Prioritization of User-Stories in Agile Environment

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Abstract

Objectives: The objective of this paper is to prioritize user stories based on importance, and effort criteria. **Methods/ Statistical Analysis:** The proposed approach is considering importance, and effort criteria for the prioritization of user stories. Importance is decided by students, and effort is decided by complexity factor. The Voting Method is used for assignment of rank based on importance, Rank Ordered Centroid Multiple Criteria Decision Analysis Method is used for calculation of weight, and Program Evaluation Review Technique is used for estimation of effort. The priority of a user story is decided by weight by effort ratio. **Findings**: Usually the user story prioritization is done by some familiar methods such as Moscow method, Business Value method, Walking Skelton method, Kano Model, and Validate learning method. In this paper an approach is proposed that consider criteria from client's side as well as developer's side. In this approach; rank, weight, and effort are determined on the basis of which the prioritization of user stories is done. So this approach considers criteria from client side as well as developer side both, but familiar methods consider criteria either from client side or developer side. **Applications/Improvements:** The proposed approach will easy to use in various agile-development-oriented organizations. In future other important criteria for clients as well as developers can be considered for prioritization of user-stories.

Keywords: Agile, Multiple Criteria Decision Analysis, Program Evaluation Review Techniques, Rank Order Centroid Method, Requirement Prioritization, User Stories

1. Introduction

In software engineering, there are several different types of software development processes and lifecycle models exist. These models are considering several specific technical goals, and non-technical goals. Examples of such models are different sequential models such as Waterfall model, V model, RAD model, and evolutionary model such as Spiral model. These models are specific to particular projects and some development constraints. Agile Software Development Methodology is a very new and young discipline is still required some quality research. In agile environment requirement prioritization is main and important task.

The product owner communicates with clients to collect requirements as soon as possible. The product owner collects the requirements in the form of user-stories from clients. The process of requirement prioritization starts from planning phase and continue throughout the project. Requirement prioritization adapts change in requirements, and maximizes the business value. To deliver a successful software to clients the product owner should keep these requirements (i.e. user-stories), in product backlog, in prioritized order. The prioritization

of user-stories is based on multiple criteria such as cost, business value, risk, duration, effort, complexity, and importance. For an example, to buy a car there is a need to consider multiple criteria by a customer like price, mileage, safety features, looks, color, brand, fuel consumption power, and size. Then the customer decides which brand of a car should I select so that it will come in range of my budget? Which type of car provides more safety features to customer? If a car consumes more fuel or it gives less mileage then customer takes less interest in it. The customer may also decide rest of criteria according to his needs. In similar manner, the product owner should select these requirements in such a way that provides maximum business value. The list of selected requirements (i.e. prioritized list of requirements) should satisfy clients more, and developer team can built them within a stimulated time-period. When requirements are more complex or require more development time then product owner splits them into some pieces so development team can accommodate them more easily.

Prioritization of user-stories depends on the number of several different factor or criteria. Some of them may belong to client's side and some of them may belong to developer's side. The business value, importance is several criteria that belong to client's side, and several other criteria are cost, risk, effort, and duration that belong to developer's side. For prioritization of user stories clients place votes to each user-story. Rank is assigned to user story by the product owner so rank represents the importance of user story for particular client. Our algorithm considers criteria from both side, client's side as well as developer's side. In our algorithm priority of user-story is decided from the weight by effort ratio. The weight expresses relative importance for user story and effort represents development time for user story. Votes are placed in the form of numeric value within a range of total number of user stories. Effort denotes development time – time required by development team to develop a user story. Hence, we are using importance and effort criteria related to clients and developers respectively.

The remainder of this paper is structured as follows: - Section 2 summarizes background and related work. Section 3 presents several existing agile prioritization methods with some challenges. Section 4 discusses the proposed research work. Section 5 describes case study conducted to evaluate results. Section 6 concludes this paper and states the future work.

2. Related Work

A number of studies are available to prioritize user-stories in agile environment. To best of our knowledge there is no systematic empirical research study is present about how the user-stories are prioritized in agile environment. Basically the agile approaches are deliver the business value to clients early and periodically throughout the whole project. In[1] authors presented a research work in which they described several factors related to importance and effort, these factors affect the prioritization of user stories in a project. They showed that the prioritization of user-stories is highly depend on the value of these factors and priority of user-stories is calculated by the ratio of importance and effort[1].

An empirical study presented in[2] in which authors showed that "Agile Requirements Engineering (RE) different from traditional software development RE, agile RE takes an iterative discovery approach. They stated that agile development occurs in an environment where developing unambiguous and complete requirement specifications is impossible or even inappropriate. They mentioned that strong or deep communication between the developers and customers is the most important RE practice. They presented several agile RE practices with some benefits and challenges, such as face to face communication, iterative requirement engineering, managing requirements change through constant planning, and test driven development. They mentioned that agile RE practices provide benefits such as improved understanding of customer needs, and the ability to adapt to the evolving need of today's dynamic environment".

