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"Empirical Identification of Parameters for Effective User Requirement Elicitation and Analysis Process in Agile and Non-agile Software Development"

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Abstract **– With the swift growth in technology and businesses in recent decades, software has become very essential component in all facets of the modern world. But Software development segment is in trouble, due to project failures, budget overruns, extended time frame, failure to meet needs and poor quality levels. Proportion of projects failure is caused by requirement affairs. Now, the crucial issue in the software development process is getting the operational requirements right and to welcome change in the requirements even late in the development process. Users have difficulty in explaining what they need and the problems multiply when developers fail to translate requirements into working software. Therefore, an effective and efficient system is required to improve requirement engineering process. This paper reviews the existing requirement engineering practices that agile and non-agile software teams follow and explores the parameters required for effective elicitation and analyzing of requirements. We also proposed a model based on these parameters that effectively handle the changing user's requirements.**

Keywords **– Requirements Engineering, Requirements Elicitation, Requirements Analysis, Agile, Traditional approach, Prioritize Requirements.**

I. Introduction

Rapid changes in business types, competitive threats, stakeholder preferences and time-to-market pressures rigorously challenge the pre-specified requirements based development of systems [1]. Requirements change rates swamp traditional methods. Agile software development is presently an emerging software engineering approach. It is creating a blend in the software development area and acknowledges the "need for an alternative to documentation driven, heavyweight software development process". Agile approach has the capability to accept the change in at any time of SDLC (Software Development Life Cycle). Issues involved in elicitation and analysis of user requirements [2]:

Stakeholder Issues:

Users don't have a clear idea of their requirements and they are not technically sound. Users do not commit to a set of written requirements and communication with users is slow. Users insist on new requirements after the cost and schedule have been fixed. Users often do not participate in reviews or are incapable of participating.

Developer Issues:

Developer starts coding immediately before they really understand the whole requirement from analyst, which usually causes lots of defect fixing or reworking in test/ verification phase. Technical personnel and end-users may have different vocabularies. Developers may try to make the requirements fit an existing system or model, rather than develop a system specific to the needs of the client.

II. Background and Motivation

F. Paetsch et al (2003) find that traditional approach does not have a good way of stakeholder involvement as agile methods [3]. S. Cronholm (2008) compares benefits of traditional and agile methods and reveals risks with benefits in agile methods [4]. D.J. Fernandez and J.D. Fernandez (2009) present fundamental information about the agile methodology to encourage its implementation by professionals [5]. Liu Jun et al (2010) reveals how agile approach could be applied to modest-sized system development [6]. Yu Beng Leau et al. (2012) suggest improvements for current agile development [7]. A. Sillitti and G. Succi (2005) present an introduction to the agile methods and their approaches to requirements elicitation and management [8]. Lucia and Qusef (2010) conclude that the secret of the success of agile approach is customer collaboration, good agile developers, and experienced project managers [9]. Eleonora Bottani (2010) analyze the profile of agile companies and the tools practically implemented by them to achieve agility [10]. S.C. Misra et al (2009) determine the factors that lead to the success of agile software development [11]. Zornitza Racheva et al (2010) conclude that requirements prioritization is important to maximize the value for the clients and to welcome changing requirements [12].

III. Research Methodology

The research methodology we used in this work is one that is typically used in survey-based research; a questionnaire was framed by taking into account the identified variables from literature review and the agile principles. It makes publicity of user requirement gathering practices to those who are not aware about agile requirements gathering practices. Sampling technique has been adopted. 75 companies have been chosen out of which 50 agreed to participate in the survey. So the response rate was relatively high i.e. 66.6%. Descriptive statistic tools (mean, standard deviation) and Person correlation, Regression analysis and Anova test have been used to screen the collected data for meaningful purpose. Requirement Elicitation-Analysis Model has been proposed using UML activity diagrams based on identified predictors of success obtained from data collection and with extensive literature survey of the related domains.

