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Qualitative Analysis Model for Software Requirements Driven by Interviews

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Abstract: Despite the recent precision of Software Engineering (SE), software systems still suffer from foremost problems, which are constantly referenced to Requirements Engineering (RE). RE is both the hardest and most critical part of software development, since errors at RE stage postponement to the end of the software development process and the hardest to repair. One of the major problems in RE is the analysis and interpretation of data driven by interviews, in view of the fact that most data comes in narrative, text, story and informal shape, which is generally called qualitative data. As well as data comes in mass appearance, which is later difficult to interpret to software requirements. In this study we have offered a brief overview of RE, interviews and qualitative models. Originally, we have offer a key improvement in the analysis of interviews, by proposing a Bottom-Up Qualitative Analysis Model (BUQAM) for enhancing the analysis of data driven by interviews, consequently well interpretation to software requirements. The BUQAM consist of the following steps: (1) Focused Oriented Questions (2) Organizing and Identifying Data (Familiarization) (3) Iterative Coding and Pattern Categorizing (4) Requirements Mapping and Classification and (5) Requirements Generation. We argue that this model will renovate most of narrative (descriptive) data into interpretive (clear-cut) information. In the same time, this model can furthermore be used in several types of narrative data such as ethnographic studies, action videos, observations, note files and surveys. In order to clarify our assumptions, we have validated this method against a case study for developing a University Wireless Network System (UWNS).

Key words: RE, Interviews, qualitative models, BUQAM, UWNS

INTRODUCTION

RE is the first and thorny stage of SE development process, where user requirements are collected, understood and specified. Therefore RE is recognized as a critical task, since many software failures originate from inconsistent, incomplete or simply incorrect requirements specifications[1]. In general, RE is a critical discipline where we need special techniques to facilitate the extraction, capturing and interpretation of this knowledge[2]. A number of researches have been shown that many software projects fails, because of inadequate and poor analysis of specification[3]. Research suggests that many system failures can be attributed either to the lack of specification or to poor interpretation of data driven by elicitation techniques[4]-[5]. Broadly speaking, RE process is vitality important stage of any project[6]. It is also a stage that can be neglected, ignored potentially at great cost to those involved. It has been found that the requirements stage of a project is the stage where the greatest percentage of errors 56% is introduced into the system[7] as shown in Fig. 1a.

By means of having an accurate and complete set of requirements, it should be possible to eliminate a considerable number of these errors. As most of these errors introduced long before coding begins they are also the most expensive to eliminate, with requirements phase errors are take up 82% of the total maintenance cost of eliminating errors[7,8] as shown in Fig. 1b below. However, wide and strong research results have shown that data analysis driven by interviews is one of the major problems in early product software development. Many requirements errors are passed undetected to the later phases, which are extremely costly. Furthermore, errors during requirements analysis that are not found until later stages of the implementation process can cost significantly more to fix[3,-9]. Correspondingly, requirements analysis is frequently referred to as being one of the most difficult aspects of expert systems development[10,11]. Ultimately based on above arguments and factual facts, there is a burly evidence that requirements interpretation from informal discussion such as interviews is a main and essential problem in SE and in particular to RE. This off beam and poor interpretation methods could lead to poor, vague and unwanted requirements, consequently to the failure of software systems.

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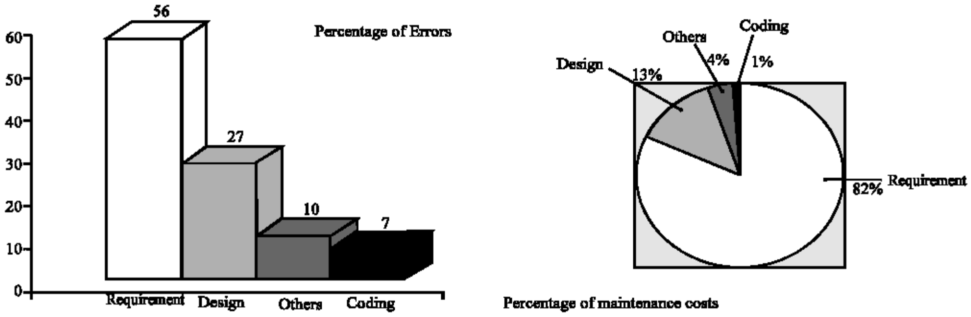


Fig. 1: Left (a): source of errors in systems, right (b): cost of eliminating errors