A research work proposed in[3] here authors identified some issues and challenges in prioritization decision making in agile projects. "They studied some existing agile requirements prioritization methods and derived a conceptual model for inter-iteration prioritization decision-making from the perspective of the client. They used this conceptual model to structure issues and solutions pertinent to agile prioritization of requirements". One more research work is proposed in[4] in that authors investigated some concepts related to reprioritizing agile

requirements from clients perspective at inter-iteration time. They proposed a conceptual model that derived by a Grounded Theory. Such a conceptual model makes explicit the concepts that are used tacitly in different agile requirements prioritization methods. In research study[5] authors concluded that "While an agile software company lets clients prioritize requirements, the requirements decision-making process can take place only when the client's interest to make changes along the way is in balance with the developer's interest for a sustainable business. They also presented that the prioritization process instantiation varies across projects at different client companies and those variations seem to be linked to project characteristics such as size of project and size of client's organization".

In research study[6] a comparative overview is presented on several Rank Ordering Criteria Weighting Methods "Which are considered to convert the ordinal ranking of a criteria into numerical value of weight. In this study author presented many real world decision making problems as well as corporate decision making problems are based on multiple conflicting criteria". In study[6] author presented that the judgements of the decision makers are vague and their preferences as well weights assigned to criteria can't evaluated exactly or truly. Hence, practically true weights of criteria still remain unknown. Even if the elicitation of true weights is possible, it would be more time consuming and difficult. While rank ordering information available in advance, the rank ordering weighting method provide approximation of true weights for considered criteria. Assigning ranks to elicit weights

using some formulas is more reliable than directly assigning weights to criteria, since experts or non-experts are more confident about the ranks than their weights of some criteria, and they can agree on ranks more easily. Several different rank ordering weight methods are developed to take criteria priorities into account. The great advantage of these methods is that they depend only on the ordinal information about the criteria. In study[6], researcher highlighted that "Decision makers can rank criteria in situation of time pressure, lack of knowledge, partial information, incomplete information, and quality nature of criteria. This follows that decision makers may not able to provide true or exact estimations of criteria or they may not reach agreement on a set of exact weights, so in such situation agreement on ranking may become realistic". In research work [7] researcher presented that "In the multi-criteria models the weights of criteria play a very significant role and they have different interpretation. Usually weights provide the information about the relative importance of the considered criteria". Researcher is mentioned in a book [8] that "Multiple Criteria Decision Making (MCDM) or Multiple Criteria Decision Analysis (MCDA) refers to screening, prioritizing, ranking, and selecting the alternatives based on the human judgement from a finite set of decision alternatives in terms of multiple conflicting criteria".

3. Agile Prioritization Methods

The process of user-stories prioritization starts from planning phase and continue throughout the project.

Table 1. User stories prioritization methods

S. No.	User-stories prioritization methods		
	Name	Method	Problem
1	MoSCoW	Requirements are prioritized to deliver the greatest and most immediate business benefits early. The plain English meaning of the prioritization categories used to better understand the impact of setting a priority. MoSCoW stands for: M – Must have (Requirements with this label are critical to current delivery of software) S – Should have (Requirements with this label are important but not necessary for delivery in current software release) C – Could have (Requirements labeled with this label are desirable but not necessary) W – Won't have (These requirements are least critical, or not appropriate at that time)	MoSCow is ambiguous when it comes to the "Won't have" rating. "Won't have" could mean either not in the next release or not ever. Such distinctions should be clear so that all stakeholders share a common understanding.

Table 1 Continued

2	Business Value Based	In this method each requirement carries a business value it could potentially generate to the clients. The requirements with highest business value are implemented during the earlier software release.	This method doesn't consider the dependency among the requirements.
3	Kano Model	The Kano model classifies customer satisfaction into five categories. Those are: Must be Quality – These attributes are granted when fulfilled and dissatisfaction when not fulfilled. One dimensional Quality – Satisfaction when fulfilled and dissatisfaction when not fulfilled. Attractive Quality – Satisfaction when achieved fully and do not cause dissatisfaction when not fulfilled. Indifferent Quality – Neither customer satisfaction nor customer dissatisfaction. Reverse Quality – High degree of customer dissatisfaction.	It can only be used for analyzing the effects. It is not for suggesting new product features, something that is quite difficult to achieve.
4	Walking Skelton	In this method requirements are selected such that minimal carefully selected requirements are built within a short span of time.	In this method client wants the product according to their desirements, not according to selected by development team.
5	Validate Learning	In this method the requirements are chosen based on the highest risk. Release them to the market to get the feedback and apply learning on to the new requirements.	This method doesn't consider the dependency among the requirements. So division on the basis of risk is a difficult task.

The existing prioritization methods are based on few factors like importance, risk, duration, and business value. R. Popli et al. proposed a research work in that they discussed several user-story's prioritization methods[1]. These methods with some challenges are mentioned in following Table 1:

4. Proposed Work

A development team's time can be wasted when they select the wrong user-stories, or features, or requirements for a release (i.e. sprint). The product owner and other stakeholders are responsible for prioritizing the backlog

– backlog contain ordered list of customer requirements. Those requirements that have been requested more often or are important to the business are listed at the top of the backlog. The product owner continuously tends the backlog as customer need shift in importance.

