the stakeholders like software developers have are proficient technically then it will help them to use efficient procedures and techniques for the prioritization process of user-stories in requirement engineering process [1].

viii. Usability

The usability means how easily an end user can use the software. The user-stories must possess usability quality factor. The usability increase the quality of the end product as well as user satisfaction [1].

ix. Complexity

The user-stories complexity depends upon the dependencies within user-stories in agile environment. The user-stories dependencies should be minimized to decrease the complexity of user-stories. The complex user-stories take more effort and skills for implementation [1].

x. Security

The security can be security in networks, security of functions, document security and security of database. So, security is the foremost important factor during the prioritization and implementation of the user-stories. The user-stories with higher security level should be implemented at early stages in project development [1].

xi. Effort

The effort factor should be considered during the prioritization process of user-stories during agile development. If the user-story requires more effort, then it should be implemented at the later stages in development process [2].

xii. Contradictory

The contradictory of user-stories should be removed during the requirement engineering process in agile environment. If two or more user-stories are contradicting with each other,

then it will decrease the quality. Such contradicting user-stories should be removed from the prioritized list and should be solved into meaningful non-contradicting user-stories [3].

xiii. Volatility

The user-stories are called volatile are changed by the customer many times during the development process. The user-stories that have volatility characteristic should be implemented during the later stages. So the user-stories should be identified that whether they are of volatile nature or not so that end product's quality can be achieved [3].

xiv. Penalty

The penalty can be referred as the loss that is related to the absence of the important function the end product. To decrease the penalty value the important user-stories should be prioritized and implemented earlier in the agile development [3].

xv. Availability of Resources

The resources can be time, cost, man power, technology, space etc. If the user-stories are important and they require less number of resources then they must be implemented first. It is the important factor that must be considered during the requirement engineering process in the agile development environment. The resources must be available for the implementation of the user-stories or user-stories of client and end users [1].

1.8 Agile Prioritization Methods

The Agile prioritization methods are based on different factors like Cost, Risk, Resources, Time, Business value etc. These methods are discussed as below:

i. MoSCoW (Must Should Could Won't)

The MoSCow method is most widely used method for user-stories prioritization in agile environment. The MoSCoW stands for [1], [2]:

- M- MUST have: The user-stories that are put in this category must be there in the current deliverable of the software.

- S- SHOULD have: The user-stories that are labeled with this keyword are important for the software but are not necessary to be delivered in the current release of the software.
- C- COULD have: The user-stories are kept in this category that are desirable by the client but are not compulsory to be implemented in the current release.
- W- WOULD have: The user-stories that are having this label are not critical for the current release of the software.

ii. Business Value Based

In this methods, the user-stories are prioritized according to the business value associated with them. The business value is estimated by the client by discussing it with stakeholders like developers and project manager. The user-stories that have higher business value are implemented at early stages whereas the user-stories with least business value are implemented in later stages or can be neglected for the implementation [1], [2].

iii. Kano Model

The Kano model is used for the prioritization task of user-stories in agile development environment. The Kano model is used to categorize the customer satisfaction according to following attributes [2]:

- Must be Quality: These attributes are taken into account when fulfilled and dissatisfaction when not fulfilled to the customer.
- One dimensional Quality: Client is satisfied whenever these qualities achieved and disappointed when not fulfilled.
- Attractive Quality: Client is satisfied when these qualities are achieved completely and they don't cause any dissatisfaction when not fulfilled.
- Indifferent Quality: This attribute shows that customer is neither satisfied nor customer dissatisfied.
- Reverse Quality: This attribute shows high degree of customer dissatisfaction about the requirement.

iv. Validate Learning

In this prioritization technique, the user-stories are selected and prioritized based on the risk value. The user-stories that have more risk value are implemented earlier to gather response from users, so that new methods or techniques can be applied to reduce the risk value related to the software product [1], [2].

v. Round the Group Prioritization

In this prioritization technique, the user-stories are written on the cards and the stakeholders associated with the software place these cards according to their thinking. While prioritizing cards the stakeholders are welcomed to explain that why they have chosen this particular order. The ordering process is unstable until the particular order of the user-stories is achieved. There are about 3 to 8 members participate in the prioritization process and the user-stories are less than 15 [4].

vi. Ping Pong Balls

In this method, a fix number of ping pong balls are given to the stakeholders. These ping pong balls can have different color and these balls represent business value or risk associated to user-stories. These balls are arranged into a dynamic order when all the members are satisfied for a particular order of the ping pong balls. This method includes 1 to 12 participants and used when user-stories are more than 15 [4].

vii. Cumulative Voting

Cumulative voting method is also known as \$100 allocation method. In this technique, the stakeholders are given \$100 virtual money to spend on the user-stories. Each stakeholder decides how much money is to spent on user-stories. After all the stakeholders are done with assigning money, the total is calculated for all the user-stories and these user-stories are then ordered [5].

viii. Multi-voting system

Multi voting system is based upon the cumulative voting. In this method, the stakeholders are allowed to give multiple votes to the user-stories. After the stakeholders

are done with voting, the facilitator calls for everyone to think and decide again. After this some discussion is allowed for the consequences and stakeholders are allowed to move their votes. This method usually include 5 to 20 participants and user-stories to be prioritized are less than 50 [4].

ix. Pair-wise Analysis

In this prioritization techniques, the user-stories are taken as in pairs and compared until the top user-stories are kept at top in the order. Pair-wise analysis works well for less number of user-stories because if the number of user-stories will be more, the number of comparisons will also be more [4].

x. Analytic Hierarchy Process (AHP)

AHP technique is most widely used for the prioritization process of user-stories in requirement engineering process. AHP was developed by Thomas Saaty. The AHP technique uses the pair-wise comparison of user-stories to compare user-stories based upon business value and risk associated with user-stories. After comparison the user-story is represented by value from 1 to 9 on scale. Where 1 value represents equality of importance and 9 represents significant difference in importance of user-stories. The number of comparisons that are to be performed are $n(n-1)/2$, where n is the number of user-stories to be compared and prioritized. As the user-stories increases, the number of comparisons are also increases which proved that this technique is not suitable for the large software user-stories [5].

xi. Binary Search Tree (BST)

Binary Search Tree is a searching algorithm which is used for searching and can be used for ordering the user-stories in agile requirement process. In this method, a user-story is taken as a parent or root node. After that another user-story is selected and compared with the root node. If it is value less than the root node then it is put to the left as a child node of root node whereas if it is has higher value than root node then it is taken as a right child node of parent node. The whole process is active until all the user-stories to be prioritized are processed [6].

xii. Planning Game

This method is based on the numerical assignment. In this method, the stakeholders of the software product assign the user-stories to the three different groups or piles that are “Those without which system functions will not work within the software”, “Those which are less essential but provides significant business value”, “Those that desirable but not compulsory”[5].

xiii. Numerical Assignment

Numerical Assignment is an easy and most common technique for prioritizing user-stories. It is based upon 3 categories of user-stories that is High, Medium and Low. The user-stories which are of high, medium and low importance are kept into high, medium and low category groups respectively. These groups can be varied in different organizations but commonly there are basically 3 groups only to prioritizing the user-stories [5].

xiv. Value-Oriented Prioritization (VOP)

The Value-Oriented Prioritization technique allows the stakeholders to prioritize the user-stories, based on the business value. It uses VOP matrix to prioritize the user-stories based upon business value and relationship among those user-stories [7].

xv. Hierarchy Analytical Hierarchy Process (Hierarchy AHP)

Hierarchy AHP is enhanced version of simple Analytic Hierarchy Process (AHP) and it was developed by Karlsson to overcome the drawbacks of the traditional AHP. In this technique medium to large user-stories are taken for the prioritization. The comparison are reduced because it does not compare user-stories pair-wise [8].

xvi. Priority Groups

The priority group techniques is same like Numerical assignment technique, where three groups like High, medium and Low are taken for prioritize user-stories. But in this technique the sub-groups of these groups are formed until there is a single user-story is left in a sub-group. So it is extended version of numerical assignment technique. The result of this method is represented by using the ordinal scale [7].

xvii. Bubble Sort

This technique is the very simplest sorting algorithm used in data structure for sorting the elements and can be used for prioritizing the user-stories in agile environment. It was introduced by Karlsson et al. [8] in the prioritization process in requirement engineering. This techniques compares the user-stories pair-wise and $n(n-1)/2$ comparisons take place. But it does not represent that up to extent user-stories are important. The result of this method is prioritized user-stories and high priority user-stories are represented at top of stack and lower priority user-stories are represented in the bottom of stack. The result of Bubble sort technique is represented by using ordinal scale [8].

xviii. Minimal Spanning Tree

The minimal spanning tree is used for the prioritization process of user-stories in agile development process. This technique was also introduced by Karlsson to enhance prioritization process. It does not contain redundant comparisons like the AHP contains. In minimal spanning tree techniques, $(n-1)$ comparisons are involved for prioritizing user-stories. The result of prioritized user-stories in minimal spanning tree technique can be represented on the ratio scale [8].

CHAPTER 2

LITERATURE SURVEY

User-stories prioritization is very important task during the development of software product in Agile environment. User-stories prioritization has been the most interesting research topic from last decade. Following are the research papers reviewed for the understanding of related subject:

Rashmi Popli et al. proposed some prioritization factors and an algorithm to prioritize user-stories in agile development environment. The proposed factors are timely delivery, dependencies, business value, risk, cost, quality delivery, technical ability, usability, complexity, security and availability of resources. The proposed algorithm consists of few steps. In first step, the importance for each and every the user-stories is identified, secondly the effort related to each user-story is calculated. After that the priority value for every user-story is calculated by dividing its importance by effort i.e. $P_i = I/E$. After Calculating priority value for all the user-stories the user-stories are prioritized [1].