INTERVIEWS

An interview is a commonly and essential requirements elicitation technique where interviewers (requirements engineers) question and ask (interviewees) users and experts for software requirements throughout a systematic process to gain levels of information about their needs in connection to the expected new system[12,13]. The most imperative advantage of interviews that it captures information in-depth as well as capturing personal feelings, perceptions and opinions which is harder to dismiss, hearing actual words of interviewees that convey their powerful emotions and passions, in addition in-depth interviews are used to determine individuals' perceptions and opinions, facts and forecasts with individuals' reactions to initial findings and potential solutions[14]. In other words, the interviewer allow the interviewee to express their knowledge and thought using their own words and are particularly valuable for generating in-sight information[15].

Generally, interviews are used in an extraordinary variety of domains and are often preferable and successful[16]. Benefit speaking, Berlin notes, “even a few hours of interviews can be very valuable, even when conducted by engineers who have had only brief training in interviewing and user needs analysis”[17]. Several sources e.g.,[18,19] argue the use of interviews for capturing software requirements. While analysts are working in requirements analysis and interpretation using a variety of tools and techniques to obtain information, the interview continues to be the favored elicitation and interpretation technique[20,21]. However, interviewing stakeholders is the most used and abused method for eliciting software requirements. Recent research shows that interviews are recognized as a potentially rich but difficult method of requirements elicitation and analysis[22]. Researchers have argued that communication between analysts and users is often problematic due to issues such as cognitive limitations and vocabulary differences, in which eventually effect the interpretation of requirements[20,23]. Therefore, the goal of interviews is to deeply explore the interviewees’ point of view, feelings and perspectives, in this sense, in-depth interviews mostly yield precious information.

Most of interviewers apply the note taking method for capturing data. When using any type of qualitative models to analyze data from interviews, it is advised to use audio or video transcription method[24]. It has been shown that interviews will be more effective, since the interviewer can totally focus with the interviewee response, in which increase the interaction level[25]. The emphasis during data analysis was on linguistic structure and interaction; therefore, it is important to include intonation, volume, pacing and other qualities of speech to capture the mood and feel of the interview. To achieve a balance between capturing all the detail necessary and providing a readable transcript, it is advised to attempt make similar work of[26-28]. With these, conventions it is ensured that overlaps, exclamations, questions, pauses and emphasis were maintained. Studies show that rich transcription can lead to better interaction, since the interview may possibly carry verbal and non-verbal data[24].

In general, there are 2 types of interviews: structured and unstructured[15], which can be applied at different situation. Structured interviews use closed-ended questions to capture requirements, which are oriented towards quantitative analysis, while unstructured interviews use a diversity of open and closed ended questions, which is oriented towards qualitative analysis[29-32]. In this study, we will deal with qualitative data, which is the most critical and richest data that can be gathered from interviews. In study, we have offered further and detailed information regarding interviews types and qualitative analysis models.

Eventually from this section, we have recognized that interviews are a potentially rich but difficult method for requirements elicitation and analysis, since it lacks from an efficient analysis and interpretation model. More attention should be focused into the qualitative models, as they carry much more than quantitive methods. In the next section, we have introduced the qualitative models and go further into our proposed model.

QUALITATIVE ANALYSIS MODELS

Qualitative models: Most of methodologies that adapt interviews for RE, are unstructured interviews (open-ended), given that this type of interviews is more comfortable, open, flexible and in-depth information can be captured[16]. Unstructured interviews usually produce qualitative data, while structured interviews produce quantitive data. These 2 types of data often collected in combination with each other[33]. Qualitative data means that the results produces in a narrative form which is more textual[34], while quantitative data means of statistics and numbers that seeks to causal determination, prediction and generation of data. The most richness type of collected data is qualitative data[33], in which comes in different shapes and forms of texts, narrative data and stories[14]. In order to analyze and interpret this type of data, we usually use qualitative models, since qualitative models are used to better understand a phenomenon about little is yet known. Nevertheless, qualitative information is also useful to gain new perspective on things about which is already known, or to gain information that may be difficult to convey quantitivly. Most of recent methods focus on natural language process instead of qualitative methods[35], however human factor remain a major element in the analysis process[36-37]. In this sense, we use qualitative method to interpret interviews data, in which make interviews more visible.

