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Review of Support to Situational Requirement Engineering from Standards and Models

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ABSTRACT

Requirement engineering (RE) process clear description can be an important factor for guiding the team members involved in the RE process, which may help organizations not exceeding the estimated schedule and budget for the software project. There can be many reasons of not having efficient RE process such as changing situations among the organizations involved in the RE process. It is certainly one of the various other reasons of having non-efficient RE process. Due to these changing situations the RE process customization accordingly should be performed. As part of our current research project, where we are investigating situational RE in Global Software Development (GSD), first we need to identify the factors which may results in changing situations. This paper we have critically reviewed the domain of "standards and models", and identified the initial list of situational factors from them. These standards and models are related to software engineering, which directly or indirectly discusses RE process. We have adopted the constant comparison and memoing techniques of the Grounded theory for identification of unique initial list of the situational factors. This initial list is a significant consideration for a comprehensive list of situational factors affecting RE process in GSD.

KEYWORDS

Software engineering, Requirement engineering (RE) process, Models, Standards, Global software development (GSD), Situational Factors.

1 INTRODUCTION

Requirements are defined as the description or the explanation about the behavior of the system; it can also be said as the system attribute, or a constraint. We can also describe requirement as what the system should perform. Requirement engineering comprises of activities; requirement discovery, analysis, specification, validation and management. This process focuses on the usage of repeatable techniques in order to come up with complete, consistent and relevant requirements.

We have come to know from the previous literature on and around requirement engineering process, that there are some factors [1] [2], which can affect the software development and more specifically they are factual for requirement engineering. Some of these factors are human related factors, technical factors, management related factors etc. It is also evident from the literature [3] that not only technical issues but besides this social, managerial, economic and organizational issues have an influence on requirement engineering process. These factors may become the source of changing situations, which need to be explored in detail.

It is to notify here that this study is one part of our investigation which deals with the identification of situational factors affecting Requirement Engineering Process in Global Software Development. This domain (standards and models of RE) is one of the ten other domains we have selected for situational factors identification. Because of the huge amount of information from each of the domain they are firstly treated individually in order to analyze them in detail. The related domains used in our research work are taken from work of Paul Clarke et al. [3], who used them for identification of situational factors that can affect software development process. Besides this, defect prediction, task sequencing and metrics are the domains which are taken from their future work. We have used these domains specific for requirement engineering phase in global software development.

In this paper, we have limited our search on standards and models which are on and around requirement engineering process for the identification of the situational factors, which may influence the requirement engineering process.

Table 1. Research domains

Domains	Reasons of selection
Standards and models on and around RE	Although models and standards on and around requirement engineering process do not directly look for identification of the situational factors that may affect the RE process, they occasionally illustrate the situational context in general.
Risk factors for RE process in GSD	This domain is concerned with identification of things results in risk that should be considered for RE process. Everything that is measured as a risk for RE is an alarm that the RE process may require to give consideration in GSD.
RE environmental factors in GSD	Research has identified environment characteristics that explains the RE settings. Such characteristics are associated with situational factors that may affect the RE process in GSD.
RE process tailoring in GSD	This domain is concerned with taking general RE approaches and tailors them to specific context. Therefore, this domain gives some explanation of the significant considerations while tailoring RE process in GSD.
RE process agility in GSD	With the introduction of agile software development, research has been performed to recognize the development process agility with the changing context. RE is the most fundamental step of software development, whose process agility is an important characteristic in GSD where rate of changing situations are at most.
RE body of knowledge	The Requirement Engineering body of knowledge (REBOK) gives a validated repository of knowledge for RE process, which ultimately provides the guidance related to situational context factors that are significant considerations for the RE process.
RE defect prediction in GSD	This domain is concerned with the defect predictions during RE process. Any thing that does not allow accurate defect prediction during RE process is a point of consideration in GSD.
RE task sequencing in GSD	This domain is concerned with aspects of sequencing of tasks during RE process. Any thing that gives rise to varying task sequences and priorities during requirement engineering process is a potential consideration in GSD.
RE metrics in GSD	The domain of RE metrics deals with the quality metrics. Research has shown number of quality metrics; therefore everything that deals with varying quality metrics is important consideration for RE process in GSD.
RE process estimation in GSD	It is concerned with estimating the accurate RE process resources in GSD. Anything that results in not accurate estimation of resources for RE process is potentially a consideration.

Standards and Models of Requirement Engineering Process describe the situational factors in general context. This is one of the reasons that this domain has been included in the list besides with various other domains like; risk factors for requirement engineering, environmental factors for requirement engineering etc as shown in *table 1* which will be discussed in our coming researches independently. These situational factors leads to varying situations among the various organization's requirement engineering team while performing requirement engineering process.

Section II of the paper describes the background of the research undertaken here, while Section III describes the research method which is adopted to identify the situational factors. Section IV describes the results of the research, whereas Section V comprises of discussion part of the research explaining the findings and future work. Section VI consists of conclusion of this research.

2 BACKGROUND

We have focused on the early development phase (Requirement Engineering) of the software life cycle due to the fact of its major effect on software functionality, productivity and development cost. Besides this poorly defines requirement engineering process by organization is also considered as another focusing reason for selection of requirement engineering phase.

We also come across from previous literature about the importance of requirement engineering process effectiveness. Boehm explained the importance of system's requirements by saying that requirement errors are hundred times more expensive to fix comparing with system's implementation errors [4]. Similarly another researcher Lutz [5] comes up with the statement that critical systems 60% errors are requirements errors. Espite by performing a survey on European companies found that 60% people considered requirement engineering problems as very significant [6]. Similarly another researcher Hall [7] identified from case studies of twelve companies that out of 268 problems identified, 128 were related to requirements problem.