Shreeram Hudda et al. proposed an algorithm to prioritize the user-stories. For prioritizing the user-stories the researcher has considered various factors like rank, weight and effort. The ranking of user-stories is done by voting method, weight is calculated by using rank order centroid (ROC) method and effort is calculated using program evaluation review technique (PERT). After calculating for weight and effort the priority is calculated by diving the weight of user-story and effort required to implement user-story i.e. $P = \text{Weight}/\text{Effort}$ [2].

Masooma Yousuf et al. represented a review paper on user-stories prioritization techniques or methodologies in agile development environment. In this paper about ten user-stories prioritization techniques are discussed. These techniques are Analytic Hierarchy Process (AHP), Cumulative Voting, Numerical Assignment, Value-Oriented Prioritization, Hierarchy AHP, Priority Groups, Planning Game, Bubble Sort, Binary Search Tree, and Minimal Spanning Tree. In addition to this comparison of these user-

stories prioritization techniques is also presented that is based on various parameters like time, ease of use, scalability, number of comparisons, accuracy, suited for user-stories (small/medium/large) [7].

Zornitza Racheva et al. reviewed various agile user-stories prioritization methods and derived a conceptual model of agile user-stories prioritization. The conceptual model consists of some steps to prioritize the user-stories. The first step is listing the features and second step is assigning business value to featured user-stories. The further steps that are numbered from 3 to 8 (knowledge/experience, work break down, prioritization process, project constraints, size measurements, new information) are the external source of information that are required to make decisions for the prioritization process of user-stories in agile development engineering environment. Furthermore the issues related to these steps are identified and solution for these issues is also discussed [4].

Ville T. Heikkila et al. conducted a mapping study on requirement engineering in agile development environment. About 28 research articles were identified and analyzed on this topic. Researchers found that the definition of agile requirement engineering is vague. The proposed benefits of agile requirement engineering included better user-stories understanding, reducing over allocation of resources, responsive to change, improved client relationship and rapid delivery. Furthermore they have discussed about the problems related to client representatives, insufficient user-story format, prioritization process, growing technical debt and imprecise effort estimation and solution for these except technical debt and imprecise effort estimation is discussed [9].

Zornitza Racheva et al. presented case study. In this eight organizations were involved. Researchers found that there are some assumption that are involved in the process to prioritize the user-stories and these are (i) Role of Customer in creation of value, (ii) Prevailing position of business value as a priority factor, (iii) Role of user-stories prioritization process to achieve project goals. These assumptions are not always considered in every project, so these assumptions are needed to be reframed. During the investigation researcher have found that first, client plays a role in prioritization of user-stories, second, the presence of objectives is really good for the project value and third, the prioritization process varies from client to client and company to company [10].

Sanjaya Kumar Saxena et al. presented an agile requirement engineering tool that is Decisively. It is based on Quantitative Analysis and Decision Science (QUADS). The decisively technique is used to elicit user-stories, analysis of user-stories and prioritization. Decisively tool uses Analytic Hierarchy Process (AHP) to prioritize the user-stories in agile environment, Lorenz function to select the user-stories to be prioritized and implemented, Box plot analysis to calculate the velocity and Text mining to identify the user-stories from the document in agile development. Decisively AHP performs comparison in user-story pairs. After comparison 1 to 9 value is assigned to a user-story, where 1 value represents equality of importance and 9 represents significant difference in importance of user-stories. Decisively also reduces the inconsistencies using SPAN technique [11].

Sultan Alyahya et al. reviewed about 30 agile user-stories prioritization tools and researchers found that all of these tools have some limitations. To resolve these limitations in the current agile user-stories prioritization tools, some features are developed. The features to improve the agile planning process are task effort notification, improving user-story prioritization, and adding new user-story or reprioritize user-story by client. The researchers used a questionnaire to evaluate the limitations and developed features. The evaluation of these of these limitations proved that these limitations are really present in the real time tools for agile user-stories prioritization process [12].

J. Richard Kiper reviewed documentation related to the software requirement engineering techniques and parameters. The goal of the researcher to select the user needs to develop the knowledge management (KM) to identify and develop the user-stories for the development of software product in agile environment, while following industrial standards and policies. The knowledge management is required to make links among training products, business process and the business policies. The main focus of the current study is to elicit the user needs to gather user-stories from stakeholders of the software product [13].

Mukhtar A. Abo Elsood et al. proposed a new goal based user-stories prioritization technique that is based on weights assigned to the user-stories of product with respect to goals of stakeholders. All the traditional techniques are not best as these techniques are used in different scenarios. Furthermore, the comparison of Analytic Hierarchy Process (AHP) and Goal based technique is done. After comparison it is found that the proposed

technique is more flexible, scalable and less time consuming. The goal based technique can be used to resolve the problem of user-stories vagueness and uncertainty [14].

Falak Sher et al. introduced a new prioritization technique that is focus on the business value aspect as well as the technical aspects. The reviewed techniques are only focusing on the technical aspects so, there is also a need to focus on business values of the software product. The identified technical aspects are risk, value, cost, speed, effort, granularity, time, sophistication, dependencies, sensitivity, contradictory, volatility, penalty, resources and complexity. The business aspects can be sales, marketing, competitive, strategic, customer retention, simplicity and innovation. So, these aspects must be considered during the user-stories prioritization process in agile environment [3].

Muhammad Imran Babar et al. proposed a user-stories prioritization technique in agile environment. Most of the prioritization techniques do not produce better and simple result so, there is the need to add artificial intelligence activities to make more scalable, efficient and effective. The proposed technique for prioritization of user-stories consists of some steps or levels. The level 1 is user-stories elicitation, level 2 is Expert level prioritization, and level 3 is based upon calculating the user-story value by introducing neural network and fuzzy logic for the prioritization of user-stories. In the traditional the level 2 was based on manual calculations of the user-story value but here in proposed technique the user-story value or requirement value (RV) is calculated with the help of artificial intelligent expert system [15].

Rahul Thakurta et al. reviewed about 135 articles based on the requirement engineering prioritization process and performed a mapping study. Researchers have proposed four research questions and answered them. They found that there are different factors that influence the user-stories prioritization process in agile environment and different artifacts (tools, techniques and frameworks) used for the prioritization process. Furthermore, they found that there are two factors i.e. internal factors and external factors that impacts on the prioritization process. The internal factors are Requirement attributes, Project attributes, Process Attributes and Product service attributes. The external factors are Subject attributes and Prioritization environment. These internal/external factor's attributes have further sub-attributes. So, this mapping study helps to understand the entire

requirement techniques, attributes and frameworks in requirement engineering prioritization process in agile environment [16].

Gurkiran Kaur et al. presented a review paper on the requirement prioritization techniques. These reviewed techniques are Analytic Hierarchy Process (AHP), Cumulative Voting, Numerical Assignment Technique, Binary Search Tree, Value Oriented Prioritization (VOP), B-tree Prioritization and Playing Game. Furthermore, the comparison of these user-story prioritization techniques is performed based on some factors. These factors are measuring scale (ordinal and ratio), fault tolerance, granularity, complexity and time consumption [6].

Mohammad Dabbagh et al. proposed a user-stories prioritization technique that take into consideration both functional and non-functional user-stories. The traditional techniques only focus on the either functional user-stories or non-functional user-stories so, it takes times to prioritize these user-stories differently. To resolve this problem researches have proposed a technique that consider both functional as well as non-functional user-stories during the prioritization process. This proposed techniques is based on the Hybrid Assessment Method (HAM). HAM technique consists of basically 5 steps that are Determining functional and non-functional user-stories, pairwise comparison of non-functional user-stories, computation of non-functional user-stories ranking, define degree of non-functional user-stories with respect to functional user-stories and calculate final ranking of functional user-stories using weights. The effectiveness and efficiency of this proposed techniques is validated after comparing it with mostly used technique for prioritization that is Analytic Hierarchy Process (AHP) [17].

Javed Ali Khan et al. performed comparison of various user-stories prioritization techniques to find out best user-stories prioritization technique in software engineering. The researchers compared Analytic Hierarchy Process (AHP), MoSCoW, Bubble Sort, Minimal Spanning Tree, Binary Search Tree, Cumulative Voting, Planning Game, Numerical Assignment, Simple Ranking and Hierarchy AHP on the basis of literature review. They found that among all of these prioritization techniques AHP technique is the best technique that provides most reliable, accurate, efficient and fault-tolerant results on ratio scale as compared to the other user-story prioritization techniques. AHP technique

has the problem with time consumption and number of comparisons [8].

Joao M. Fernandes et al. compared two Multi Criteria Decision Method (MCDM) techniques for the prioritization of user-stories that is ELECTRE I and Analytic Hierarchy Process (AHP). AHP is the most popular technique whereas ELECTRE I is not much popular as AHP prioritization technique. In this research 4 stakeholders (2 from company and 2 from client side) were involved. During the research they have found that ELECTRE I prioritization technique is easy to use and it takes less time as compared to the Analytic Hierarchy Process. Due to complexity of the AHP and more number of comparisons, ELECTRE I is preferable by the stakeholders and proved that it is a good alternative to AHP technique [18].