4.1 Ranking User-Stories with Voting Method

The product owner is viewed as the backlog decider who decides the ordering of requirements in the product backlog. But actually product owner depends upon clients since the clients are the one who decide the importance of each user-story. Ranking of user-stories requires to keep complete concentration to the task and applies the best of decision making capabilities, best of thinking, and best of communication skills to face the challenge by the product owner. Hence, the product owner is one who provides the facility so product owner is a facilitator not a decider. This method contains following steps:

- Select all the user-stories and enables them to receive votes from clients.
- Ask the clients to place their votes to user-stories. Clients should place their votes to show their own preference.
- Take sum of all votes for each user story received from every client.
- Order the product backlog from the user-stories which receive less sum of votes to the user-stories which receive high sum of votes.

4.2 Rank Order Centroid MCDA Method

We are using ROC method for converting the rank into respective numerical weight. The ROC method provides an estimation of weights that minimizes the maximum error of each weight by identifying the centroid of all possible weights. This method has following steps:

- Take the list of ranked requirements (i.e. user-stories).
- Take the inverse of rank (r) for every ranked requirement, which is $\left|\dfrac{1}{r}\right|$.

- Now take the sum of the current requirement's inverse-rank and all lower ranked requirement's inverse-rank.
- Then divide the sum by total number of ranked requirements.

This method can be expressed in mathematical form as follows:

$$W_j = \left(\frac{1}{N}\right) * \sum_{r=j}^{N}\left(\frac{1}{r}\right) \tag{1}$$

Where N is the total number of ranked user stories, W_j is the weight of jth user story, and r is rank of user story.

4.3 Estimating Effort with PERT

We are using PERT to calculate effort (i.e. development time) for each user story. PERT used to take uncertainty, surroundings the estimation of task duration, into account that allows to build a task in little extra time. For example, if a task might take five days but that there is a small chance it might need four or six days, and a smaller chance of three and seven days, and so on. PERT requires following estimations:

- Most Likely Time (t_{ml}) – the best possible time required to accomplish a task under normal circumstances.
- Optimistic Time (t_{opt}) – the minimal possible time required to accomplish a task under better than normal circumstances.
- Pessimistic Time (t_{pess}) – the maximum possible time required to accomplish a task, assuming everything proceeds as wrong.
- Expected Time (t_e) – combines these three estimates to form a single expected duration.

$$\textit{Expected time } (t_e) = \frac{1}{6} * (t_{opt} + t_{pess} + 4 * t_{ml}) \tag{2}$$

In this research work the definition of priority for user story is given by following mathematical formula:

$$\textit{Priority} = \frac{\textbf{\textit{Weight}}}{\textbf{\textit{Effort}}} \tag{3}$$

In our research work, weight represents relative importance of a user story. Weight depends on the rank since weight is calculated using mathematical formula taking rank as an input. Rank represents preference of user story for clients. Hence, clients attach importance to user story in form of vote. Effort denotes the time required for development of user story. Clients want the development of user story; in how much time user story will be developed this is concern of developers not clients. Hence, weight belongs to client's side and time belongs to developer's side.

5. Result and Evaluation

Here we are showing the feasibility of our algorithm by using a case study. In this case study, we have calculated prioritization order of user stories. Several user stories have been created by us from online account of faculty members – University Management System (UMS), Lovely Professional University. Total 21 user stories are created from this online account of faculty members – UMS. Using this online account, faculty members can perform several different activities like mark daily attendance, give practical marks, allocate assignments to students, and they can see their daily time table also.

A. Phase 1

In this phase the ranking of user stories has been cal-culated by voting method. In this case study, the votes are placed to user stories from several different department's students of Lovely Professional University (LPU) as well as students of other universities also. Total 63 students are participated in the voting process. The participating students are belonging to several different departments such as Physics, Mathematics, Computer Science and Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, and Information Technology. They belong from different course program such as B. Tech., L.L.B., B.B.A., M.Sc., B.Sc. (Hons.), M. Tech., and M.B.A. from LPU and several other universities as well. The user stories with sum of votes and ranks are shown below in Table 2 and Table 3 respectively.

We are representing sum of votes for each user story by a graph as shown in Figure 1. Due to the lack of space we are representing user stories only by their serial numbers (as shown in Table 2) instead of their names. In following graph user stories with serial numbers "A" and "O" (as mentioned in Table 2) are with less sum of votes and more sum of votes respectively. So user story "A" receive more importance from students, and user story "O" receive less importance from students. Sum of votes for user story 'A', 'G', 'F', and 'O' are 370, 385, 442, and 982 respectively. So we assign rank 1 to the user story 'A', rank 2 to 'G', rank 3 to 'F', and so on. Table 2 contains sum of votes for each user story. The votes of user story "A" and "O" are also drawn by separate graphs.