So from above it is clearly shown about the importance of Requirement Engineering Process, as there are number of significant benefits by having improved requirement engineering process and quality requirements. Besides with all this discussion it is also notified from the literature [1,2,3] that there are some factors which act as a barrier for having quality requirement engineering process like; factors related to humans, technical, management, social, organizational and economic etc. these factors vary with the organizational context, which leads to varying situations; ultimately influencing the requirement engineering process.There is a need to explore and identify these situational factors, which can help the practitioners and researchers for having an improved (quality) Requirement Engineering Process. In order to do so, we have selected the domain of standards and models on and around requirement engineering among the various other domains for this part of our research as shown in *table 1*. This domain of standards and models is included in the list with various other domains related to Requirement Engineering process as they can be a good source for situational factors as they describe them in general context. Hence domain of standards and models which are on and around the requirement engineering process are critically reviewed and investigated in this paper for situational factors identification.

3 METHODOLOGY:

For situational factors identification, we have adopted a theory called Grounded Theory.

Grounded Theory: This theory by Glaser [8] is the methodology for analysis linked with the collection of data in a systematic manner which applies certain methods for the theory generation about a substantive area. Grounded theory as argued by Knigge et al. [9] is used to build the theories on the basis of data taken from the social world in such a manner that these theories are grounded in ones daily experiences and actions. These theories also have some philosophical disagreements for its application in practice as discussed by Boychuk Duchscher et al. [10]. However as this research is related with the methods of data analysis used by the theorists therefore this dispute is not relevant concerns. As discussed by Douglas [11] that the theory emphasize on the approach that is systematic for data collection, its handling and its analysis.

This research has also to adopt a likewise systematic approach to handle data and analyze it and therefore uses three main techniques of data management and analysis from Grounded Theory that is coding, constant comparison, and memoing. Coding means to gather or take raw data and raise it to a conceptual level as described by Corbin [12]. They also argue that coding consist of interaction with data by using techniques such as inquiring for the data, doing comparisons among the data, and deriving concepts to position the data, then making those concepts in form of their properties and dimensions. Therefore, it is basically ‘‘the process of defining what the data is about’’ Bryant et al. [13], of ‘‘deriving and developing concepts from data’’ by Corbin [12], where ‘‘codes capture patterns and themes and cluster them under an evocative title’’ by Glaser [14]. For our study, the identifiers and classifications are the data codes that the data sources use to recognize the data and their related concepts. Now the researchers Corbin [12] also argue that the theory relate with ‘‘the analytic process of comparing different pieces of data for similarities and differences’’. This type of analysis as argued by Bryant et al. [13] ‘‘generates successively more abstract concepts and theories through inductive processes of comparing data with data, data with category, category with category, and category with concept’’. In this research, a variety of data codes from the diverse data sources must be compared through constant comparison for their similarities and differences until we get main factors and their categories so coding with such constant comparison becomes complex, as argued by Glaser [14] ‘‘simultaneously many categories and their properties may be emerging at different levels of conceptualization and different ways of being related by theoretical codes’’. Researcher also says that this complexity can be tracked by the memoing process. Researchers Bryant et al. [13] say that theory data coding occurs ‘‘in conjunction with analysis through a process of conceptual memoing, capturing the theorist’s ideation of the emerging theory’’. They also argue that Grounded Theory’s coding and memoing process helps to lessen uncertainty by stop and capture process for their conceptual ideas about the codes finding.

Our study has been divided into several steps for identification of situational factors which may impact Requirement Engineering process. Figure 1 shown below describes the steps which are undertaken in order to find the situational factors from standards and models. It is a 6 steps process where;

Step1 deals with the extraction of data units. For this we have reviewed the standards and models which are directly or indirectly relating to requirement engineering process and get the data units from there which are considered to be raw data for factors identification.

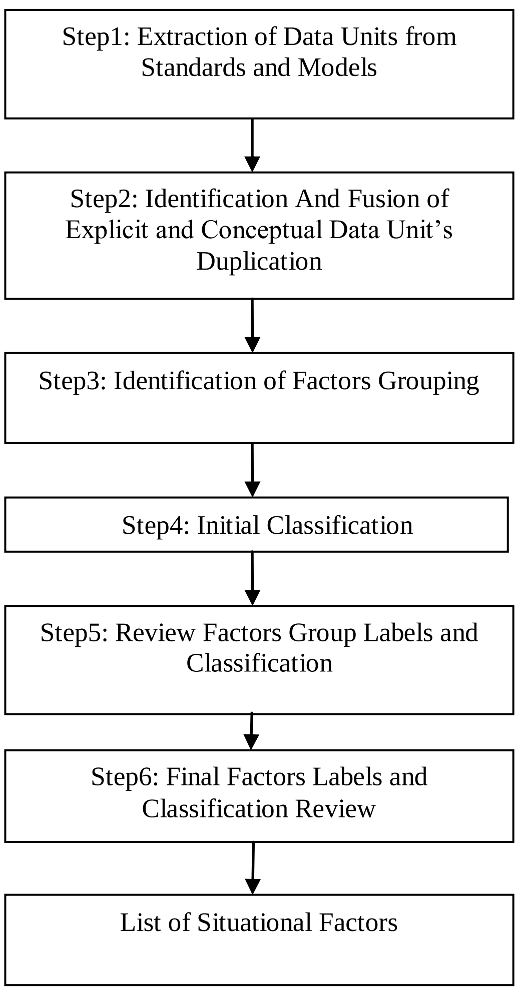

Figure 1. Situational Factors Identification Steps

Step2 search for those data units which are having clear duplications present. This step consists of scanning the data to find the duplication instances. As there is direct mapping among the individual data units that are joined or combined in this comparison, so memoing is not required as it shows the thoughts that influenced the joining or combination of data units. Where while combining the data units, careful steps are taken to maintain the source information. So, if two different data units are having same textual depiction or explanation and meaning, they are combined into a single unit – but it is also to be making sure that both sources of data units are apparent and clear in the combined data unit testimony in the main table. Now following the identification and removal of clear duplication among the data units, conceptual duplications in data units are identified. We combine two data units which are not having same textual tags but are having same meaning. In order to do this, memoing is also done which records the thought process behind this. Besides this, as previously done with the removal of clear duplication stage, combined data units sources links are maintained.