Balsam A. Mustafa et al. presented empirical research design for the comparison of three user-stories prioritization techniques based on three parameters i.e. time consumption to complete prioritization, result accuracy and ease of use of the technique. The three techniques Numerical Assignment, Cumulative Voting and Analytic Hierarchy Process (AHP) were taken into account throughout the research to find the best efficient and effective techniques in terms of user-stories prioritization. The empirical design consists of few steps that are research objectives, research questions, hypothesis and variables, subjects, experiment (setup, design, pre-test, structure, post-test) and threats to validity. So, this experimental design can be considered in future for the comparison of these user-stories prioritization techniques [19].

Ishaya P. Gambo et al. proposed a model for the user-stories elicitation and prioritization process in software development using Delphi technique. The proposed techniques consists of three level. The very first level is user-story elicitation process by the stakeholders by using the interview, case study, secondary data and observation. The second step of the proposed technique is Expert prioritization which involve the expert profiles and agreement and disagreement for user-stories are analyzed. The last level is Expert Ranking of User-stories in which the experts are allowed to revise their judgement for ranked user-stories. If the target consensus is achieved then result is reported otherwise feedback to expert is given [20].

Muhammad Aasem et al. reviewed the various existing user-stories prioritization techniques (AHP, Cumulative voting, Numerical Assignment, Planning game, Ranking method and Binary Search Tree) and proposed a framework for the prioritization of user-stories which is composed of three processes α , β and γ . The α process is subjective in nature and based on the Cumulative Voting or 100 point technique, β process is the ranking method used by stakeholders and γ process is an automated process which is composed of Analytic Hierarchy Process, Binary Search Tree and Numerical Assignment. This proposed method is a unified prioritization method for small, medium and large user-stories in agile environment for software development [5].

Patrik Berander et al. discussed the strengths and weaknesses of the Cumulative Voting (CV) and Analytical Hierarchical Process (AHP). They discussed that AHP and CV both do not support hierarchical user-stories prioritization process. So, to overcome the weaknesses of AHP and CV they have presented Hierarchical cumulative voting technique for the prioritization of user-stories in requirement engineering process. In addition to this they have also presented an empirical results that shows the scalability improves with HCV technique as compared to the cumulative voting [21].

Mikael Svahnberg et al. performed an experiment by using cumulative voting method to know whether the initial order of user-stories influences the prioritization. In this experiment total 113 students participated. The features were arranged into 4 group i.e. most important features first, least important first and two random order feature groups. Students were divided into 4 groups and they were given \$1000 points to prioritize the user-stories according to assigned feature group. Researchers found that most and least importance user-stories, the initial order does not matter whereas for random groups, the initial order matters and it influences the prioritization [22].

Zornitza Racheva et al. investigated the question that what concepts should be considered by the customer during the prioritization process. They presented two conceptual models i.e. model A and model B that can be used for the client centric prioritization process. The first model A presents generic prioritization process in agile. The model B presents generic framework for the decision making in the prioritization process. The model B uses various artefacts like learning experience, value estimation,

business value, risk, effort estimation, sprint planning and project constraints. So, this conceptual model can be used in the client-centric prioritization process in agile [23].

Philip Achimugu et al. presented systematic literature review and they found that there are total 49 requirement prioritization techniques and they have discussed the limitations of these prioritization techniques like scalability, computational complexity, rank update, communication among stakeholders, requirement dependencies and error proneness. They discussed various taxonomies like nominal scale, ordinal scale, interval scale and ratio scale. Furthermore, they have discussed the processes that are involved in the prioritization of user user-stories. So, this systematic review can be used for the further improvement in the field of requirement prioritization process [24].

E. Triantaphyllou et al. discussed about various multi-criteria decision making (MCDM) methods that are used for the decision making. They discussed about weighted sum mode (WSM), weighted product model (WPM), analytical Hierarchical process (AHP). MCDM techniques are used to choose best alternative. Furthermore, researcher discussed some challenges of the multi-criteria decision making techniques like the decision maker has to estimate the data with accuracy [25].

Nils C. Haugen investigated that whether planning poker estimation process has achieved improved performance as compared to unstructured group estimation. Researcher collected data from 4 projects. After analysis it was found that the estimation error rate of planning poker is 0.25 whereas unstructured estimation group's estimation error rate is 0.33. The researcher found that the planning poker process produces more accurate results when the development team has prior knowledge and experience from similar projects or tasks and it will produce less accurate results when the development team does not have experience from similar projects [26].

Kjetil et al. investigated that planning poker estimation process by comparing it with statistical combination of individual expert estimates. They found that optimism was not increased with group discussion, the common reason is opinion taken from the group discussions. They discussed that the group discussion helps in identifying the sub tasks and complexity. The planning poker estimation technique reduces the anchoring effect in the individual estimation process [27].

Viljan Mahnic et al. performed the effort estimation process with the help of 13 student teams for the estimation of project named web based student record system. They found that the planning poker effort estimation technique is more optimistic than statistical combination of individual estimates provided by students. They discussed that estimates done with planning poker are more accurate than statistical combination of individual estimation. Their result shows that optimism bias is reduced by increasing the experts from different domains in the effort estimation process [28].

Muhammad Usman et al. presented a systematic review on effort estimation in the agile software development process. They found that there are variety of effort estimation techniques are applied in agile software development process. But the most commonly used techniques are expert judgement, planning poker and use case points method. They found that except extreme programming (XP) and Scrum there was not any agile method investigated in estimation process. Based on systematic review the researcher suggested that there is a need of research in the fird of effort estimation process to improve the accuracy [29].

CHAPTER 3

SCOPE OF THE STUDY

During literature survey, it was found that most of the authors in their work defined a need for improvement in requirement prioritization and scope of development in agile user-stories prioritization. A few of the work have been listed out as below:

In agile software development environment, the user-stories prioritization process is very important for the quality and business value of the quality based software product. To enhance the prioritization process, the stakeholders thinking and decision making are main players [2].

Over the last few years there are many user-stories prioritization tools, techniques, frameworks developed but all of these artifacts are facing some problems with their complexity, ease of use, decision making, cost, effort and quality [16].

Most of the tools and techniques do not consider the perspective of clients, product owner and developers. Moreover, these tools and techniques do not consider the different criteria for the prioritization of user-stories in agile environment.

The proposed research work can done by taking multiple criteria or factors into considerations to prioritize the agile user-stories to achieve the software product quality and business value.

Before the development of this proposed technique, there is not much work done in the field of enhancing the ease of use of prioritization technique, result accuracy of prioritization technique and multi criteria decision making in prioritization technique.

4.1 Problem Formulation

The problem was formulated from the literature reviewed done in the area of prioritization of user-stories in agile environment. The future work discussed in some research papers helped in defining the problem for our research work to enhance the user-stories prioritization process in agile software development methodologies. The future work that acts as motivation for this research work is listed out as below:

- **Rashmi Popli et al. [1]**, discussed in the future work section that they have considered the importance and effort for the calculation of the priority of the user-stories and they also discussed that other factors which are important for the prioritization process, can be considered to calculate the user-stories prioritization process in agile software development.
- **Gurkiran Kaur et al. [6]**, discussed and compared various prioritization of user-stories in agile software development process. They also discussed future work section that there is more work need to be done to improve the current state of the work and to improve the effectiveness of prioritization techniques.
- **Javed Ali Khan et al. [8]**, performed the comparison of various prioritization techniques and discussed in conclusion and future work section that Analytical Hierachy Process (AHP) produces good results in the prioritization of user-stories but AHP becomes problematic when the project is large because in it large number of comparisons are performed.
- **Nils C. Haugen [26]**, suggested that planning poker can be used to improve the effort estimation process in agile environment. They discussed in conclusion section that after analysis from real world estimates from projects, suggests the estimation process is better with planning poker than unstructured group.

So, after the literature reviewed from research papers, we proposed some factors that must be considered for the prioritization user-stories, which includes business value, quality delivery, timely delivery, usability and complexity.

4.2 Objectives of the Study

The objective of the proposed research in the field of agile user-stories prioritization is explained with the help of points given as below:

- To develop the technique for prioritizing the user-stories in agile software development environment based on multiple criteria like business value, timely delivery, quality delivery, usability and complexity.
- To find out the hidden factors that can impact on the prioritization process of requirement engineering in agile environment to enhance the prioritization process by using artifacts like factors, criteria, methodologies and framework.
- To minimize the number of comparisons, time and achieving accuracy of the prioritization process.

4.3 Research Methodology

In this research work, following are steps that are used to prioritize the user-stories in the product backlog:

4.3.1 Ranking of User-Stories with Cumulative Voting Method

- Cumulative voting method is used to know about client's perspective for each user-story. At the beginning, product owner gives the instructions to all the participants. If anyone has doubt or question regarding voting, the product owner answer their questions.
- In this technique the stakeholders are given \$1000 virtual money to spend on the user-stories.
- Each stakeholder decides how much money is to be spent on each user-story according to his perspective.

- After all the stakeholders are done with assigning virtual money, the total is calculated for all the user-stories and these user-stories are then ordered.