Table 2. User stories with sum of votes

S. No.	User Story	Sum of Votes
	User stories with sum of votes	
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	370
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	574

Table 2 Continued

C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	536
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	804
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	608
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	442
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	385
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	457
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	704
J.	As a teacher I want to apply for leave so that I can do my urgent work.	739
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	770
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	921
M.	As a teacher I want to know daily activities so that I can keep record of them.	724
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	906
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	982
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	677
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	701

Table 2 Continued

|		
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	750
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	821
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	671
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	775
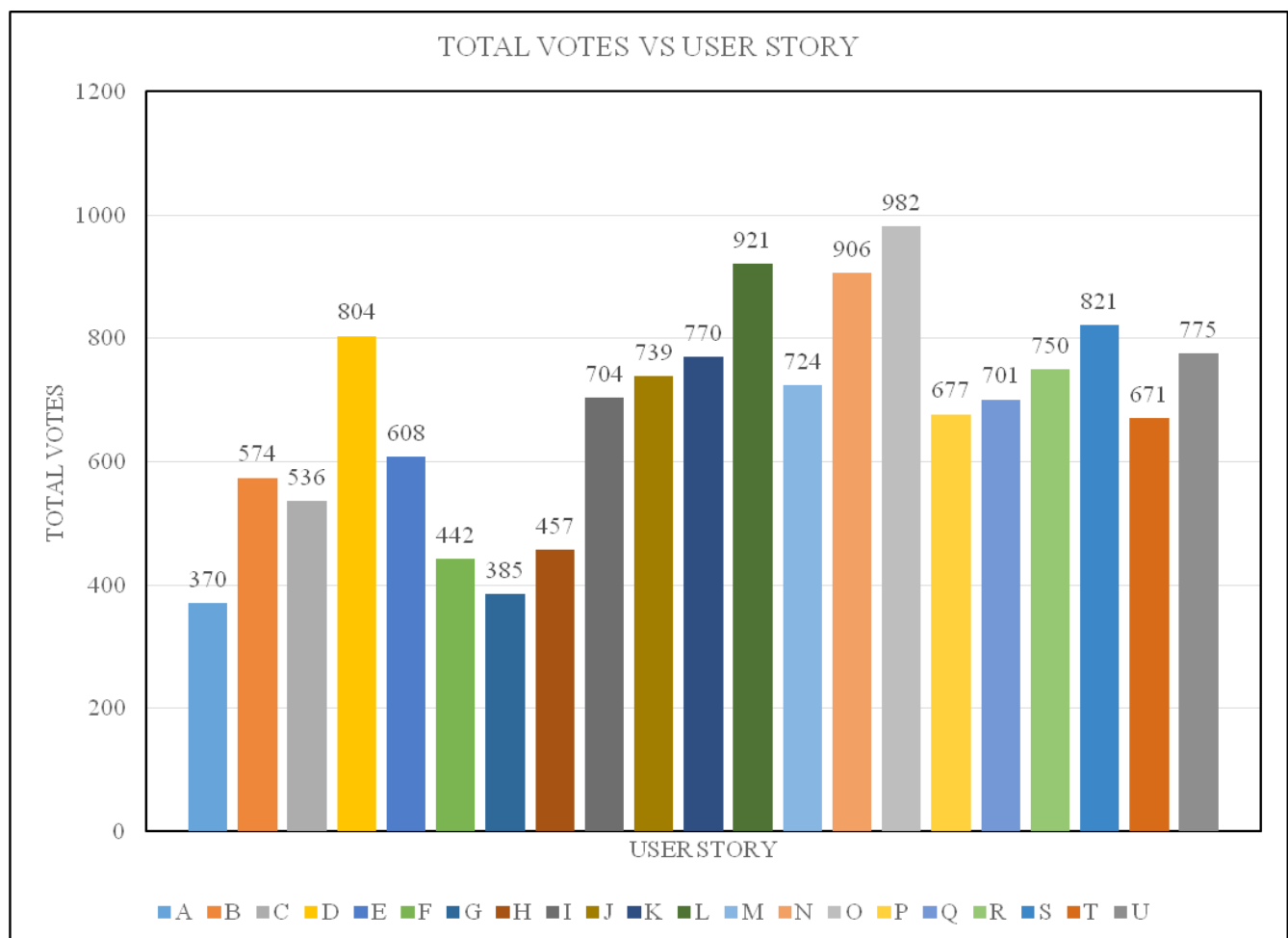
Figure 1. Hudda total votes for each user story.

Here user stories 'A', and 'O' are mentioned in detail. User-story 'A', and 'O' are received less number of votes, and more number of votes from students. Total number of votes for user story 'A', and 'O' are shown in Table 3, and Table 4 respectively. Votes for user story 'A' and 'O' are also represented by graph in Figure 2, and Figure 3. In Figure 2 and Figure 3, X-axis represents votes that are received from students, and Y-axis represents frequency i.e. how many number of students assign that vote.