Step3 consists of factors grouping, where every group is given a label. Here each of the data units is combined into factor groups where every group is given a label. These grouping are on basis of factors relatedness to each other and the labels given to them are according to the specific area they are concern with. Memos are used to record the justification for grouping and labeling.

Step4 consists of actions to come up with initial classification for data units. This time also, memos draft the motivation or justification that has initiated or created the initial classification. Under this initial classification, factors groups are present with their appropriate labeling. Similar to the previous steps, memos are used here to record the justification for classification and labeling.

Step5 comprises of constant comparison for evaluating the precision of the group labels and classifications. The group labels are renamed when suitable data units are moved to alternating factors or to completely novel factors – as believed suitable in regard of the rising factors and classification. Similarly some of the classifications are renamed or combined or decomposed as considered appropriate. For this step similar to the previous one, memos are used to draft the thought process with that of the historical trace of the actions. This assists in envisioning the factors and classification sources, and allows an assessment of the impact of each data sources on the main list as it come forward.

Step6 consist of a review for a list of final factors and labels for classification in order to make sure that every individual item is correctly named. Once the initial list of situational factors at its final form is created, then it is being reviewed by experts to have Situational Factors evaluation and modification base upon their comments. The experts are selected from academia on basis of their experience in Requirement Engineering field. More specifically two experts are selected having more than ten years of experience in field of requirement engineering. The tasks provided to them is to evaluate the list for its comprehensiveness, as well as to review if the factors are grouped under right classification with that of any recommended modification both at factors and classification level.

4 RESULTS

This section consists of results explanation against each of the steps mentioned in Section III.

4.1. Extraction of Data Units from Standards and Models

In this step, 189 data units are identified from 16 standards and models which are on and around requirement engineering process and are explained below. Every individual data units correspond to a factor that can affect the requirement engineering process. In addition to this, if we find any classification from the data source (standards and models) then they are also extracted, in order to have raw listing containing not only factors but also the classification from the data source. Nevertheless, this list of raw data is then inspected for data duplication. As a result core concepts are developed with the support of the constant comparison and memoing techniques. Situational factors are identified from the standards and models on and around requirement engineering process, which are explained below.

ISO 9001: This International Standard ISO 9001 [15] is by Technical Committee ISO/TC 176, Subcommittee SC 2 and Quality systems. This mentioned standard is the third edition of ISO 9001 which not only cancels but also replaces the 2nd edition (ISO 9001:1994) with that of ISO 9002:1994 and ISO 9003:1994. ISO 9001 identify requirements for systems of quality management for an organization who a) wants to exhibit its capability to consistently give product that meets up customer requirements b) plans to improve customer satisfaction via valuable system application, together with processes for continuous system improvement and the guarantee of compliance to customer requirements. ISO 9001 requirements are generic and are planned to be appropriate to all organizations, in spite of organization type, organization size and organization product provided for enhancing the customer satisfaction by meeting customer requirements.

Some of the situational factors we have identified from *ISO 9001* are as follows. The standard focuses on some aspects which actually vary among the developing teams like: activity priorities are different in development teams when they work together as they identify the linked activities and manage them in different ways. So in order to have an effective organizational functionality these linked activities should properly be prioritized. Similarly this standard also talks about the nature of the organization and says that it varies as different organization has different nature, (mature and immature) so this varying nature of organization impacts on meeting customer and regulatory requirements. The process to perform any activity also varies with organizational context. Besides this the standard also talks about the varying organizational size, activity type, process complexity, process interaction and personal competence. It says that the documentation is influenced by these factors. We also come across some more factors which influence the system effectiveness like; quality policy, quality objective, availability of resources, management review intervals. Besides these factors, resource management (human resource, infrastructure, work environment, customer related processes) also has an influence on system effectiveness. All these factors vary with among multiple organizations leads to changing situations.

ISO 15504: This is an International standard [16] for assessing the software processes and is developed in corresponding with other standards of software engineering. The purpose of this standard is to have continuous process improvement with that of the capability determination. The scope of the standard is both on comprehensive and modular scale. Processes comprise acquisition, supply, development, operation, maintenance and support on comprehensive level. On modular level it covers the selection of processes to be assessed and this assess activity is done on capability scale. The standard is the result of the SPiCE-Project (Software Process Improvement and Capability Determination- project). This SPiCE (Software Process Improvement and Capability Determination) is an assessment model which is two dimensional; process dimension and capability dimension. There are various versions of this standard like ISO/IEC 15504-2 situates the least requirements for having assessment that guarantee ratings steadiness and repeatability. Similarly ISO/IEC 15504-3 gives direction for inferring the requirements to perform assessment. ISO/IEC 15504-4 recognizes assessment of process as a doing that can be carried out either as initiative for process improvement or as an approach for capability determination. The reason of process improvement is to constantly progress effectiveness and efficiency of the organizations. The point or reason of process capability identification is to recognize the selected processes strengths and weaknesses. ISO/IEC 15504-5 consists of a Process Assessment Model which is based on the Process Reference Model which is explained in ISO/IEC 12207. The standard focuses on the fact that the organization context in which the process is implemented, competency of the assessor and models for assessment of the process vary. This varying situation influences the process quality.