4.3.2 Weighted Sum Model (MCDA) to Calculate User-Stories Weighted Score

In this model, the weighted score of each and every user-story is calculated. C_j 's are the criteria that can be considered by the product owner during the calculation of weighted score of user-stories. w_i denotes the relative weight of the criteria. a_{ij} is the importance value of user-story U_i with respect to criterion C_j .

$$U_i \text{ (weighted score)} = \sum_{j=1}^n w_j * a_{ij}, \quad \text{for } i = 1, 2, 3, \dots, n$$

The importance value i.e a_{ij} can be calculated by an ordinal scale as shown in below given figure:

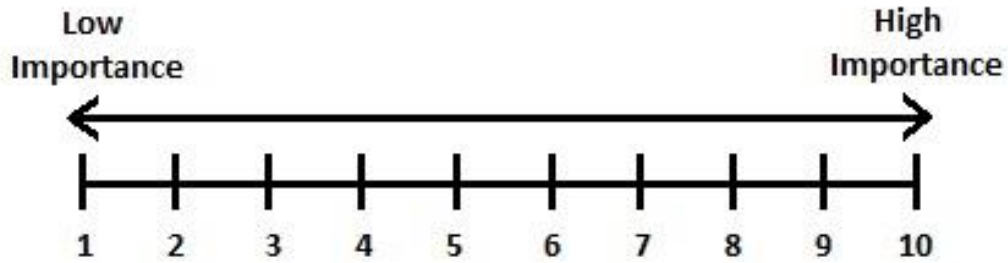


Figure 4.1: Importance Scale

Let's suppose that there are three user-stories that are to be prioritized and each of them is described in terms of four criteria C_1 , C_2 , C_3 and C_4 . Furthermore, the numerical data for these user-stories is presented in following decision matrix:

Table 4.1: Weighted Sum Model Matrix

User-Story	C1 (Timely Delivery)	C2 (Quality Delivery)	C3 (Business Value)	C4 (Usability)
	0.30	0.25	0.25	0.20
U1	10	10	9	9
U2	9	9	8	9
U3	10	9	8	9

$$U_1 = 0.30 * 10 + 0.25 * 10 + 0.25 * 9 + 0.20 * 9 = 9.55$$

$$U_2 = 0.30 * 9 + 0.25 * 9 + 0.25 * 8 + 0.20 * 9 = 8.75$$

$$U_3 = 0.30 * 10 + 0.25 * 9 + 0.25 * 8 + 0.20 * 9 = 9.05$$

So, the ranking of these user-stories will be $U_1 > U_3 > U_2$.

4.3.3 Planning Poker for Effort Estimation

Planning Poker is most used technique in agile software development process to calculate effort (i.e. development time) for every user story. It is consensus based estimation method.

It consists of following steps:

- Each stakeholder is given a deck of cards that contains values 0, 1, 2, 3, 5, 8, 13, 21, 34, 55 and 89. These values represent the number of hours, ideal days, story points or other units in which the development team estimates.
- The moderator selects a user-story for estimation and the estimators can ask questions to product owner if they want.
- Each estimator selects a card privately according to his/her estimate.
- After everybody has selected a card, the cards are then revealed simultaneously by each estimator.
- If all the estimators select the same card then that value will be the estimate for that user-story. If estimators have different value cards then the estimators with highest and lowest values have to discuss their reason. After some discussion, each estimator estimates again and cards are revealed simultaneously.
- This process is repeated until estimation is done for each user-story.

4.3.4 Calculate Priority

In our research work the priority for a user story can be calculated by the following mathematical formula:

$$Priority (U_i) = \frac{\text{Weighted Score}}{\text{Effort}}$$

In our research work, weighted score represents the importance value of the user-story that is calculated by the product owner of the software project.

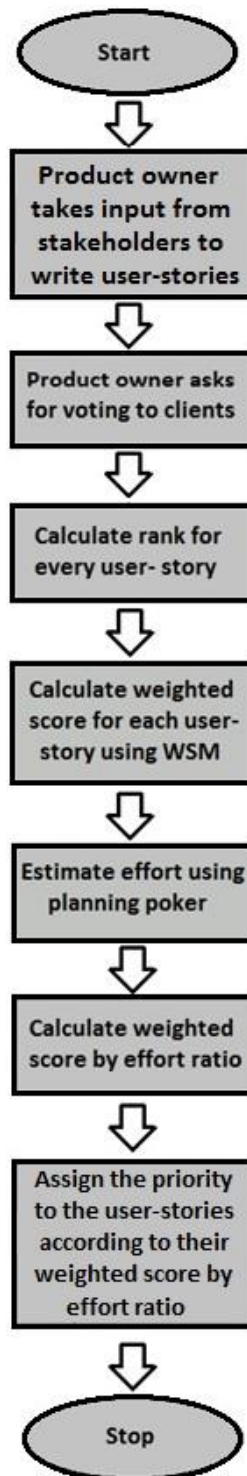


Figure 4.2: Research Methodology

5.1 Experimental Results

Here we are showing the feasibility of our algorithm by calculating results using a case study. In this case study, we have calculated prioritization order of user stories by using our proposed technique. University Management System- LPU (UMS) is the web-based ERP solution, which is an innovative step of the university to provide significant information regarding admissions, academics, placements and other important logistic for helping faculty, students and parents [33]. The students of Master of Technology program from Computer Science and Engineering (CSE) department of LPU participated in the ranking phase. We have considered the user-stories from UMS account of students of Lovely Professional University. From their online account, they can perform several different activities like login, view attendance, view marks, view and upload assignment, view lab assignment marks, and they can see their daily time table etc.

5.1.1 Phase 1

In this phase the ranking of user stories has been calculated by cumulative voting method. This phase is performed to take the customer’s perspective for each user-story. In our case study, 1000 virtual points were given to students to allocate to the user-stories according to their perspective. After everybody finished with assigning votes, the total points for each user-story were calculated. The user stories with sum of points and their ranks are shown below in Table 5.1.

Table 5.1: User-Stories with Ranking from Customer

Sr. No	User-Story	Total Points	Rank
U1	As a Student I want to login to UMS so that I can access UMS.	940	1
U2	As a Student I want to logout my UMS account so that other person can’t access my account	870	2

U3	As a Student I want to see my today's time table so that I can know about the class timing and venue of the class.	757	5
U4	As a Student I want to check Instruction Plan (IP) of my courses so that I can know about lecture details like lecture numbers, topics, test books, lecture description, lecture outcome regarding particular lecture.	674	14
U5	As a Student I want to check my attendance so that I can track the attendance record for different courses.	754	6
U6	As a Student I want to I want to view the assignment, assigned by the teacher so that I can submit the assignment before the submission date.	744	8
U7	As a Student I want to upload assignment so that it can be evaluated by the teacher.	739	9
U8	As a Student I want to view assignment marks so that I can track my performance.	644	18
U9	As a Student I want to view courses material uploaded by the teacher so that I can use it for my preparation.	672	15
U10	As a Student I want to view lab assignment question so that I can solve it.	713	12
U11	As a Student I want to upload lab assignment so that it can be evaluated by the teacher.	641	19
U12	As a Student I want to view my result so that I can know about my performance in all subjects in all terms/semesters.	728	10
U13	As a Student I want to view my capstone project/ dissertation marks so that I can check my monthly performance according to the teacher.	655	17
U14	As a Student I want to check my messages so that I can know about various activities or tasks given by teachers.	620	23

U15	As a Student I want to view upcoming events so that I can get information about the upcoming events and will plan to participate in those events.	484	38
U16	As a Student I want to view my examination seating plan so that I can know about the details of the scheduled examination and venue of the examination.	763	4
U17	As a Student I want to register for backlog/reappear courses so that I can pass incomplete/ unfinished courses.	631	21
U18	As a Student I want to fill the feedback form for teachers/mentors/AO/Heads or guest lectures so that university management can identify the areas of improvement in various aspects to improve the quality of university.	517	35
U19	As a Student I want to view my fee structure for the particular program and specific fee schedule for the specific semester so that I can pay my university fee within the specific schedule.	623	22
U20	As a Student I want to see my fee status so that I can know about transactions detail or any remaining fee balance for the particular semester.	599	25
U21	As a Student I want to put RMS log request so that I can suggest, complaint, request, enquire about something.	518	34
U22	As a Student I want to apply for new RFID so that I can get pass to park my vehicle in university parking area.	461	40
U23	As a Student I want to register for activity/event so that I can participate in those events.	469	39
U24	As a Student I want to view all announcements so that I can know about important announcements regarding academics/ examination or placements.	746	7
U25	As a Student I want to change my UMS account password so that I can secure my UMS profile.	661	16

U26	As a Student I want to see academic calendar for the term so that I can know about schedule regarding class commencement, MTE or ETE.	579	28
U27	As a Student I want to put certificate request so that I can get my academic transcripts, Provisionals, character certificate.	608	24
U28	As a Student I want check Academic course syllabus so that I can know unit wise division of chapters for easy preparation.	679	13
U29	As a Student I want to check CR nomination so that I can apply for becoming class representative at the beginning of session.	421	41
U30	As a Student I want to view event duty leaves so that I can keep the record that during which lectures the event was attended.	516	36
U31	As a Student I want to view lab manuals so that I have access to specific course material where they can be downloaded as per requirement.	525	33
U32	As a Student I want to opt for minor elective so that I can opt for minor courses during my major course.	580	27
U33	As a Student I want to access open elective so that I can opt for extra open elective courses.	567	30
U34	As a Student I want to put request for duty leave so that I can request the authority to update my duty leaves in duty leave section.	543	31
U35	As a Student I want to apply for provisional admit card so that I can sit for university examinations in case my id card is lost/stolen.	723	11
U36	As a Student I want to apply for summer term so that I can pass incomplete/unfinished courses.	635	20
U37	As a Student I want to view e-deposit slip so that I can have online record for fee deposited.	502	37
U38	As a Student I want to get token allotment so that I don't have to wait for long hours while depositing fee.	595	26

U39	As a Student I want to have access to placement services so that I can register for placement events, update Student portal, register for placement policy and summer internship.	799	3
U40	As a Student I want to access hostel services so that I can apply for mess card, apply for hostel leave, get acknowledgement for confiscated items.	575	29
U41	As a Student I want to fill online form for parent pass so that my parents are allowed to enter the university premises.	530	32

We are drawing total number of points for each user story by graph as shown in Figure 5.1. Due to the lack of space we are representing user stories only by their serial numbers instead of names. In following graph, user stories of serial numbers “U29” and “U1” (as mentioned in Table 5.1) get less total number of votes and more total number of votes respectively. So user-story “U1” and “U29” receive highest and smallest importance from clients.