Table 3. Total votes for user story A

Vote	Frequency
1st	8
2nd	8
3rd	10
4th	6
5th	6
6th	2
7th	2
8th	4
9th	5
10th	2
11th	2
12th	0
13th	1
14th	1
15th	1
16th	0
17th	2
18th	0
19th	0
20th	1
21th	1
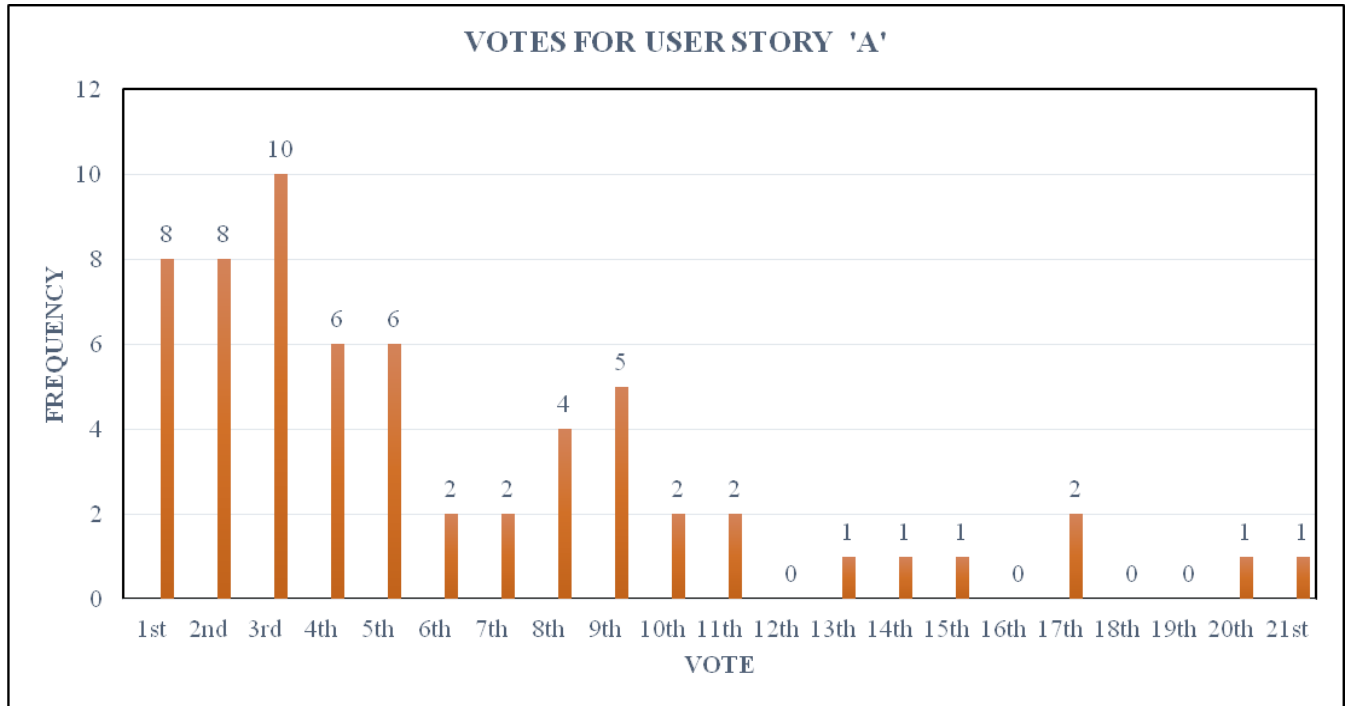
Figure 2. Hudda votes for user story A.

Table 4. Total votes for user story O

Vote	Frequency
1st	0
2nd	0
3rd	1
4th	1
5th	1
6th	0
7th	0
8th	4
9th	3
10th	1
11th	1
12th	2