IV. Results and Discussion

Survey questions and hypotheses were formulated from parameters identified from literature review and the agile principles. It is a relationship study, and we had 12 independent variables and a consolidated dependent variable ‘‘Success” (Ind13). Success has 5 parts in our study-reduced delivery schedules, increased return on investment, increased ability to meet with the current customer requirements, increased flexibility to meet with the changing customer requirements, improved business processes. Independent variables are: organizational culture (Ind1), team capability (Ind2), personal characteristics (Ind3), team distribution (Ind4), communication and negotiation (Ind5), customer satisfaction (Ind6), customer commitment (Ind7), customer collaboration (Ind8), prioritization (Ind9), team size (Ind10), reviews and tests (Ind11), planning (Ind12).

Test of Reliability

Cronbach’s alpha helps in estimating the proportion of systematic or consistent variance in a given sample of test scores. It was calculated with the help of statistical tool SPSS. A Cronbach’s alpha with value greater than 0.6 is considered standard in survey research. Table 1 depicts reliability statistics.

Table 1. Reliability statistics.

Coefficient of Reliability	Value of Cronbach's Alpha
Cronbach's Alpha	.742 (Acceptable)

Descriptive Statistics

To recapitulate the information latent in the collected data we calculated minimum, maximum, mean, and standard deviation of the data. Table 2 shows the descriptive statistical results.

Table 2. Descriptive statistics.

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Ind1	50	1.00	2.40	1.5760	.38469
Ind2	50	1.00	3.00	1.6800	.62073
Ind3	50	1.00	3.60	1.9320	.55345
Ind4	50	1.00	3.50	2.2500	.63286
Ind5	50	1.00	4.00	1.9400	.76692
Ind6	50	1.00	3.00	1.4000	.53452
Ind7	50	1.00	2.00	1.2800	.45356
Ind8	50	1.00	3.00	1.3800	.56749
Ind9	50	1.00	2.50	1.6420	.41458
Ind10	50	1.33	5.33	2.4674	.86527
Ind11	50	1.00	3.00	2.0440	.40515
Ind12	50	1.00	3.00	1.3200	.51270
Ind13	50	1.20	2.80	1.9720	.43894

By considering the mean values in table 2, amongst all the 12 independent variables, Ind7 (customer commitment) has the lowest mean of 1.2800 with a standard deviation of .45356 that means most of the respondents strongly agree and give highest priority to customer commitment more than anything else. Ind12 (planning), Ind8 (customer collaboration), Ind6 (customer satisfaction), Ind1 (organization culture), Ind2 (Team capability), Ind9 (prioritization), Ind3 (personal characteristics) and Ind5 (communication and negotiation) are in the range of "agree, strongly agree". Ind10 and Ind 4, has the highest mean value, this shows that most of the respondents are "somewhat agree" with parameters team distribution and team size. It is observed that none of the independent variables has a mean score above 3 (in the 7-point Likert scale). This shows that on an average, the respondents were not in disagreement with the factors in their projects.

Correlation Analysis

Correlation analysis helps us to understand the degree of relationship between all our 12 independent variables and the dependent variable "Success" (Ind13). Table 3 summarize correlation results.

Table 3. Correlation analysis.

Variables	Correlation Coeff.	Significance. (2-tailed)	Statement
Ind1	.301	.034	Correlation is significant at the 0.05 level
Ind2	.176	.221	Not significant
Ind3	.318	.024	Correlation is significant at the 0.05 level
Ind4	-.253	.076	Not significant
Ind5	.237	.097	Not significant
Ind6	.431	.002	Correlation is significant at the 0.01 level
Ind7	.409	.003	Correlation is significant at the 0.01 level
Ind8	.437	.002	Correlation is significant at the 0.01 level
Ind9	.330	.019	Correlation is significant at the 0.05 level
Ind10	-.004	.976	Not significant
Ind11	.296	.037	Correlation is significant at the 0.05 level
Ind12	.422	.002	Correlation is significant at the 0.01 level

On the bases of correlation analysis, the variables significantly related to Success are: organizational culture, personal characteristics, customer satisfaction, customer commitment, customer collaboration, prioritization, reviews and tests, planning. Variables not significantly related with Success are: team capability, team size, team distribution, communication and negotiation.