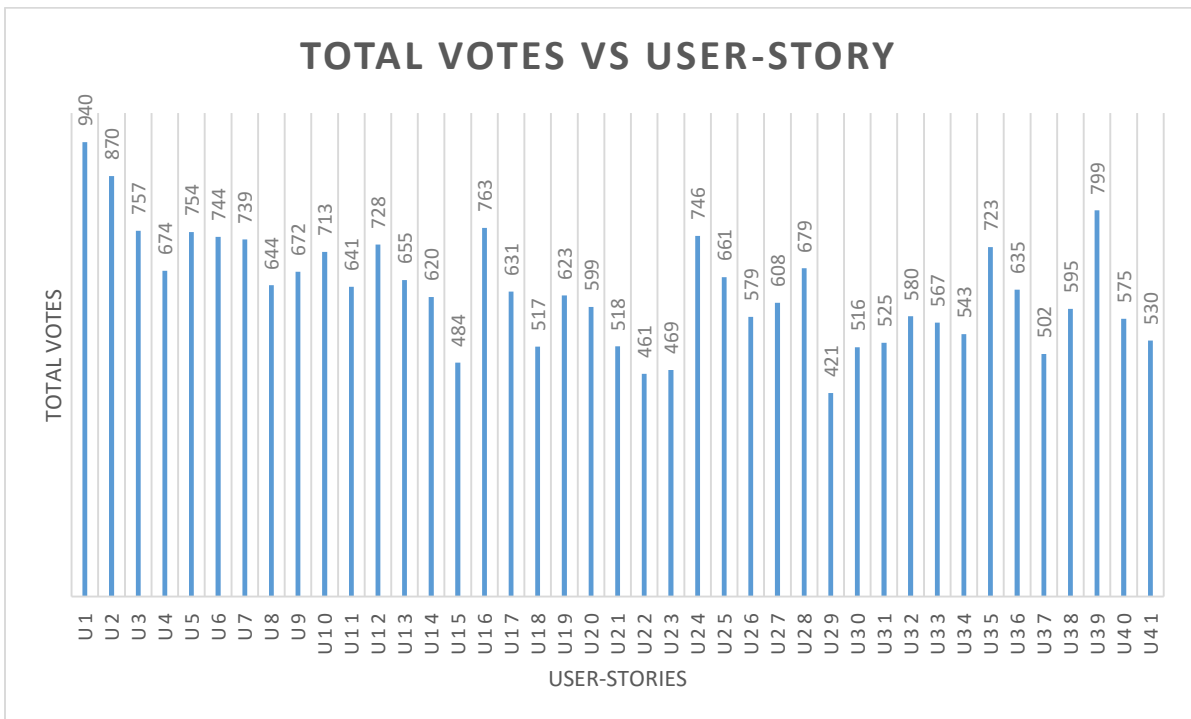


Figure 5.1: Total Votes for Each User-Story

5.1.2 Phase 2

In this section, the weighted score of user stories has been calculated by weighted sum model. Initially, the product owner selects the different criteria C_i that are important for the quality and the business value of the product. The product owner is the one who provides product vision and product boundaries. Based upon the discussion with the team, the product owner finalized four criteria for the project, which are business value, quality delivery, timely delivery and usability. The product owner then assign weights to business value, quality delivery, timely delivery and usability that is 0.25, 0.20, 0.30 and 0.25 respectively. In the next step, the importance value of each criteria with respect to a particular user-story is calculated by using ordinal importance scale as shown in Figure 4.1. The importance value a_{ij} and weights w_i of each criteria related to a particular user-story are multiplied. Finally the weighted score of each user-story is calculated. The user stories with weighted score are shown in the following Table 5.2.

Table 5.2: User-Stories with Weighted Score

Sr. No	User-Story	Rank	Weighted Score
U1	As a Student I want to login to UMS so that I can access UMS.	1	10.0
U2	As a Student I want to logout my UMS account so that other person can't access my account	2	9.80
U3	As a Student I want to see my today's time table so that I can know about the class timing and venue of the class.	5	8.20
U4	As a Student I want to check Instruction Plan (IP) of my courses so that I can know about lecture details like lecture numbers, topics, test books, lecture description, lecture outcome regarding particular lecture.	14	6.80
U5	As a Student I want to check my attendance so that I can track the attendance record for different courses.	6	8.05

U6	As a Student I want to I want to view the assignment, assigned by the teacher so that I can submit the assignment before the submission date.	8	7.70
U7	As a Student I want to upload assignment so that it can be evaluated by the teacher.	9	7.50
U8	As a Student I want to view assignment marks so that I can track my performance.	18	6.45
U9	As a Student I want to view courses material uploaded by the teacher so that I can use it for my preparation.	15	6.75
U10	As a Student I want to view lab assignment question so that I can solve it.	12	7.10
U11	As a Student I want to upload lab assignment so that it can be evaluated by the teacher.	19	6.30
U12	As a Student I want to view my result so that I can know about my performance in all subjects in all terms/semesters.	10	7.35
U13	As a Student I want to view my capstone project/ dissertation marks so that I can check my monthly performance according to the teacher.	17	6.50
U14	As a Student I want to check my messages so that I can know about various activities or tasks given by teachers.	23	5.75
U15	As a Student I want to view upcoming events so that I can get information about the upcoming events and will plan to participate in those events.	38	4.0
U16	As a Student I want to view my examination seating plan so that I can know about the details of the scheduled examination and venue of the examination.	4	8.50
U17	As a Student I want to register for backlog/reappear courses so that I can pass incomplete/ unfinished courses.	21	6.0
U18	As a Student I want to fill the feedback form for teachers/mentors/AO/Heads or guest lectures so that	35	4.45

	university management can identify the areas of improvement in various aspects to improve the quality of university.		
U19	As a Student I want to view my fee structure for the particular program and specific fee schedule for the specific semester so that I can pay my university fee within the specific schedule.	22	5.95
U20	As a Student I want to see my fee status so that I can know about transactions detail or any remaining fee balance for the particular semester.	25	5.55
U21	As a Student I want to put RMS log request so that I can suggest, complaint, request, enquire about something.	34	4.60
U22	As a Student I want to apply for new RFID so that I can get pass to park my vehicle in university parking area.	40	3.70
U23	As a Student I want to register for activity/event so that I can participate in those events.	39	3.90
U24	As a Student I want to view all announcements so that I can know about important announcements regarding academics/examination or placements.	7	8.0
U25	As a Student I want to change my UMS account password so that I can secure my UMS profile.	16	6.55
U26	As a Student I want to see academic calendar for the term so that I can know about schedule regarding class commencement, MTE or ETE.	28	5.25
U27	As a Student I want to put certificate request so that I can get my academic transcripts, Provisionals, character certificate.	24	5.70
U28	As a Student I want check Academic course syllabus so that I can know unit wise division of chapters for easy preparation.	13	7.05

U29	As a Student I want to check CR nomination so that I can apply for becoming class representative at the beginning of session.	41	3.45
U30	As a Student I want to view event duty leaves so that I can keep the record that during which lectures the event was attended.	36	4.35
U31	As a Student I want to view lab manuals so that I have access to specific course material where they can be downloaded as per requirement.	33	4.65
U32	As a Student I want to opt for minor elective so that I can opt for minor courses during my major course.	27	5.35
U33	As a Student I want to access open elective so that I can opt for extra open elective courses.	30	4.95
U34	As a Student I want to put request for duty leave so that I can request the authority to update my duty leaves in duty leave section.	31	4.90
U35	As a Student I want to apply for provisional admit card so that I can sit for university examinations in case my id card is lost/stolen.	11	7.25
U36	As a Student I want to apply for summer term so that I can pass incomplete/unfinished courses.	20	6.25
U37	As a Student I want to view e-deposit slip so that I can have online record for fee deposited.	37	4.20
U38	As a Student I want to get token allotment so that I don't have to wait for long hours while depositing fee.	26	5.45
U39	As a Student I want to have access to placement services so that I can register for placement events, update Student portal, register for placement policy and summer internship.	3	9.0

U40	As a Student I want to access hostel services so that I can apply for mess card, apply for hostel leave, get acknowledgement for confiscated items.	29	5.15
U41	As a Student I want to fill online form for parent pass so that my parents are allowed to enter the university premises.	32	4.85