Table 4 Continued

13th	4
14th	2
15th	2
16th	5
17th	5
18th	5
19th	8
20th	8
21th	9
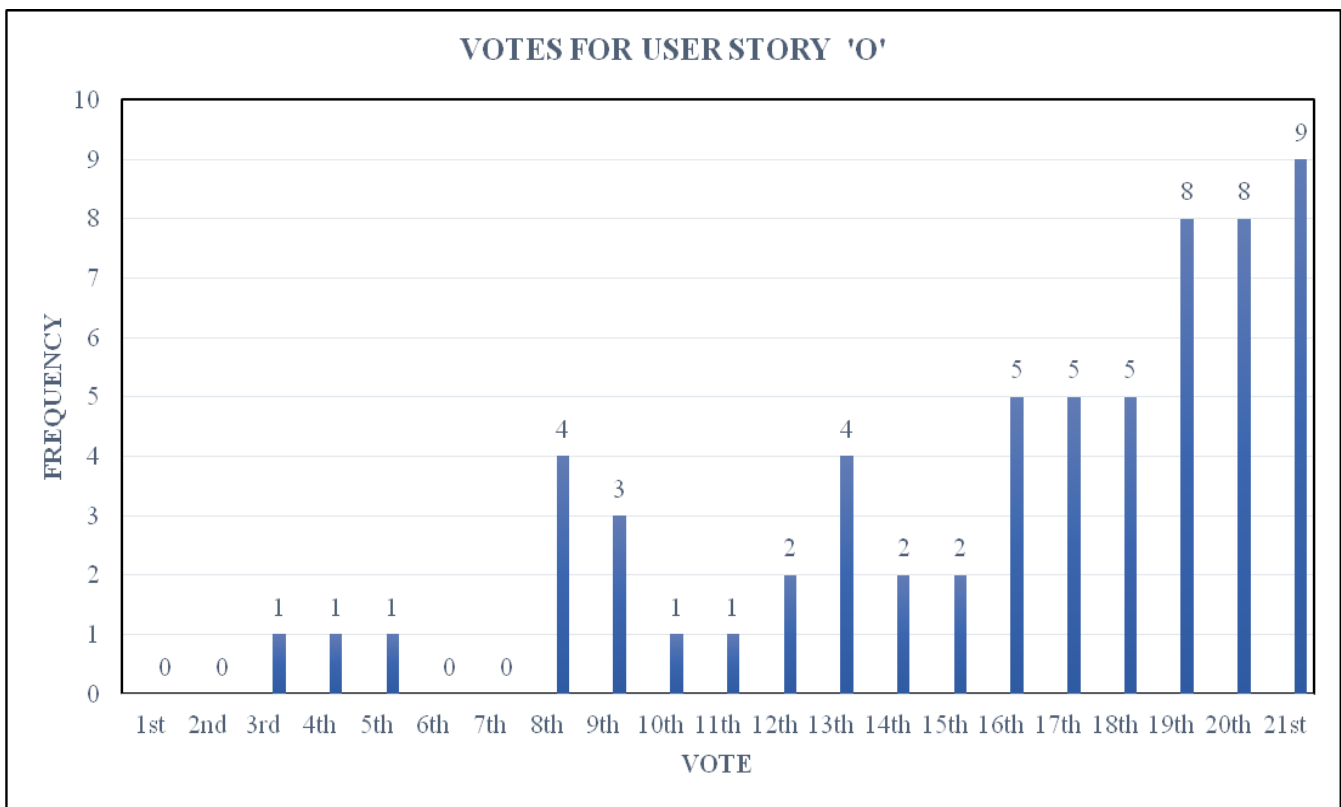
Figure 3. Hudda votes for user story O.

Table 5.   User stories with ranks (r)

	User stories with ranks		
S. No.	**User Story**	**Sum of Votes**	**Rank**
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	370	1
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	574	6
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	536	5
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	804	17
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	608	7
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	442	3
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	385	2
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	457	4
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	704	11
J.	As a teacher I want to apply for leave so that I can do my urgent work.	739	13
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	770	15
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	921	20
M.	As a teacher I want to know daily activities so that I can keep record of them.	724	12
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	906	19

Table 5 Continued

O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	982	21
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	677	9
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	701	10
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	750	14
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	821	18
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	671	8
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	775	16

Now rank is assigned to user stories on the basis of total number of votes. The rank for each user story is mentioned in following Table 5.

B. Phase 2

In this section the weights of user stories have been calculated using mathematical formula of ROC method, taking rank as an input. Weight of a user story depends on user story's inverse-rank as well as the inverse-rank of all lower ranked user stories. The user stories with weights are presented in following Table 6.

Table 6. User stories with weights (w)

	User stories with weights		
S. No.	**User Story**	**Rank**	**Weight**
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	1	0.173588509
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	2	0.125969462

Table 6 Continued

F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	3	0.102159938
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	4	0.086286922
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	5	0.074382160
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	6	0.064858350
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	7	0.056921843
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	8	0.050119121
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	9	0.044166741
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	10	0.038875735
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	11	0.034113830
M.	As a teacher I want to know daily activities so that I can keep record of them.	12	0.029784826
J.	As a teacher I want to apply for leave so that I can do my urgent work.	13	0.025816572

Table 6 Continued

R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	14	0.022153569
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	15	0.018752208
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	16	0.015577605
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	17	0.012601414
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	18	0.009800294
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	19	0.007154791
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	20	0.004648526
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	21	0.002267573

C. **Phase 3**

In this section effort of each user story has been calculated using PERT. For each user-story the effort is calculated in hours. Each user story has three estimates of effort that are: 1. Optimistic Time (t_{opt}), 2. Most Likely Time (t_{ml}), and 3. Pessimistic Time (t_{pess}). The final estimation (i.e. Expected Time) calculated on the basis of all these three estimates. The below Table 7 contains these three estimates as well as final estimation also. In the Table 7; optimistic time represented by t_{opt}, most likely time represented by t_{ml}, pessimistic time represented by t_{pess}, and final expected time represented by t_e.