Multiple Regression Analysis

Table 4. Regression model.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.437[a]	.191	.174	.39893
2	.597[b]	.357	.329	.35952
3	.654[c]	.428	.391	.34254
a. Predictors: (Constant), Ind8				
b. Predictors: (Constant), Ind8, Ind9				
c. Predictors: (Constant), Ind8, Ind9, Ind12				

Table 4. Regression Model depicts the summary of regression model. The R values for each model estimate the coefficients of multiple correlations. It implies the degree of linear relationship between the observed and predicted values of Success. The values of R for all three models produced by the stepwise regression fit into the range (0, 1). Greater the R values, the stronger the relationships are. The R squared values is to estimate the proportion of variation in Success. The R squared values also fit into the range (0, 1). Model 3 has the highest value of R squared amongst all the four models and has three predictors: Ind8, Ind9 and Ind12. Thus, stepwise regression reveals only three variables as predictors of Success. The adjusted R squared reflects the goodness of fit and it is also highest in Model 3 amongst all the three models.

Table 5. Regression coefficients.

Model	Unstandardized Coeff.		Standardized Coeff.	T	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	1.506	.150		10.063	.000					
Ind8	.338	.100	.437	3.365	.002	.437	.437	.437	1.000	1.000
2 (Constant)	.716	.264		2.710	.009					
Ind8	.390	.092	.505	4.255	.000	.437	.527	.498	.973	1.028
Ind9	.437	.126	.413	3.479	.001	.330	.453	.407	.973	1.028
3 (Constant)	.561	.260		2.158	.036					
Ind8	.340	.090	.439	3.778	.000	.437	.487	.421	.919	1.088
Ind9	.382	.122	.361	3.138	.003	.330	.420	.350	.939	1.065
Ind12	.239	.099	.279	2.403	.020	.422	.334	.268	.925	1.082
a. Dependent Variable: Ind13										

The t-statistics in table 5 shows the importance of one variable relative to another in the model. The general rule for looking at t values is to look for t values below -2 or above +2. Here, all the variables Ind8, Ind9, and Ind12 have t value well above +2. Also, the collinearity statistics indicates that in Model 3, all the VIF values are well below the threshold of 2 (VIF values greater than 2 are considered problematic), and all the tolerance values are above the threshold of 0. This indicates that in model 3, multicollinearity is not a problem.

Table 6. ANOVA Regression analysis.

Model	Sum of Squares	Df	Mean Square	F	Sig.
1 Regression	1.802	1	1.802	11.321	.002[a]
Residual	7.639	48	.159		
Total	9.441	49			
2 Regression	3.366	2	1.683	13.021	.000[b]
Residual	6.075	47	.129		
Total	9.441	49			
3 Regression	4.043	3	1.348	11.487	.000[c]
Residual	5.397	46	.117		
Total	9.441	49			
a. Predictors: (Constant), Ind8 b. Predictors: (Constant), Ind8, Ind9 c. Predictors: (Constant), Ind8, Ind9, Ind12 d. Dependent Variable: Ind13					

ANOVA text in Table 6 from regression analysis shows the variance equivalent to each of the 3 models. Regression row depicts the amount of variation that can be accounted for by each of these three models, the amount of variation that cannot be accounted for by each of these models is shown in the Residual row, and the total variation is the sum of the variations accounted by both the Regression, and the Residual. Amongst all the three models, Model 3 has the largest regression sum of squares and it has the least residual compared to the other three models. The F statistic outcome shows that the independent variables Ind8 (Customer collaboration), Ind9 (Prioritization of requirements), and Ind12 (Planning) are good (significant) predictors of variation in success, because the corresponding significance value .000 is less than .05 (the test of significance cut-off value).