ISO/IEC 12207:2008: ISO/IEC 12207:2008 standard [17] creates a general framework for software life cycle processes, besides with that of well-defined terminology which can be used by the software industry. It relate to the attainment of systems or software products and their services whether carried out with in or external to an organization. Considering these aspects the system definition is desired to present the software product or services context. It is to notify that the revision join together ISO/IEC 12207:1995 with its two modification and was synchronized with the corresponding revision of system life cycle processes (ISO/IEC 15288:2002) to align equivalent processes of organization and projects. It is also to consider that this standard may be used independently or together with ISO/IEC 15288, and provides a process related reference model that supports capability assessment of process in unity with process assessment from ISO/IEC 15504-2. So we come across this learning that this standard came into being for the following reasons; to include and rationalize revisions, to present a common terminology among the amendment of ISO/IEC 15288 and ISO/IEC 12207, to offer common names and structure of process where applicable between the amendment of the ISO/IEC 15288 and ISO/IEC 12207:2008, to facilitate the users to progress towards fully synchronized standards and to make available a steady standard, while capitalize on backward compatibility.

This standard clearly describes the fact related to project conduction that it is always in context of the organization. Besides this it also focuses on the software project outcomes and says that they are influenced by the business process of the organizations. Similarly the models to develop software are also influenced by the varying projects activity scope, magnitude, complexity, changing needs and opportunities. It is also to be notified that the life cycle stages, policies, process, procedure to support projects needs vary with organizational context. Operational environment and operational conditions also vary with organizational context which make difficult for the team to model the stakeholders requirement as it vary with the organizational operational environment and conditions. Standard describes the fact that the requirement definition process is influenced by human capabilities and skills. Besides this requirement definition process is also influenced by the workplace, environment, facilities and equipment provided. These factors vary with the organizational context and have an influence on requirement definition process.

IEEE Std 830-1998: This standard [18] relates with that of a good software requirements specification (SRS). This suggested practice is intended for software requirements specification to be developed and used to help in the selection of software products for in-house and commercial usage. This practice illustrates approaches for the software requirement specification. Practice is based on a model whose result is an unambiguous and complete software requirement specification document. SRS can be created directly from this practice or indirectly by using a model for a more precise standard. It is also to be notified that this practice does not discover any specific method or tool for preparing a System or Software

Requirement Specification. The factors identified from the standard are related to; requirement specification language, requirement representation tools, process approaches and says that these vary among the organizations which influence the system or software requirement specification.

IEEE Std 1233, 1998: This standard [19] provides guidance for software requirements development, System Requirements Specification (SyRS). It includes requirement identification, requirement organization, requirement presentation, and requirement modification. It is also to be notified that it also addresses the conditions for including operational concepts, constraints related to design, and requirements configuration into the specification. Besides this it also covers the essential distinctiveness and qualities of individual or set of requirements. The factors identified from this standard is on system requirement specification which influence it like; operational and logistical terms, organization political environment, organization market, organization standard, technical policies and organizational culture. Besides this system requirement specification is influenced by customer community and environment. The standard also describes the fact that the techniques and approaches to identify the requirements also varies on basis of organizational context which influence the requirements gathering or definition process.

IEEE Std 1362™-1998: This standard [20] deals with the concept of operations (ConOps) document. It is a user-oriented document that explains proposed system characteristics from the users' perspective. The concept of operation (ConOps) document is used to communicate the system characteristics to the stakeholders and other organizational elements like staffing, training etc. It is also notified that the standard is used to describe not only the user organization(s) but also the user mission(s) besides with that of the objectives of an organization from an integrated systems perspective. It acts as a guide for all software-intensive systems. Irrespective of this; concept in this guide can also be applied for hardware-only systems. The standard is applicable to all software products irrespective of its size, scope, complexity, or criticality. Similar to other standards, we have identified some of the situational factors related to; operational policies and constraints, operational environment (hardware, software, equipment, personnel), organizational structure, responsibilities, skill level, work activities, model of interaction with system and says that these lead to changing situations.

ISO/IEC 15288: It is an International Standard [21] ascertains a process framework for explaining systems life cycle. It explains the processes and related terminology for the life cycle from conception till retirement phase. Besides this; ISO/IEC 15288 also supports the process definition, process control, process assessment, and process improvement. This standard is created for following reasons: to come up with a common terminology between the amendment of the ISO/IEC 15288 and ISO/IEC 12207, to provide common names and structure of process between the amendment of the ISO/IEC 15288 and ISO/IEC 12207, to facilitate the users to progress towards fully synchronized standards and to make available a steady standard, while capitalize on backward compatibility. This standard also highlights the hardware, software elements as the factors vary with organizational context. Besides this the standard also focuses on the human factors, technology factors and processes for the development of product and services as the factors which vary with the organizational context.

ISO/IEC 24748: It is a standard [22] which directs for the application base on ISO/IEC 12207:2008. It deals with the concepts of system, project, life cycle, process, organizations concepts, mainly via reference to ISO/IEC 24748-1 and ISO/IEC 12207:2008. This standard also provides guidance for applying ISO/IEC 12207:2008 in organizations and on projects from the perspective of application, strategy and planning. The standard has three editions and this is the most recent one which is deliberately associated with both ISO/IEC 24748-1 and ISO/IEC 24748-2 (which is a guide to the application of ISO/IEC 15288) in terms of terminology, structure and content. It is also to be notified that ISO/IEC 24748 gives amalgamated and consolidated for system's or software's life cycle management. Its goal is to ensure stability in system or life cycle's concepts, models, stages, processes, application and adaptation.