Qualitative interviews may be used as a primary strategy for data collection, in which utilize open-ended questions that allows for individual variation. This type of interviews is more realistic and (2-way) interaction[38]. During open-ended interviews, it is free to probe and explain more with predetermined requirements subjects[15], which help to keep interaction focused[39]. However interaction is important to gain in-depth truly information[40]. Recent studies shows that interaction between correspondents is important, which is the intention of human-computer interaction[41].

However, when data became much more informal and more qualitative, it produce strong in-depth information, in the same time much more effort is needed to analyze it[33] and it will be more time and resource consuming. As a result, studies show that qualitative information is the more difficult part of interpretation than quantitative[42], in addition, one other major problem with qualitative data that it comes in mass shapes[14]. There is no key analysis method for interviews, since most of qualitative data located toward the fiction end of the continuing without being fictional in the narrow sense of the term[43]. In the same time, there is no perfect method quick fix technique in qualitative analysis. Sutton[44] suggests that different social realities bring forth different languages and users are most of the time inhabiting worlds with very different concerns and objects of interest from each other, let alone from providers. Yet, while much attention has been given to the problematic nature of analyst-client communication and language usage, very little of the research is based on the analysis and interpretation of this conversation.

The model in this paper draws on critical importance in narrative and qualitative analysis[45-50]. Narratives are particular types of discourse that emerge during requirements interviews. Research shows that during interviews people use the narrative form as a pattern for uniting the events of their lives[51]. Through narratives, people organize their temporal experiences and make them meaningful. Other research sees the narrative as a politically motivated production of a certain way of perceiving the world which privileges certain interests over others[49]. They are used to create believable explanations for the teller's actions. To better understand narratives, theorists have developed definitions describing the structure and function of narratives. Some suggest a somewhat narrow definition where narratives are stories about specific past events[52,53]. These stories follow a chronological sequence where order of events move in a linear way in time. Dube and Robey[54] examine stories as a symbol of organizational culture to generate insights into the collective interpretation of management practices by competing groups during a software development project.

We have realized that the best and most usual data comes in narrative and qualitative forms, mainly from un-structured interviews, however it is difficult to analyze. Most of researches have ignored the integration between qualitative models and RE. In the following section, we have proposed a model for qualitative data analysis driven by interviews. This analysis made a supple model to convert narrative data into software requirements.

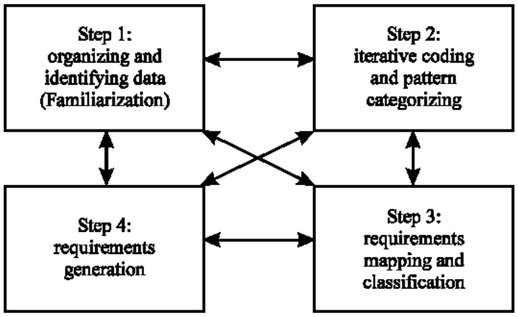

Step 1: organizing and identifying data (Familiarization)
Step 2: iterative coding and pattern categorizing
Step 3: requirements mapping and classification
Step 4: requirements generation

Fig. 2: BUQAM as an iterative, progressive, recursive and holographic model

Bottom-Up Qualitative Analysis Model (BUQAM): In this section, we proposed our Model BUQAM. This model is used for Interviews as well as in several types of narrative data such as ethnographic studies, action video, observation, personal notes and surveys. The proposed Model is based on different types of qualitative models. Besides, we have employed and adapt many general models and add a number of original works to them, which made them appropriate for software requirements analysis as shown in Fig. 2.

BUQAM is non-linear model. Non-linear means that the proposed model has the following characteristics. Iterative and Progressive: The process is iterative and progressive because it is a cycle that keeps repeating. For example, when you are thinking about things you also start noticing new things in the data. You then collect and think about these new things. In principle the process is an infinite spiral, Recursive: The process is recursive because one part can call you back to a previous part, For example, while you are busy collecting things you might simultaneously start noticing new things to collect, Holographic: The process is holographic in that each step in the process contains the entire process, For example, when you first notice things you are already mentally collecting and thinking about those things. Fig. 3 offers us a comprehensible representation of the detailed model BUQAM and its major steps.

In the following section, we have offered a detail explanation of the process model with examples.

Focus oriented questioning (Pre-Level Analysis): In fact most of qualitative analysis models should start before the actual model steps begin, by setting high level goals, as well as with planned oriented and focused open-ended questions. This can take place by sorting and grouping our intended questions into related subjects and more fashion appearance. These simple strategies will shortly reduce the pains that are needed to organizing and coding and analyzing software requirements[14]. For example: if we are developing an university library system software, we should group our open-ended questions into, The library catalog system, Students information, Borrowing Information, User interface Material information and so on.