Requirement Elicitation-Analysis Model

Due to large variety of stakeholders, long list of requirements and a frequently varying environment, user requirement management is a difficult task. So the Requirement Elicitation-Analysis Model has been proposed to help organizations to establish a systematic process improvement in requirement engineering phase. This model is independent from any particular method of software development rather it is based on the parameters identified in empirical analysis i.e. customer collaboration, planning and prioritization of requirements. To prevent mess and unnecessary complexity, the model is broken down into three layers of abstraction. The first layer is Level-A which presents the main activities in requirement engineering process. Fig. 1 shows the Level-A. The second and third layer i.e. level-B and level-C respectively further details only the parameters identified in empirical analysis by demonstrating their sub-activities.

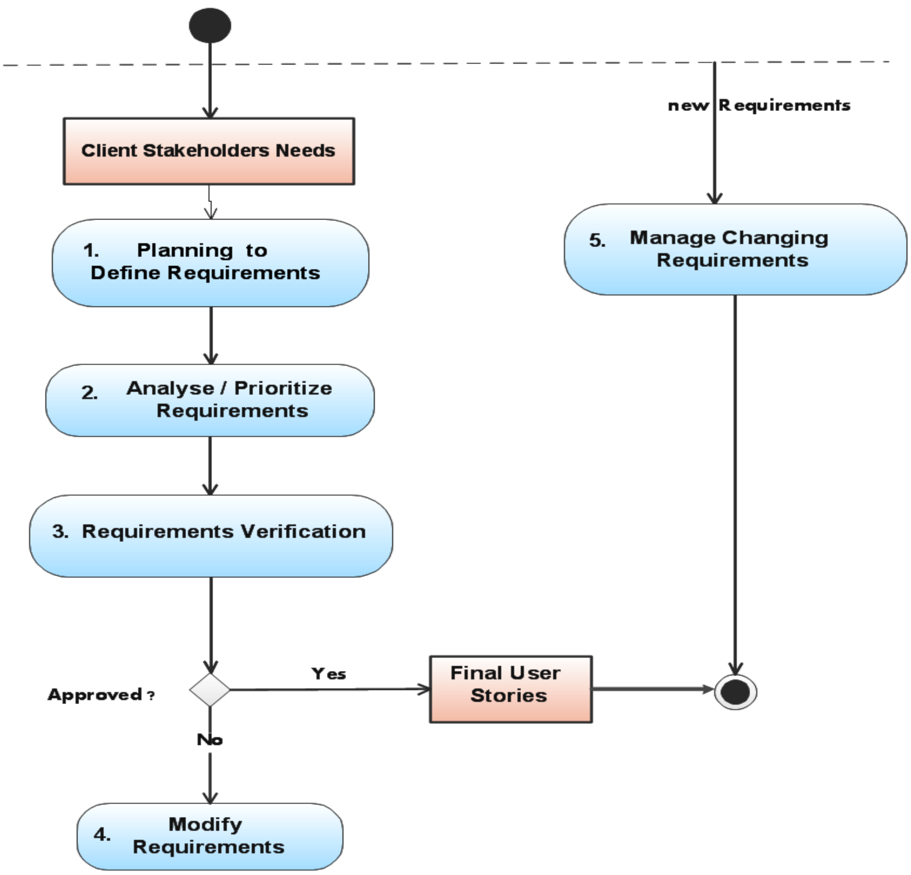

Fig 1. Level-A: requirement engineering process.

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Model: LEVEL-B1: Planning to Define Requirements

It is a refinement of client stakeholders needs from coarse-grained to fine grained abstraction level that means each need is refined from its current stage to the next level of detail i.e. from problem vision to problem concepts to detailed requirement definition. The result of this level is a Requirement product backlog, the list of customer requirements with smaller granularity. Fig. 2 shows level B1.