We have identified some of the situational factors related to; Tools, technologies, process, facilities, equipments and workforce, as standard says that they are required by the development team and organization, which vary with organizational context. Similarly the project relationship management also varies with that of the organizations like formal or informal for specification as policies and procedures varies.Following are the models on and around requirement engineering process.

BOOTSTRAP: This is a methodology [23] which continues to evolve. At the end of 1993 "The European Software Institute" actually decided to uphold transfer of technology and methodologies related to improvement within Europe, besides this they also decides to utilize Bootstrap as a considered tool to not only assess but also analyze the software processes and to set up improvement related programs. In their work author explains the model elements and tells that how this model can be utilized to assess the need to improve the process besides with its readiness for ISO 9001 certification. We have identified the fact of varying process among organizations from the model as this model highlights the fact of varying process among the organizations by focusing on organizational contexts.

The Personal Software Process (PSP): Watts comes up with "Personal Software Process (PSP)". This model [24] gives engineers with a framework in order to perform software work. The PSP process comprises of methods, forms, and scripts which illustrate software engineers about planning, measuring, and managing their work. The PSP can be used with any design methodology. Besides this PSP can be used with different aspects of software work like; requirements specification, processes definition, and repairing defects. When engineers use the PSP, the objectives of products with zero defect rates, on time or on schedule production and within estimated costs. The factors we have identified from this model are related to; engineer knowledge, process quality evaluation and engineer personal work quality as the varying factors among the organizations and has strong impact and influence on software quality.

Requirement Engineering Maturity Measurement Framework (REMMF): Mahmood Niazi et al. came up with a framework (REMMF) [25] which is based on Sommerville's model [31][32]. The key reason of coming up with REMMF is to effectively compute or evaluate the requirement engineering process maturity which are used by organizations and to support practitioners in evaluating the requirement engineering process maturity. We identified that the framework is based on model focuses the attention towards the requirement engineering problems and says that it varies with the organizational context. It says that communication style, application complexity, lack of training and undefined requirement process is some of the factors which create these problems as they vary with organizational context. Hence also highlights the organizational context aspects.

Software Capability Maturity Model (SW-CMM): The SW-CMM [26] shows sets of suggested practices in form of key process areas (initial, repeatable, defined, managed and optimized) to improve software process capability. Besides this, it not only guides the software organizations to get control of processes use for software development and maintenance but also guides to progress toward software engineering and excellence culture. We identified from the model that it focuses on the varying quality objective factor among organizations for process or product evaluation.

Software Capability Maturity Model Integration (SW-CMMI): The model CMM Integration [27] gives guidance to improve organizations besides with the management of product or service from development till maintenance. CMMI help organizations to appraise the organizational maturity, developing improvement priorities and to implement them via approaches. Initial, Managed, Defined, Quantitatively Managed and Optimizing are the key areas of this model.

We identified the factors related to; quality objectives, models, application domain, organizational structure and size and process vary with organizational context. Besides this we came to know that the model focuses the attention towards the fact that the organization process operates in the business context it means that the process improvement efforts vary with organizational business environment. Similarly the model also describes the fact that the process varies among the organizations because the organizations have different contextual variables like; domain, nature of customers, costs, schedule, quality tradeoffs, technical difficulty of work, experience of the people who are indulged in implementing process. We also identified that the terminologies meaning vary among the development teams, which have influence on the software quality. Similarly it also says that the requirement management is greatly influenced by some of the factors like; distinct locations of the team members, engineering capabilities, staff and facilities available and staff experience. Model continues to explain some more factors which have influence on requirement process like; techniques due to varying economy and accountability, training techniques or approaches which vary on basis of work environment, organizational context, knowledge, cost and schedule, availability of critical resources and availability of key personals.

Requirements Capability Maturity Model (R-CMM): Sarah Beecham et al. [28] come up with a requirement process improvement model. The model centers the attention on the requirements engineering process as distinct from the Software Engineering Institute's (SEI's) software process improvement framework. This model can be used either together with SW-CMM or separately to assess capability of Requirement Engineering process. The R-CMM comprises an assessment method which helps the user to be aware of their current Requirement Engineering process with perspective of its implementation in opposition to maturity goals. From this model we identified the factors related to requirement engineering and says that it is greatly influenced by the organizational and technical factors like; poor stakeholders communication, staff retention rate, change resistance, resource allocation, skills, application complexity, requirement understanding, requirement traceability and undefined requirement engineering process. Besides this it also focuses attention towards the varying organizational culture and says that it greatly influences the development and support. Model describes the process improvement aspect and says that it is context sensitive like; product nature, its usage, customer perception about product and evolution and organizational structure. These factors vary with context and have an impact on process improvement.

Requirements Engineering Process Maturity Model (Uni—REPM): There are number of models discussed above which particularly focus on requirement engineering process but it is also not to be ignored that all these models are restricted to Bespoke development. This Uni-REPM is a model [29] which via set of activities presents the requirement engineering process maturity. These activities are comprised of seven areas: Organizational support, Requirements Management Process, Elicitation, Requirements Analysis, Release Planning, Documentation & Requirements Specification and Requirements Validation. The model provides support to the organizations to identify their process strengths and weaknesses. Besides this it also guides the organizations to better improve the requirement engineering process.

Similar with other models, we have identified that, this model also describes the processes varying nature with the characteristics of organization or environment. Similarly the requirements methods or techniques vary with usage context like, knowledge type and purpose of requirement. It is also notified that the sources of requirements are influenced by social and political aspects. Besides this the model says that the standard for the requirement documentation vary with organizational context as the organization customs, type of product and development process vary in them.