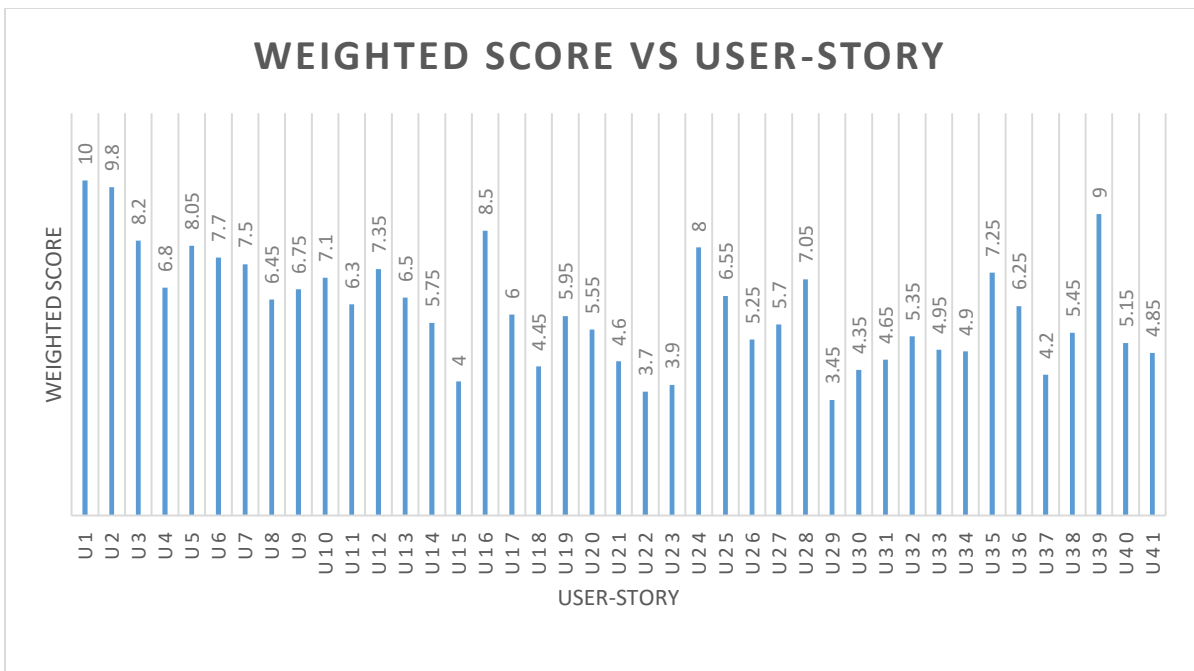


Figure 5.2: Weighted Score for Each User Story

5.1.3 Phase 3

In this section, effort of each user story has been calculated using planning poker. In planning poker we have use modified Fibonacci series to select story points. In this effort estimation technique, experts from development, database and testing team are involved to calculate the effort of user-stories based on story points. We are calculating effort in hours for each user-story. In our research, one story point is taken of eight ideal hours approximately. User stories with estimated effort are described in following Table 5.3.

Table 5.3: User-Stories with Effort

Sr. No	User-Story	Story Points	Effort
U1	As a Student I want to login to UMS so that I can access UMS.	1	8
U2	As a Student I want to logout my UMS account so that other person can't access my account	1	8
U3	As a Student I want to see my today's time table so that I can know about the class timing and venue of the class.	2	16
U4	As a Student I want to check Instruction Plan (IP) of my courses so that I can know about lecture details like lecture numbers, topics, test books, lecture description, lecture outcome regarding particular lecture.	2	16
U5	As a Student I want to check my attendance so that I can track the attendance record for different courses.	2	16
U6	As a Student I want to I want to view the assignment, assigned by the teacher so that I can submit the assignment before the submission date.	2	16
U7	As a Student I want to upload assignment so that it can be evaluated by the teacher.	3	24
U8	As a Student I want to view assignment marks so that I can track my performance.	3	24
U9	As a Student I want to view courses material uploaded by the teacher so that I can use it for my preparation.	3	24
U10	As a Student I want to view lab assignment question so that I can solve it.	2	16
U11	As a Student I want to upload lab assignment so that it can be evaluated by the teacher.	3	24

U12	As a Student I want to view my result so that I can know about my performance in all subjects in all terms/semesters.	3	24
U13	As a Student I want to view my capstone project/ dissertation marks so that I can check my monthly performance according to the teacher.	2	16
U14	As a Student I want to check my messages so that I can know about various activities or tasks given by teachers.	2	16
U15	As a Student I want to view upcoming events so that I can get information about the upcoming events and will plan to participate in those events.	3	24
U16	As a Student I want to view my examination seating plan so that I can know about the details of the scheduled examination and venue of the examination.	2	16
U17	As a Student I want to register for backlog/reappear courses so that I can pass incomplete/ unfinished courses.	3	24
U18	As a Student I want to fill the feedback form for teachers/mentors/AO/Heads or guest lectures so that university management can identify the areas of improvement in various aspects to improve the quality of university.	5	40
U19	As a Student I want to view my fee structure for the particular program and specific fee schedule for the specific semester so that I can pay my university fee within the specific schedule.	2	16
U20	As a Student I want to see my fee status so that I can know about transactions detail or any remaining fee balance for the particular semester.	3	24
U21	As a Student I want to put RMS log request so that I can suggest, complaint, request, enquire about something.	3	24

U22	As a Student I want to apply for new RFID so that I can get pass to park my vehicle in university parking area.	3	24
U23	As a Student I want to register for activity/event so that I can participate in those events.	3	24
U24	As a Student I want to view all announcements so that I can know about important announcements regarding academics/ examination or placements.	3	24
U25	As a Student I want to change my UMS account password so that I can secure my UMS profile.	2	16
U26	As a Student I want to see academic calendar for the term so that I can know about schedule regarding class commencement, MTE or ETE.	2	16
U27	As a Student I want to put certificate request so that I can get my academic transcripts, Provisionals, character certificate.	3	24
U28	As a Student I want check Academic course syllabus so that I can know unit wise division of chapters for easy preparation.	2	16
U29	As a Student I want to check CR nomination so that I can apply for becoming class representative at the beginning of session.	2	16
U30	As a Student I want to view event duty leaves so that I can keep the record that during which lectures the event was attended.	3	24
U31	As a Student I want to view lab manuals so that I have access to specific course material where they can be downloaded as per requirement.	2	16
U32	As a Student I want to opt for minor elective so that I can opt for minor courses during my major course.	3	24

U33	As a Student I want to access open elective so that I can opt for extra open elective courses.	3	24
U34	As a Student I want to put request for duty leave so that I can request the authority to update my duty leaves in duty leave section.	3	24
U35	As a Student I want to apply for provisional admit card so that I can sit for university examinations in case my id card is lost/stolen.	3	24
U36	As a Student I want to apply for summer term so that I can pass incomplete/unfinished courses.	3	24
U37	As a Student I want to view e-deposit slip so that I can have online record for fee deposited.	2	16
U38	As a Student I want to get token allotment so that I don't have to wait for long hours while depositing fee.	3	24
U39	As a Student I want to have access to placement services so that I can register for placement events, update Student portal, register for placement policy and summer internship.	5	40
U40	As a Student I want to access hostel services so that I can apply for mess card, apply for hostel leave, get acknowledgement for confiscated items.	5	40
U41	As a Student I want to fill online form for parent pass so that my parents are allowed to enter the university premises.	3	24

5.1.4 Phase 4

In this phase, we are calculating weighted score by effort ratio on the basis of which user-stories prioritization is done. For each user-story weighted score by effort ratio is shown in Table 5.4.

Table 5.4: User Stories with Weighted Score by Effort Ratio

Sr. No	User-Story	Weighted Score	Effort	Weighted Score by Effort Ratio
U1	As a Student I want to login to UMS so that I can access UMS.	10.0	8	1.25
U2	As a Student I want to logout my UMS account so that other person can't access my account	9.80	8	1.225
U3	As a Student I want to see my today's time table so that I can know about the class timing and venue of the class.	8.20	16	0.5125
U4	As a Student I want to check Instruction Plan (IP) of my courses so that I can know about lecture details like lecture numbers, topics, test books, lecture description, lecture outcome regarding particular lecture.	6.80	16	0.425
U5	As a Student I want to check my attendance so that I can track the attendance record for different courses.	8.05	16	0.503125
U6	As a Student I want to I want to view the assignment, assigned by the teacher so that I can submit the assignment before the submission date.	7.70	16	0.48125
U7	As a Student I want to upload assignment so that it can be evaluated by the teacher.	7.50	24	0.3125
U8	As a Student I want to view assignment marks so that I can track my performance.	6.45	24	0.26875
U9	As a Student I want to view courses material uploaded by the teacher so that I can use it for my preparation.	6.75	24	0.28125

U10	As a Student I want to view lab assignment question so that I can solve it.	7.10	16	0.44375
U11	As a Student I want to upload lab assignment so that it can be evaluated by the teacher.	6.30	24	0.2625
U12	As a Student I want to view my result so that I can know about my performance in all subjects in all terms/semesters.	7.35	24	0.30625
U13	As a Student I want to view my capstone project/ dissertation marks so that I can check my monthly performance according to the teacher.	6.50	16	0.40625
U14	As a Student I want to check my messages so that I can know about various activities or tasks given by teachers.	5.75	16	0.359375
U15	As a Student I want to view upcoming events so that I can get information about the upcoming events and will plan to participate in those events.	4.0	24	0.166666667
U16	As a Student I want to view my examination seating plan so that I can know about the details of the scheduled examination and venue of the examination.	8.50	16	0.53125
U17	As a Student I want to register for backlog/reappear courses so that I can pass incomplete/ unfinished courses.	6.0	24	0.25
U18	As a Student I want to fill the feedback form for teachers/mentors/AO/Heads or guest lectures so that university management can identify the areas of improvement in various aspects to improve the quality of university.	4.45	40	0.11125