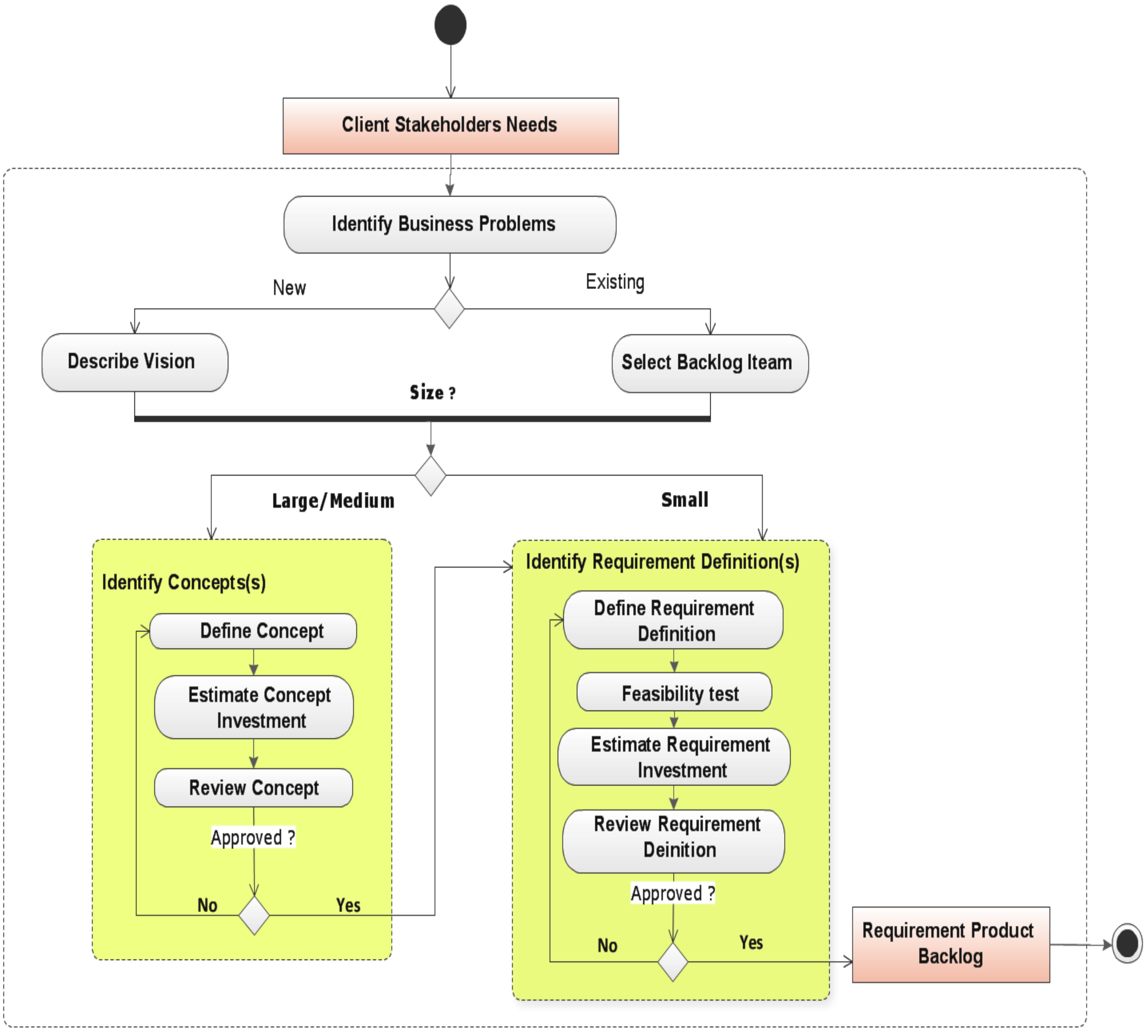

Fig 2. Planning to Define Requirements.