TRILLIUM: This model is for Telecom Product Development & Support Process Capability. *Trillium* model [30] is on basis of a customer perspective, as apparent in a competitive setting. In this context, capability is to develop a product according to the customer needs, in less cost and with in schedule. This Trillium model is used by the organizations for continuous product development and improvement. This model is based on *Capability Maturity Model* (CMM). We identified the factors from the model related to; organizational culture and says that it influences the development capability, process improvement and selection.

4.2. Identification and Fusion of Explicit and Conceptual Data Unit's Duplication:

189 factors are identified in the identification phase of data unit, which are progressively and systematically refined into 37 factors and 7 related classifications (for this whole cleansing process, wide-ranging notes are maintained in form of memos). This refinement is done by identification and removal of clear duplication and conceptual duplications among the data units. We combine two data units which are not having same textual tags but are having same meaning. These refined factors are shown in *Table 3*.

4.3. Identification of Factors Grouping and Classification:

As shown in *Table 3* the factors are associated with classifications and are mapped to the data sources. The factors naming with that of classification is greatly influenced by the classifications and terminology used in the data sources. Similarly the data duplication is seen at two levels i.e. explicit and conceptual level. So the data units which have duplications at any level is then removed and combined to a single data unit.

For example: organization nature, organization and organization characteristics are combined in a single name that is: 'organization nature' factor. In the similar manner personnel knowledge, education and knowledge are combined into 'personnel knowledge'; similarly changing needs and requirement change are same so they are also combined together in requirement growth etc.

4.4. Reviewing Group Labels and Classification and Generating the Final List

These factors are further decomposed into several sub-factors which are discussed and shown below in *Table 3*.Each of the situational factors identified is organized after the filtration against the explicit and conceptual duplication into respective groups and classification. These factors are further comprised of certain sub-factors which has an impact on them as changes in sub-factors ultimately results in the situational factor which further changes the situation for requirement engineering process.

In this last phase, 37 factors and 7 classifications that were formed via constant comparison and memoing are inspected for potential omissions. The theory includes omissions for entire classification, sub-factors and factors. And after omissions and modifications at classification, factors and sub- factors level 28 factors and 6 classifications are found.

As shown above in *table 3* **"Organization"** has eight factors that is; *Nature:* by nature it means the maturity of the organization i.e. mature and immature, *size:* by size it means the size of an organization i.e. small, medium and large size organizations, *Infrastructure:* by infrastructure it means all the things which are related to organizations setups like; utilities of an organization, working facilities etc., *work environment:* this factor covers all the constraints, laws, policies and conditions related to organizations, *business process:* by business process it means the organization business set of steps and activities, which they use adopt for their business execution, *structure:* this factor relates to the organizational structure like: functional structure, Divisional structure and Matrix structure where each of the structure relates to different working strategies for example in functional structure employees work in departments (engineering, maintenance finance etc) where as divisional is on basis of location, product etc and matrix is combination of both. *Economy:* deals with all the things which actually limit the organization economy like; organization internal resources and external market situation. *Training:* is the factor which covers the aspects related to training which organization's provide to their employee for any specific field or area like; if for example some new tool comes in the market for requirement design then whether the organization provides training provided to its employees for that new tool etc. The sub factors discussed for each of the factor comes under classification "Organization" actually shows that base upon them how these factors vary among organizations. Like for *"nature"* Communication with client, application complexity, and training and un-defined requirement engineering processes are some of the sub factors which actually make any organization nature different from the other one. Similarly *"size"* of the organization varies with the resources the organizations has which makes it small size organization, medium size organization or large organization. Building, workspace, supported services, utilities vary among organizations which make the *"infrastructure"* of the organization different for each of them. Similarly the other sub factors related to "*work environment", "business process", "structure", "economy*" and "*training"* as shown in *table 3* actually varies due to which the specific factor varies among the organizations.

"Software Life Cycle" has five factors which are further decomposed into several sub factors as shown in *table 3. Model:* is the factor which deals with the process models the organization adopt for completion of any product. This factor is further comprised of sub factors like: scope or magnitude of project, project complexity, changing needs, changing opportunities. These factors in fact vary among organizations which lead to varying organizational process models to be adopted by them in order to complete any product. Similarly S*tages:* is another factor which deals with the organizational software life cycle stages which vary with the organizational context. By organizational context it means; organization structure, skills, capabilities, processes, technologies, culture and level of formality. *Policies*, *procedures or process* are other factors deals with the organization varying nature on basis of these factors. The sub factors which actually varies and due to them these factors vary among organizations are related to organizational context.

"Resources" is the classification which contains three factors related to the resources of an organization like: Availability, Management and Humans. *Availability:* is the factor which deals with the extent to which the resources are available to an organization. The sub factors which influence the resource availability are organization policy, resourcing plan, economic environment, and schedule. Similarly *Management:* is another factor deals with the resource management and tells the fact that each of the organizations having varying resource management strategies. The sub factors skill, understanding and experience are found to be the one who make the resource management vary among organizations. *Human:* is the factor which is found to be varying among organizations. Here humans are also considered as the organizational resource and the sub factors like: Personal competence, training, skills, experience, responsibility, mode of interaction with system and client are found to be one who make the human resources vary among the organizations.