U19	As a Student I want to view my fee structure for the particular program and specific fee schedule for the specific semester so that I can pay my university fee within the specific schedule.	5.95	16	0.371875
U20	As a Student I want to see my fee status so that I can know about transactions detail or any remaining fee balance for the particular semester.	5.55	24	0.23125
U21	As a Student I want to put RMS log request so that I can suggest, complaint, request, enquire about something.	4.60	24	0.191666667
U22	As a Student I want to apply for new RFID so that I can get pass to park my vehicle in university parking area.	3.70	24	0.154166667
U23	As a Student I want to register for activity/event so that I can participate in those events.	3.90	24	0.1625
U24	As a Student I want to view all announcements so that I can know about important announcements regarding academics/examination or placements.	8.0	24	0.333333333
U25	As a Student I want to change my UMS account password so that I can secure my UMS profile.	6.55	16	0.409375
U26	As a Student I want to see academic calendar for the term so that I can know about schedule regarding class commencement, MTE or ETE.	5.25	16	0.328125
U27	As a Student I want to put certificate request so that I can get my academic transcripts, Provisionals, character certificate.	5.70	24	0.2375

U28	As a Student I want check Academic course syllabus so that I can know unit wise division of chapters for easy preparation.	7.05	16	0.440625
U29	As a Student I want to check CR nomination so that I can apply for becoming class representative at the beginning of session.	3.45	16	0.215625
U30	As a Student I want to view event duty leaves so that I can keep the record that during which lectures the event was attended.	4.35	24	0.18125
U31	As a Student I want to view lab manuals so that I have access to specific course material where they can be downloaded as per requirement.	4.65	16	0.290625
U32	As a Student I want to opt for minor elective so that I can opt for minor courses during my major course.	5.35	24	0.222916667
U33	As a Student I want to access open elective so that I can opt for extra open elective courses.	4.95	24	0.20625
U34	As a Student I want to put request for duty leave so that I can request the authority to update my duty leaves in duty leave section.	4.90	24	0.204166667
U35	As a Student I want to apply for provisional admit card so that I can sit for university examinations in case my id card is lost/stolen.	7.25	24	0.302083333
U36	As a Student I want to apply for summer term so that I can pass incomplete/unfinished courses.	6.25	24	0.260416667
U37	As a Student I want to view e-deposit slip so that I can have online record for fee deposited.	4.20	16	0.2625

U38	As a Student I want to get token allotment so that I don't have to wait for long hours while depositing fee.	5.45	24	0.227083333
U39	As a Student I want to have access to placement services so that I can register for placement events, update Student portal, register for placement policy and summer internship.	9.0	40	0.225
U40	As a Student I want to access hostel services so that I can apply for mess card, apply for hostel leave, get acknowledgement for confiscated items.	5.15	40	0.12875
U41	As a Student I want to fill online form for parent pass so that my parents are allowed to enter the university premises.	4.85	24	0.202083333

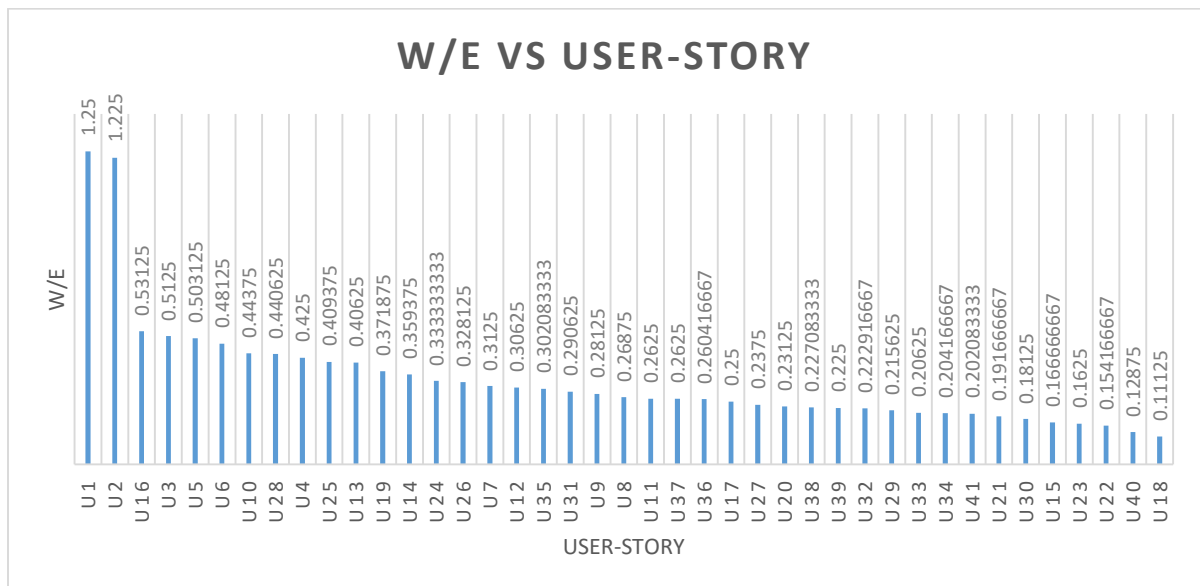


Figure 5.3: Weighted Score by Effort Ratio for Each User-Story

Now, we are assigning priority to user stories. The user-story that has highest value of weight by effort ratio receive highest priority and that has lowest value of weight by effort ratio receive lowest priority. So, the user-story “U1” received highest priority and user-story “U18” received smallest priority. The priority shown in Table 5.5.

According to ranking from the customers, the user-story “U1” received highest importance and “U29” received lowest importance. But after the calculation from the final step show that the “U1” received highest priority and “U18” received lowest priority. It is because of effort is calculated from the development team.

Table 5.5: User-Story with Priority

Sr. No	User-Story	Weighted Score by Effort Ratio	Priority
U1	As a Student I want to login to UMS so that I can access UMS.	1.25	1
U2	As a Student I want to logout my UMS account so that other person can't access my account	1.225	2
U3	As a Student I want to see my today's time table so that I can know about the class timing and venue of the class.	0.5125	4
U4	As a Student I want to check Instruction Plan (IP) of my courses so that I can know about lecture details like lecture numbers, topics, test books, lecture description, lecture outcome regarding particular lecture.	0.425	9
U5	As a Student I want to check my attendance so that I can track the attendance record for different courses.	0.503125	5
U6	As a Student I want to I want to view the assignment, assigned by the teacher so that I can submit the assignment before the submission date.	0.48125	6

U7	As a Student I want to upload assignment so that it can be evaluated by the teacher.	0.3125	16
U8	As a Student I want to view assignment marks so that I can track my performance.	0.26875	21
U9	As a Student I want to view courses material uploaded by the teacher so that I can use it for my preparation.	0.28125	20
U10	As a Student I want to view lab assignment question so that I can solve it.	0.44375	7
U11	As a Student I want to upload lab assignment so that it can be evaluated by the teacher.	0.2625	22
U12	As a Student I want to view my result so that I can know about my performance in all subjects in all terms/semesters.	0.30625	17
U13	As a Student I want to view my capstone project/ dissertation marks so that I can check my monthly performance according to the teacher.	0.40625	11
U14	As a Student I want to check my messages so that I can know about various activities or tasks given by teachers.	0.359375	13
U15	As a Student I want to view upcoming events so that I can get information about the upcoming events and will plan to participate in those events.	0.25	37
U16	As a Student I want to view my examination seating plan so that I can know about the details of the scheduled examination and venue of the examination.	0.53125	3
U17	As a Student I want to register for backlog/reappear courses so that I can pass incomplete/ unfinished courses.	0.25	25
U18	As a Student I want to fill the feedback form for teachers/mentors/AO/Heads or guest lectures so that	0.11125	41

	university management can identify the areas of improvement in various aspects to improve the quality of university.		
U19	As a Student I want to view my fee structure for the particular program and specific fee schedule for the specific semester so that I can pay my university fee within the specific schedule.	0.371875	12
U20	As a Student I want to see my fee status so that I can know about transactions detail or any remaining fee balance for the particular semester.	0.23125	27
U21	As a Student I want to put RMS log request so that I can suggest, complaint, request, enquire about something.	0.191666667	35
U22	As a Student I want to apply for new RFID so that I can get pass to park my vehicle in university parking area.	0.154166667	39
U23	As a Student I want to register for activity/event so that I can participate in those events.	0.1625	38
U24	As a Student I want to view all announcements so that I can know about important announcements regarding academics/ examination or placements.	0.333333333	14
U25	As a Student I want to change my UMS account password so that I can secure my UMS profile.	0.409375	10
U26	As a Student I want to see academic calendar for the term so that I can know about schedule regarding class commencement, MTE or ETE.	0.328125	15
U27	As a Student I want to put certificate request so that I can get my academic transcripts, Provisionals, character certificate.	0.2375	26

U28	As a Student I want check Academic course syllabus so that I can know unit wise division of chapters for easy preparation.	0.440625	8
U29	As a Student I want to check CR nomination so that I can apply for becoming class representative at the beginning of session.	0.215625	31
U30	As a Student I want to view event duty leaves so that I can keep the record that during which lectures the event was attended.	0.18125	36
U31	As a Student I want to view lab manuals so that I have access to specific course material where they can be downloaded as per requirement.	0.290625	19
U32	As a Student I want to opt for minor elective so that I can opt for minor courses during my major course.	0.222916667	30
U33	As a Student I want to access open elective so that I can opt for extra open elective courses.	0.20625	32
U34	As a Student I want to put request for duty leave so that I can request the authority to update my duty leaves in duty leave section.	0.204166667	33
U35	As a Student I want to apply for provisional admit card so that I can sit for university examinations in case my id card is lost/stolen.	0.302083333	18
U36	As a Student I want to apply for summer term so that I can pass incomplete/unfinished courses.	0.260416667	24
U37	As a Student I want to view e-deposit slip so that I can have online record for fee deposited.	0.2625	23
U38	As a Student I want to get token allotment so that I don't have to wait for long hours while depositing fee.	0.227083333	28
U39	As a Student I want to have access to placement services so that I can register for placement events,	0.225	29

	update Student portal, register for placement policy and summer internship.		
U40	As a Student I want to access hostel services so that I can apply for mess card, apply for hostel leave, get acknowledgement for confiscated items.	0.12875	40
U41	As a Student I want to fill online form for parent pass so that my parents are allowed to enter the university premises.	0.202083333	34

5.2 Comparison with Existing Technique

In the proposed prioritization technique the importance is calculated by clients/customers and the product owner of the project. The proposed technique is based on the multi-criteria decision making (MCDM) that is weighted sum model, and it is performed by the product owner of the product.