Model: LEVEL-B2: Analyse / Prioritize Requirements

It starts with listing all requirements from requirement product backlog followed by estimating value of each requirement based on some aspects. Then the entire team subsequently assigns priority to each requirement based on their value and other aspects. This process results in prioritized product backlog. Then requirement modeling is performed i.e. the brief description of the prioritized requirements and their functionality in a graphical form is presented to customer for a review. Finally, the project manager creates an iteration backlog that contains a subset of prioritized requirements that are to be implemented in the next development iteration of software product so as to perform released planning of software. The prioritized requirement backlog and released planning are also approved from client stakeholders to ensure customer collaboration. Fig. 3 shows Level B2.

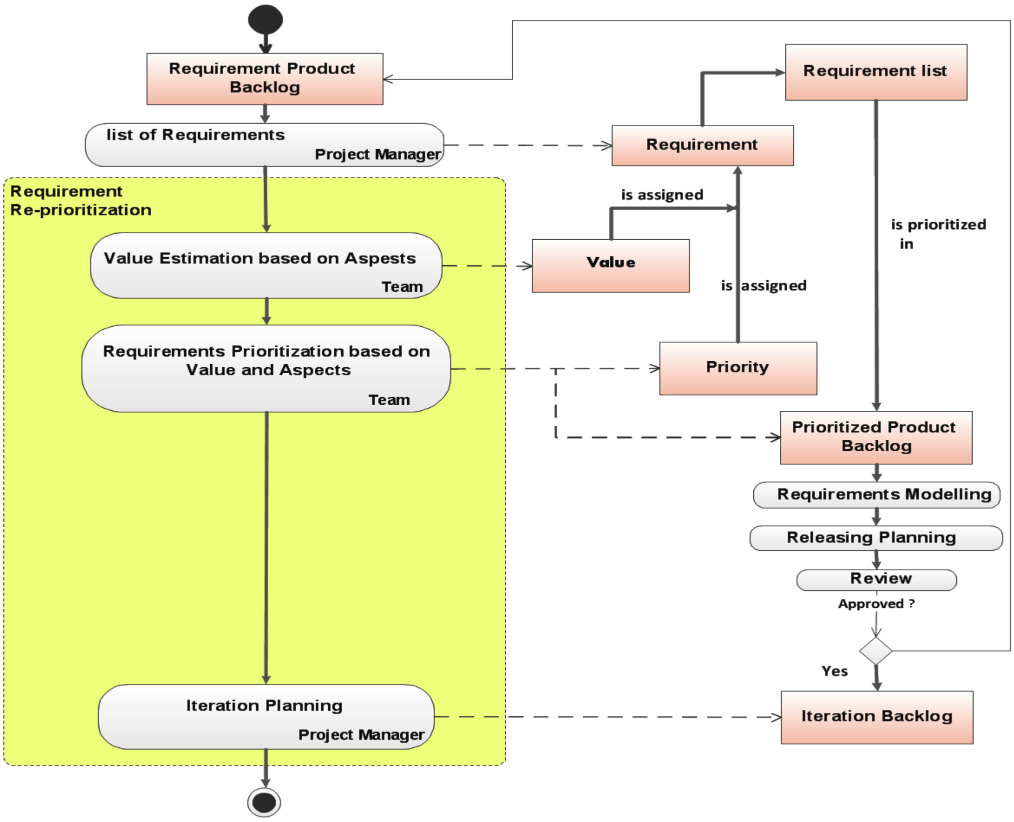

Fig 3. Analyse / Prioritize Requirements.

Model: LEVEL-C is further divided into two parts:

- Value Estimation: Fig 4 lists the aspects based on which value of each requirement is estimated.
- Requirements Prioritization: Fig 5 lists the aspects based on which priority to each requirement is assigned.