Table 7. User stories with effort (E)

S. No.	User Story	Effort			
		t_{opt}	t_{ml}	t_{pess}	t_e
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	182	196	205	195.16
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	153	165	165	163
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	150	161	168	160.33
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	152	160	169	160.16
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	150	150	158	151.33
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	173	185	185	183
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	210	213	228	215
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	225	229	240	230.16
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	173	173	180	174.16
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	180	188	200	188.66

I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	172	182	205	184.16
M.	As a teacher I want to know daily activities so that I can keep record of them.	202	215	226	214.66
J.	As a teacher I want to apply for leave so that I can do my urgent work.	180	180	184	180.66
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	200	209	221	209.5
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	187	190	203	191.66
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	191	201	201	199.33
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	237	245	250	244.5
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	191	191	203	193
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	180	180	195	182.5
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	240	241	247	241.83
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	220	223	233	224.16

Now we are calculating weight by effort ratio on the basis of which prioritization is done. The weight by effort ratio is calculated in terms of numerical value. For each user-story weight by effort ratio is shown in following Table 8.

Table 8. User stories with weight by effort ratio

S. No.	User Story	Weight	Effort	Weight/Effort
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	0.173588509	195.16	8.894676624E-04
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	0.125969462	163	7.728187853E-04
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	0.102159938	160.33	6.371854176E-04
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	0.086286922	160.16	5.38754508E-04
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	0.074382160	151.33	4.91522897E-04
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	0.064858350	183	3.544172131E-04
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	0.056921843	215	2.647527581E-04
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	0.050119121	230.16	2.177577381E-04
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	0.044166741	174.16	2.535986507E-04
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	0.038875735	188.66	2.060624139E-04

Table 8 Continued

I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	0.034113830	184.16	1.852401716E-04
M.	As a teacher I want to know daily activities so that I can keep record of them.	0.029784826	214.66	1.387534986E-04
J.	As a teacher I want to apply for leave so that I can do my urgent work.	0.025816572	180.66	1.429014281E-04
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	0.022153569	209.5	1.057449594E-04
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	0.018752208	191.66	9.784101012E-05
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	0.015577605	199.33	7.814982692E-05
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	0.012601414	244.5	5.153952556E-05
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	0.009800294	193	5.077872539E-05
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	0.007154791	182.5	3.920433425E-05
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	0.004648526	241.83	1.922228838E-05
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	0.002267573	224.16	1.011586813E-05

Now we are assigning priority to each user story. The user story with largest value of weight by effort ratio receives highest priority, and with smallest value of weight by effort ratio receives lowest priority. So user story "A" receives highest priority and user story "O" receives smallest priority. The priority for each user stories is shown in Table 9.

We draw the graph between weight by effort (W/E) ratio for each user story and user story as shown in Figure 4. In this graph longest bar represents highest priority and smallest bar represents lowest priority. So user story 'A' is with longest bar, and user story 'O' is with smallest bar. Hence, user 'A' has highest priority, and user story 'O' has lowest priority.

Table 9. User stories with priority

S. No.	User Story	Weight/Effort	Priority
A.	As a teacher I want to view student's attendance so that I can observe regularity of a student in the class.	8.894676624E-04	1
B.	As a teacher I want to reserve a room so that I can take makeup of my missing classes.	3.544172131E-04	6
C.	As a teacher I want to see my evaluation performance so that I can see my remarks given by seniors.	4.91522897E-04	5
D.	As a teacher I want to take doctor's appointment in the hospital so that I can take doctor prescription for my illness.	5.153952556E-05	17
E.	As a teacher I want to see CCTV footage of my class students so that I can check their discipline.	2.647527581E-04	7
F.	As a teacher I want to check Instruction Plan pf my subject so that I can know about contents deliver in the next class lecture.	6.371854176E-04	3
G.	As a teacher I want to see syllabus of my subject so that I can know the content of subject.	7.728187853E-04	2
H.	As a teacher I want to know Class Representative of class so that I can deliver my message to the class.	5.38754508E-04	4
I.	As a teacher I want to know my Mid Term Examination's duty room or End Term Examination's duty room so that I can reach into the room within the time.	1.852401716E-04	11