Organizing and identifying data (Familiarization): Good requirements analysis depends on deep understanding of the data[39]. For qualitive analysis, this means you read and re-read the interviews transcripts, in the same time you need to organize your data, by numbering your interviews, interviewees, subjects and your data. In addition you need to "organize" your data into groups, because this makes the process easy to manage and will help out the interviewer extremely to a great extent, to effortless go backward and forward within the process[33]. If you have a tape recording or video footage, you watch or listen to them several times, so you can be familiar with your data, which is called "familiarization". Write down any impressions you have as you go through the data. These impressions may be useful later for converting to efficient requirements. After reading and reading through your gathered data, highlight and "identify" significant chunk (portions of your data). A chunk might be as short as a phrase or as long as several paragraphs. A significant chunk is one that includes ideas or information that surprises you, that are important to you and/or that are personally significant and interesting to you.

Iterative coding and pattern categorization: This step is the most critical step in the BUQAM. Most qualitative models called this step "the core and heart step". It codes, labels and assign meaning to piece of data. An iterative process of coding and categorizing the data, until meanings comes up. "Coding" means, you assign abbreviated codes of a few letters, words or symbols and place them next to the themes and ideas you find[26]. This is an iterative, holographic and incremental understanding of the data within the process as mentioned previously. Initially we assign the 1st codes "initial coding" which called present category, to identify and organize data, then we assign the 2nd codes to the data, which formulate meaning that will appears and later we assign 3rd codes to data "focused coding", which make allow emergent categories to appear and bring fine understanding and analyzing of the data. This process will open relationships between requirements and make initial inference of requirements. We may keep going on to "n" codes until

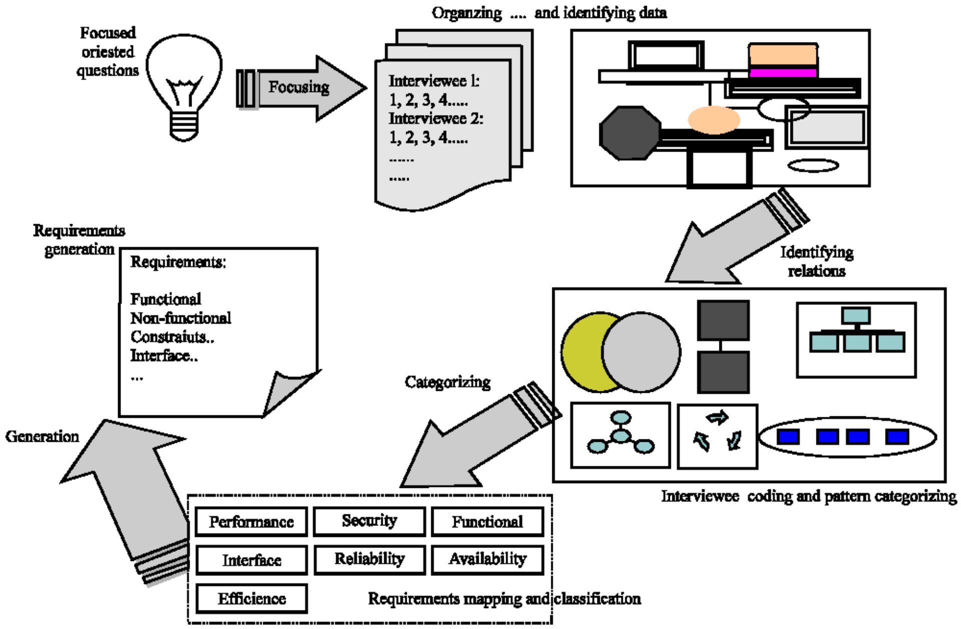


Fig. 3: The main steps of the BUQAM

clear understanding of words comes. This process can be fairly labor-intensive depending on the amount of data you have. But this is the crux of qualitative analysis. It involves reading and re-reading the transcript and identifying coherent categories

Requirements mapping and classification: This step completely depends on the previous steps. After gathering and understanding the meaning of the transcriptions, we will match present and emergent categories to requirements types, such as functional, security, safety, availability, reliability, performance, interface, constraints and so on. Based on this matching we will link each requirements type and group them under the main requirements classification. We will use Davis[55] classification which represents: Functional requirements, Non- functional requirements, Constraints, Usability requirements, Reliability/Performance requirements.