"Requirements" is the classification which consists of seven factors which vary among organizations related to requirements. *Process:* is the factor which deals with the fact that the requirement engineering process vary among the organizations. The sub factors; quality tradeoff, schedule, application domain, organizational context, human skills, capabilities, workforce, cost, interaction (experience, knowledge, skill), process assessment (tools, competency, models, reference models), activity priority, activity type, process quality (organizational context, engineer quality work), process management (engineer knowledge, engineering capability, staff and facilities available, experience, schedule, plan and effort) are found to be varying among organization which leads to varying process. *Specification:* requirement specification is found to be varying among organizations and the sub factors which results in varying requirement specification are found to be Customer, technical community, environment, communication, policies and procedures. *Utilities:* is found to be a factor which deals with tools, models, standards, approaches and techniques and the sub factors; Behavioral approaches, Style (textual, formal), organizational operational environment, organization condition, usage context, knowledge type, requirement purpose, Organization customs, type of product, development process are found to be varying among organizations leading to varying requirement utilities. *Growth:* it is found that the growth of requirements vary among organizations due to the sub factors of vague requirements or changing requirements. Similarly *conflict:* is another factor which deals with the requirements conflict and it is also found that the conflicting requirements are due to requirements incompleteness, ambiguity, communication mode, knowledge, client type and communication style (formal or informal). *Terminology:* is the factor which deals with the concept of different requirement terminologies meanings among organizations and it is found that the sub factors of culture, language, client type, words and terms vary with organization which lead to varying terminology meaning. Similarly *source:* relates to the requirements sources and deals with the fact that this factor also contributes to the changing situation among organizations. Social aspects, political aspects, relationships, understanding are found to be sub factors which vary among organizations leading to varying requirement sources.

"Management" is the classification which consists of two factors related to organization management people. *Review:* this factor deals with the management review process for the requirement engineering which is found to be varying among organizations. Communication style, client type, skills are found to be varying sub factors leading to varying management reviews. *Commitment:* deals with the fact that the management commitment varies with organizations and it has impact on the requirement engineering process. The sub factors; values, skills and leadership styles are found to be varying among organizations which lead to varying commitment level.

"Risks" is the last identified classification which consists of four risks related factors which can impact the requirement engineering process. There are four type of risks which are identified like; *requirement:* this risk factor is found to be a source of changing situations among organizations. The sub factors which actually lead to this varying situation are uncertain requirements, vague requirements and infeasible requirements. Similarly *technology:* deals with changing situations due to changing technology. Now the sub factors which results in such changing situations is unavailable technology. *Estimation:* is identified as another factor which can generate risk and due to which the situation can be changed among organizations. The sub factor resulting in this changing situation is unrealistic estimation of cost, schedule and effort. Skills and understanding are also found to be sub factors which can lead to estimation risks. *Staff:* is the risk related to organization workforce. This factor is found to result in varying situations among organizations and the sub factor identified for this varying situation is inadequate staff.

In order to further check the accurateness of the list of situational factors, sub factors and classification, it is forwarded to two experts from the academia. Both of them are having above ten years of experience in requirement engineering field. They recommended some very important changes which are then incorporated in our study by performing modifications like: they said that sub factor *"organizational context"* should further elaborated, so it is then modified into *organization structure, skills, capabilities, processes, technologies, culture and level of formality*. Similarly there were some sub factors which comes under same heading but are separately written like *organization technology, tools, environment, workplace facilities* all come under organizational context hence they are then combined together and modified in *organizational context* word. Similarly the recommendation from the experts to combine the factors *Tools, Models, Techniques and Approaches, Traceability and Standards* into a single factor is done by combining them together and giving the name of *utilities.*

The *client* classification is removed from the list and combined with the factor *"source"* which comes under classification "*Requirements"*. Besides this its factors *relationship and understanding* are included in the list of sub factors of "*source"* (one of the factors comes under "Requirement" classification). Similarly *values* and *leadership* styles are the two sub factors included with the sub factors of "*commitment"* (a factor coming under "*Management*" classification). After the final review phase, we come up with situational factors consisting of 6 classifications and 28 factors that may influence the requirement engineering process as shown in *Table 3*. Table also consists of listing of 144 sub-factors – which are factors components, which are carefully consolidated from the various data sources.

5 DISCUSSIONS

In this section, we talk about how this work can be helpful for research communities. This work also leads to some possible future work areas. In the end some limitations are also discussed.

5.1. Utilizing Situational Factors:

The situational factors which are identified from the standards and models on and around the area of requirement engineering process are the important reference for researchers, who are working in situational requirement engineering standards and models as it shows the list of factors which are identified from the existing standards and models deals directly or indirectly to requirement engineering. Specifically it is useful for the researchers who are working in requirement engineering process improvement with perspective of changing situations. The initial list can also guide the researchers and practitioners working in situational requirement engineering, to consider the standards and models as a significant consideration for dealing with changing situations faced by them while performing RE process. Besides with the initial list identification, this work also contributes in describing all the related standards and models on and around RE process in detail by explaining its purpose and the domain in which these standards and models are used. But the main contribution which is the initial list of factors identified, represents the technical (tools, techniques etc) and non-technical (motivation, values etc) aspects hence fully covering the requirement engineering process from the standards and models data source.

5.2. FUTURE WORK

The list of factors identified is from one of the domain from the areas which can affect requirement engineering process by changing the situations for the process. The domain we have searched for this study is standards and models which are on and around requirement engineering process. The other domains can be risks factors affecting requirement engineering, environmental factors affecting requirement engineering, body of knowledge etc as shown in *Table 1*, which are also to be investigated for the identification of the situational factors.
Our upcoming research is focusing to identify the situational factors from other domains; risks related to requirement engineering, environmental factors, requirement engineering process tailoring etc. hence this study will act as a basis for the upcoming research and will also become one of the various other important inputs for the comprehensive list of situational factors which affect requirement engineering process in global software development (GSD).