Table 9 Continued

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J.	As a teacher I want to apply for leave so that I can do my urgent work.	1.429014281E-04	12
K.	As a teacher I want to check my makeups so that I can know about my next makeup's time table.	9.784101012E-05	15
L.	As a teacher I want to check my leave details so that I can know my remaining leave of current academic term.	1.922229938E-05	20
M.	As a teacher I want to know daily activities so that I can keep record of them.	1.387534986E-04	13
N.	As a teacher I want to check live status of bus so that I can make me available on pickup point within time.	3.920433425E-05	19
O.	As a teacher I want visitor gate pass so that I can take my guest inside the campus.	1.011586813E-05	21
P.	As a teacher I want to mark class attendance so that students can check their attendance status timely.	2.535986507E-04	8
Q.	As a teacher I want to give assignments to class so that every student know about its own assignments.	2.060624139E-04	10
R.	As a teacher I want to give practical marks to students so that students can see their performance in practical.	1.057449594E-04	14
S.	As a teacher I want to check new announcements so that I can make me aware about the new announcements.	5.077872539E-05	18
T.	As a teacher I want to see my today's time table so that I can know about the class time and class room.	2.177577381E-04	9
U.	As a teacher I want to give dissertation marks to students so that students can check their performance.	7.814982692E-05	16
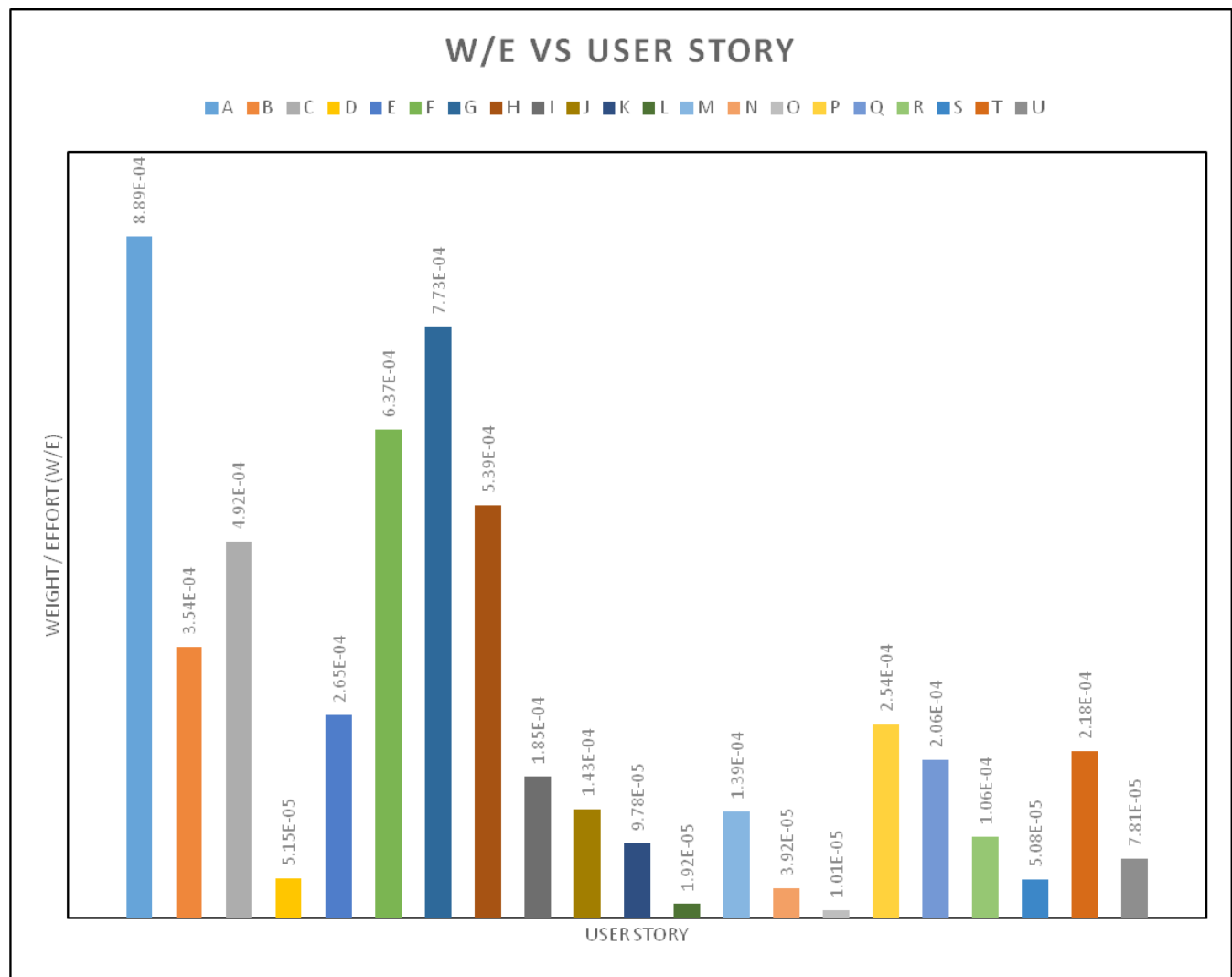
Figure 4. Hudda prioritization of user story by calculating W/E.

6. Conclusion

In this paper we proposed an approach that considers criteria from client's side as well as developer's side. In this approach; rank, weight, and effort are determined on the basis of which the prioritization of user stories is done. In this paper we are considering importance and effort criteria factors for the prioritization of user stories. Importance is decided by students, and effort is decided by complexity factor. So prioritization of user-stories highly depends on these factors. In this work relative importance is represented by weight. We are using the weight by effort ratio to decide the priority of a user story. Hence, the user-stories which are highly important for clients (i.e. students) as well as require less time for development should be considered first in prioritization of product backlog. In future the other factors which are important for clients as well as developers can be considered for prioritization of user-stories.

7. Acknowledgements

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