The effort is calculated using panning poker techniques which involves developers and testers for the effort estimation. The comparison of proposed technique and existing technique is given in the below Table 5.6.

Table 5.6: Comparison with Existing Technique

Sr. No.	Aspects of user-stories prioritization	Existing Prioritization Technique	Proposed Prioritization Technique
1.	Criteria of Prioritization	Importance is calculated based on criteria business value and risk.	Importance is calculated based on criteria weights of business value, quality delivery, timely delivery usability, complexity and risk.
2.	Type of Approach	Simple Approach	Hybrid Approach i.e. Combination of the cumulative voting for

			importance from customer, weighted sum model for importance from product owner and planning poker for effort estimation.
3.	Ranking from customers	Not performed	Yes, using cumulative voting method.
4.	Project Size	Small to Medium	Medium to Large.

CONCLUSION AND FUTURE SCOPE

The product owner is the one who plays an important role in prioritization of user-stories of product backlog. But actually product owner's decision making depends upon clients or stakeholders who decide the importance of each user-story of software product. For prioritization process, it is required that the product owner and other stakeholders should keep focus to the activities of product development and applies the best thinking, best of decision making, and best of communication skills for the quality of the product.

In this research, multiple hidden factors are considered to calculate the prioritization of user stories. Importance is decided by customers and the product owner, and effort estimation is calculated by developers and testers. Since prioritization process of user-stories highly depends upon multiple factor, the software product quality is more. The relative importance represented by weighted score calculated by considering multiple criteria factors. So, weighted score by effort ratio is calculated to get user-story priority. The user-stories which are critical, important and require minimum implementation time, those user-stories are taken first in product backlog for implementation. In the future the various factors which are important for users, developers and testers can be taken into account for prioritization of user-stories and new methods can be involved in the prioritization process in agile environment for the quality and rapid delivery to the customers.

REFERENCES

- [1] R. Popli, N. Chauhan, and H. Sharma, "Prioritising user stories in agile environment," *2014 Int. Conf. Issues Challenges Intell. Comput. Tech.*, pp. 515–519, 2014.
- [2] S. Hudda, R. Mahajan, and S. Chopra, "Prioritization of User-Stories in Agile Environment," *Indian Journal of Science and Technology*, 2016.
- [3] F. Sher, D. N. A. Jawawi, R. Mohamad, and M. I. Babar, "Multi-aspects based requirements prioritization technique for value-based software developments," *Proc. - 2014 Int. Conf. Emerg. Technol. ICET 2014*, pp. 1–6, 2015.
- [4] Z. Racheva, M. Daneva, and L. Buglione, "Supporting the dynamic reprioritization of requirements in agile development of software products," *2008 2nd Int. Work. Softw. Prod. Manag. ISWPM'08*, no. i, 2008.
- [5] M. Aasem, M. Ramzan, A. Jaffar, and E. S. Islamabad, "Analysis and optimization of software requirements prioritization techniques," 2010.
- [6] G. Kaur and S. Bawa, "A Survey of Requirement Prioritization Methods," *Int. J. Eng. Res. Technol.*, vol. 2, no. 5, pp. 958–962, 2013.
- [7] G. K. N. Pdvrrp and J. Frp, "An Analysis of Software Requirements Prioritization Techniques: A Detailed Study," pp. 3966–3970, 2016.
- [8] J. A. Khan, "Comparison of Requirement Prioritization Techniques to Find Best Prioritization Technique," no. November, pp. 53–59, 2015.
- [9] V. T. Heikkila, D. Damian, C. Lassenius, and M. Paasivaara, "A Mapping Study on Requirements Engineering in Agile Software Development," *Proc. - 41st Euromicro Conf. Softw. Eng. Adv. Appl. SEAA 2015*, pp. 199–207, 2015.
- [10] Z. Racheva, M. Daneva, K. Sikkil, R. Wieringa, and A. Herrmann, "Do we know enough about requirements prioritization in agile projects: Insights from a case

- study,” *Proc. 2010 18th IEEE Int. Requir. Eng. Conf. RE2010*, pp. 147–156, 2010.
- [11] S. K. Saxena and R. Chakraborty, “Decisively: Application of quantitative analysis and decision science in agile requirements engineering,” *2014 IEEE 22nd Int. Requir. Eng. Conf. RE 2014 - Proc.*, pp. 323–324, 2014.
- [12] S. Alyahya, M. Alqahtani, and M. Maddeh, “Evaluation and improvements for agile planning tools,” *2016 IEEE/ACIS 14th Int. Conf. Softw. Eng. Res. Manag. Appl. SERA 2016*, pp. 217–224, 2016.
- [13] J. R. Kiper, “Eliciting user needs for a knowledge management system to align training programs with processes and policies in large organizations,” *Proc. Annu. Hawaii Int. Conf. Syst. Sci.*, vol. 2015–March, pp. 3970–3979, 2015.
- [14] M. A. A. Elsood, H. A. Hefny, and E. S. Nasr, “A goal-based technique for requirements prioritization,” *2014 9th Int. Conf. Informatics Syst. INFOS 2014*, p. SW18-SW24, 2015.
- [15] M. I. Babar, M. Ramzan, and S. a. K. Ghayyur, “Challenges and future trends in software requirements prioritization,” *Int. Conf. Comput. Networks Inf. Technol.*, no. August, pp. 319–324, 2011.
- [16] R. Thakurta, “Understanding requirement prioritization artifacts: a systematic mapping study,” *Requir. Eng.*, pp. 1–36, 2016.
- [17] M. Dabbagh, S. P. Lee, and R. M. Parizi, “Application of hybrid assessment method for priority assessment of functional and non-functional requirements,” *ICISA 2014 - 2014 5th Int. Conf. Inf. Sci. Appl.*, pp. 0–3, 2014.
- [18] S. P. Rodrigues, L. A. Costa, D. Produc, and U. Minho, “Comparing AHP and ELECTRE I for prioritizing software requirements,” 2015.
- [19] B. A. Mustafa and A. Zainuddin, “An experimental design to compare software requirements prioritization techniques,” *2014 Int. Conf. Comput. Sci. Technol. ICCST 2014*, 2014.
- [20] I. P. Gambo, A. H. Soriyan, and R. N. Ikono, “A Proposed Process Model for

- Requirements Engineering using Delphi Techniques for Prioritisation,” *Int. J. Inf. Technol. Comput. Sci. December*, vol. 7, no. 1, pp. 73–80, 2014.
- [21] A. H. Process, “Hierarchical Cumulative Voting (HCV)- Prioritization of Requirements in Hierarchies,” vol. 16, no. 6, pp. 819–849, 2006.
- [22] M. Svahnberg, “A Study on the Importance of Order in Requirements Prioritisation,” 2010.
- [23] Z. Racheva and M. Daneva, “A Conceptual Model and Process for Client-driven Agile Requirements Prioritization,” 2010.
- [24] P. Achimugu, A. Selamat, R. Ibrahim, and M. Naz, “A systematic literature review of software requirements prioritization research,” *Inf. Softw. Technol.*, vol. 56, no. 6, pp. 568–585, 2014.
- [25] E. Triantaphyllou, B. Shu, S. N. Sanchez, and T. Ray, “Multi-Criteria Decision Making : An Operations Research Approach,” vol. 15, pp. 175–186, 1998.
- [26] C. Nils, “An Empirical Study of Using Planning Poker for User Story Estimation,” 2006.
- [27] K. Moløkken-østvold, N. Christian, and H. Christian, “The Journal of Systems and Software Using planning poker for combining expert estimates in software projects,” *J. Syst. Softw.*, vol. 81, no. 12, pp. 2106–2117, 2008.
- [28] I. Science, “The Journal of Systems and Software,” vol. 85, pp. 2086–2095, 2012.
- [29] M. Usman, E. Mendes, F. Weidt, and R. Britto, “Effort Estimation in Agile Software Development : A Systematic Literature Review,” pp. 82–91, 2014.
- [30] E. Triantaphyllou, *Multi-Criteria Decision Making Methods: A Comparative Study*.
- [31] <https://www.versionone.com/agile-101/agile-methodologies/>
- [32] www.smartsheet.com/comprehensive-guide-values-principles-agile-manifesto
- [33] LPU UMS site, <https://ums.lpu.in/lpuums>