5.3. LIMITATIONS

We have given care in selection of the data source but it can become its limitation as the scope of the situational factors list is limited to the standards and models related to requirement engineering directly or in-directly (like we have also included the standards and models which deals with software development besides with the one which are directly dealing with requirements engineering). This limitation will be overcome by completing our future work (covering all the related domains as describe in *table 1*).
Another limitation of the study is that it does not cover the identification of factors from industry as the study comprises of the situational factors which are identified from the state-of-the knowledge. The steps to overcome this limitation is taken by designing a questionnaire and surveying the situational factors from the industry which will be ultimately included in the final comprehensive list of situational factors affecting RE process in GSD.We make every effort to cover all the related standards and models on and around RE process but still possible, that we may miss any related standard and model. Similarly the paper is forwarded to other researchers in order to deal with biasness about the search protocol used, but still biasness aspect can not be ignored as well. The threat of misinterpretation can also not be ignored, as it is one of the must factor in every literature review, although we tried our best to overcome these aspect by dealing it carefully. We also cannot ignore the threat related to precision. In our work we tried to have high precision rate but still the maximum precision is not assured.

6 CONCLUSIONS

This paper shows the evidence that the situational context is involved in finding the most suitable requirement process definition for any product. So we do not come across any study which identifies the situational factors which affect requirement engineering process. Its absence motivates us to identify the situational factors from various domains related to requirement engineering which can lead to changing situations during requirement engineering process. For that we have selected one of the various domains that are standards and modes directly or indirectly related to requirement engineering process for this study.

In order to come up with the unique situational factors we used the constant comparison and memoing phases of Grounded theory [8]. So by following this theory we have organized our work in six steps. Each of the step lead to some contribution to our study. In the end we come up with the list of unique situational factors which are

filtered on basis of explicit and conceptual duplications. After which they are grouped with various labels and then classified accordingly.
We think that the list of situational factors consisting of key situational elements related to requirement engineering process represents a strong initial input from the domain of standards and models of RE process towards a comprehensive list of situational factors, which we will have after having factors from all the related domains of requirement engineering process.

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Table 2. Situational Factors from Standards and Models

Classification	**Std & Models/ SF**	ISO 9001-2000	ISO / IEC 15504	ISO / IEC 12207	IEEE 830-1998	IEEE 1233-1988	IEEE 1362-1998	ISO/ IEC 15288-2008	ISO / IEC 24748	BOOTSTRAP	PSP	REMMF	SW-CMM	SW-CMMI	RW-CMM	REPM	TRILLIUM
Organization	Nature	x							x			x				x	
	Size	x												x			
	Infrastructure	x		x		x	x	x	x					x			
	Work environment	x		x		x	x		x		x			x		x	
	Business process			x		x								x			
	Structure						x							x			x
	Economy							x						x			
	Training												x	x			
SW Life – Cycle	Model		x						x					x			
	Stages			x													
	Policies			x													
	Process			x						x							
	Procedures			x													
Resources	Availability	x												x			
	Management	x											x				
	Human resource	x					x	x						x			
Requirement	Process	x		x	x			x	x	x				x		x	x
	Project Complexity	x		x								x	x	x			
	Specification				x				x				x				
	Tools				x				x								
	Models			x										x			
	Techniques & approaches					x			x							x	
	Growth			x									x				
	Traceability												x				
	Conflicts	x															
	Terminology													x			
	Source					x								x			
	Standard					x										x	
Client	Related process	x															x
	Relationship								x							x	
	Understanding	x											x				
Management	Reviews	x															
	Commitment	x						x									
Risks	Requirement												x	x			
	Technology								x					x			
	Estimation										x			x			
	Staff													x			

Table 3: Classifications of Factors and Sub-factors

Classification	Situational Factors	Sub-factors
ORGANIZATION	Nature	Communication, application complexity, training, un-defined requirement engineering process
	Size	Resources (Small size organization, medium size organization, large organization)
	Infrastructure	Building, workspace, supported services, utilities
	Work environment	Conditions, politics, market, standard, technical policy, cultural policy, physical environment, operational policy, quality policy, quality objective
	Business process	Poor stakeholder communication, staff retention, change resistance, lack of training, lack of skills, poor resource allocation
	Structure	Functional, divisional and matrix
	Economy	People, material, infrastructure, capital, customer behavior, competitive position.
	Training	Knowledge, cost, schedule, work environment
SOFTWARE LIFE CYCLE	Model	Project scope or magnitude, project complexity, changing needs, changing opportunities.
	Stages	organization structure, skills, capabilities, processes, technologies, culture and level of formality
	Polices	Organization structure, culture.
	Procedures	Organization structure, skills, capabilities, culture and level of formality
RESOURCES	Availability	Organization policy, resourcing plan, economic environment, and schedule
	Management	Skill, understanding, experience
	Human	Personal competence, training, skills, experience, responsibility, mode of interaction with system and client
REQUIREMENT	Process	Technological differences, quality tradeoff, schedule, application domain, organizational context, human skills, capabilities, workplace, environment, application domain, facilities, equipment (HW, SW), facilities, tools, workforce, cost, interaction (experience, knowledge, skill), process assessment (tools, competency, models, reference models), activity priority, activity type, process quality (organizational context, engineer quality work), process management
	Specification	Customer, technical community, environment, communication, policies, procedures
	Utilities (tools, models, standards, approaches, techniques)	Behavioral approaches, Style (textual, formal), organizational operational environment, organization condition, usage context, knowledge type, requirement purpose, Organization customs, type of product, development process
	Growth	Requirements change, vague requirements.
	Conflict	Requirements incompleteness, incorrect requirement, ambiguous requirement, communication mode, communication style, understanding, knowledge, client type
	Terminology	Culture, language, client type, words and terms.
	Source	Social aspects, political aspects, Relationship with client (formal or informal), policies, procedures, communication style, client type, feedback.
MANAGEMENT	Reviews	Communication style, client type, skills
	Commitment	Values, skills, leadership style
RISKS	Requirement	Uncertain requirements, vague requirements, infeasible design
	Technology	Unavailable technology
	Estimation	Unrealistic estimates (cost, schedule, effort), skills, understanding
	Staff	Inadequate staff