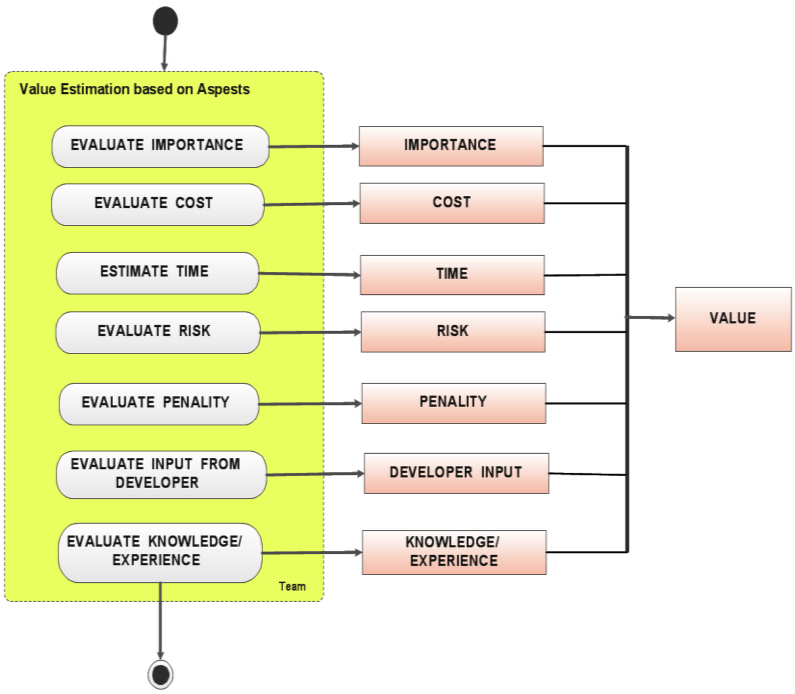

Fig. 4. Value Estimation.

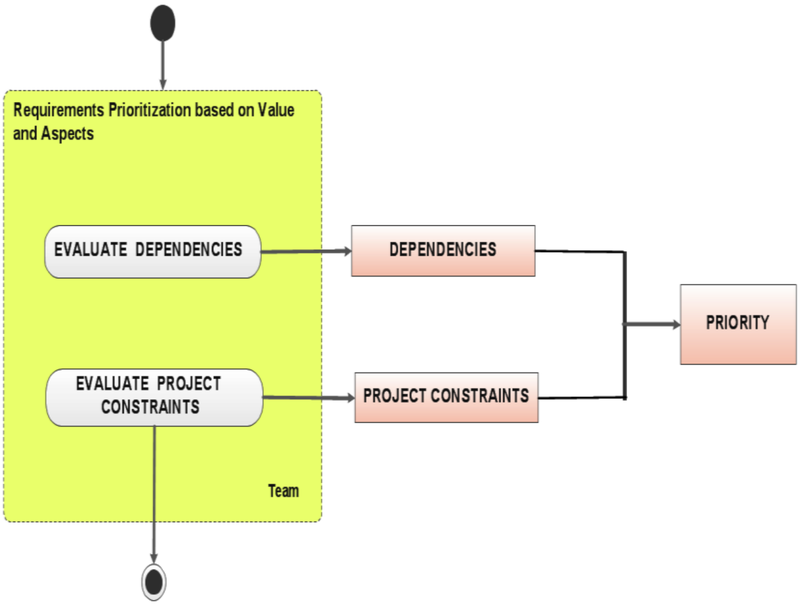

Fig. 5. Requirements Prioritization.

V. Conclusion

The present research study is based on the premise that effective user requirement elicitation and analysis helps in improving software development process and leads in success of software project. Requirement engineering is the main activity in the software development and if requirements are not clear, it will act as one of the main reasons of project failure. According to results of analysis only three parameters emerge to have statistically significant relationship with success. These three parameters are customer collaboration, prioritizati--on of requirements and planning. Requirement Elicitation-Analysis Model which guides software organizations to establish a systematic process improvement in requirement engineering phase by providing a mechanism of understanding the customer needs effectively and a way of analysing and prioritizing of elicited user requirements. Model also encourages customer collaboration and welcome changing requirements by customers even late in development. So the investigation of current requirement engineering practices in the environment of agile and non-agile software development and modelling of requirement engineering phase can support organizations in successful software development.

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