Requirements generation: In this step we will "formulate" and "inferences" software requirements. There is no large, complex and technical process that can be done here. A big part of this step will depend on the interviewer. Based on the previous steps (till step 4), we will end up with a grouped storylines that contains similar and communicated needs of different users that are classified with the software requirements types. These storylines contain a discrete clear of users' needs that is easy to analyzed and converted to software requirements. Based on this clear (straightforward) grouped text, we can inference a number of accurate software requirements driven by several interviews. In the following section we provided a simple case study for developing a UWNS which explain the BUQAM more visibly.

CASE STUDY

University Wireless Network System (UWNS): In order to clarify the BUQAM we undertook a case study for developing a UWNS, which is intended to serve current students within a local wireless network no more than 3 Kilo-Meters from the main access point, which sits above the main server. Subsequently the case study has been followed by a detail analysis that explains the BUQAM. Unstructured interviews have been conducted with 20 students from Anna University. During the interviews, we have captured qualitive critical data that is related to UWNS. Results have been elicited using the note taking method. The gathered data attempted us to create different note files based on the interviewed students. In this paper, we have shown the results of 3 students which is part of the entire interviewing process, due to space limitations. The interviews data has been collected according to the interviews questions as shown in Table 1, which explain step 1 from the entire process. We have offered a detailed analysis about the conducted interviews and an explanation with each step in the BUQAM process in the following section. In particular, we have explored the collected data and what it tells us about the implications of developing UWNS. This factual case study gave us the opportunity to simulate the proposed Model. The overall goal was to understand the substance of BUQAM and the mechanism behind it.

Table 1: Step 1: Part of the total open-ended questions (3 students) for developing UWNS

No.	Interviewees		Focused Open-Ended Questions
1	Student 1…	-	What is your bad experience with internet ?
		-	Do you use internet from a long time ? Why ?
		-	What kind of physical problems do you face when you set in front of the computer ?
		-	Do you prefer to have the network available 24 hours ? Why ?
		-	Tell me do the your study consume all of your day time ?
		-	What kind of information you don't want to share with others ? Why ?
		-	
2	Student 2…	-	How much files do you download daily ? What are these types of files?
		-	Are you happy with the current internet speed ? Why ?
		-	As an average tell me your experience with downloading files and how much time you need to download these files?
		-	Do you find some improvements in the internet speed ? How ?
		-	What is the most comfortable interface to you ? How would you like screens appear to you ?
		-	Do you complete you jobs within the time of working hours ? Why ?
		-	Do you move around the university ? For how much distance ? Is your classes far from each other ?
		-	
…	…	-	…..?
20	Student 20…	-	Do you have bad experience with security over the internet ? How ?
		-	To whom you would like your information to be visible ? Why ?
		-	How do you feel about computers, easy or hard ? Why ?
		-	What do you think about current internet rate ? Why ?
		-	Is there anything else you need from computer systems inside the university ? Why ?
		-	When do you have extra time ? Why ?

Tabel 2: Step 2: Organizing and identifying data (familiarization)

No.	Type	Classification	Requirements Generation1
1	Performance	Performance requirement	Performance requirements: The new system shall increase the internet rate to 1MB/Minite, because current system is slow for all students.
2	Availability	Design constraint	Constraint requirements: The new system shall provide internet to student for 22 hours/Day, hence students can browse and read at early morning or late evening times.
3	Usability	Interface requirement	Usability requirements: 1- The new system shall be more comfortable to the students that have problems with their eyes, by providing the student the flexibility to increase icons size and re-coloring feature. 2- The new system shall provide to handicapped students pointing tools to assist their guidance when using the system.
4	Usability	Interface requirement	
5	Privacy	Non functional requirement	Non-functional requirements: 1- The new system shall provide an encryption protocol to insure information hiding within the sender and receiver. 2- The new system shall provide 128-bit RSA security algorithm, to insure proper security provided within the system. 3- The new system shall allow the student to send and receive information from any spot from the university, which is 3 KM.
6	Security	Non functional requirement	
7	Efficiency	Non functional requirement	
8	Functional	Functional requirement	Functional Requirements: 1- The new system shall allow the student to browse the University Library Catalog to read materials (Books, Papers…etc) electronically.
9	Functional	Functional requirement	2- The new system shall be compatible with many types of OS, such as Windows 98, Me, 2000,XP, Linux, Unix...etc.

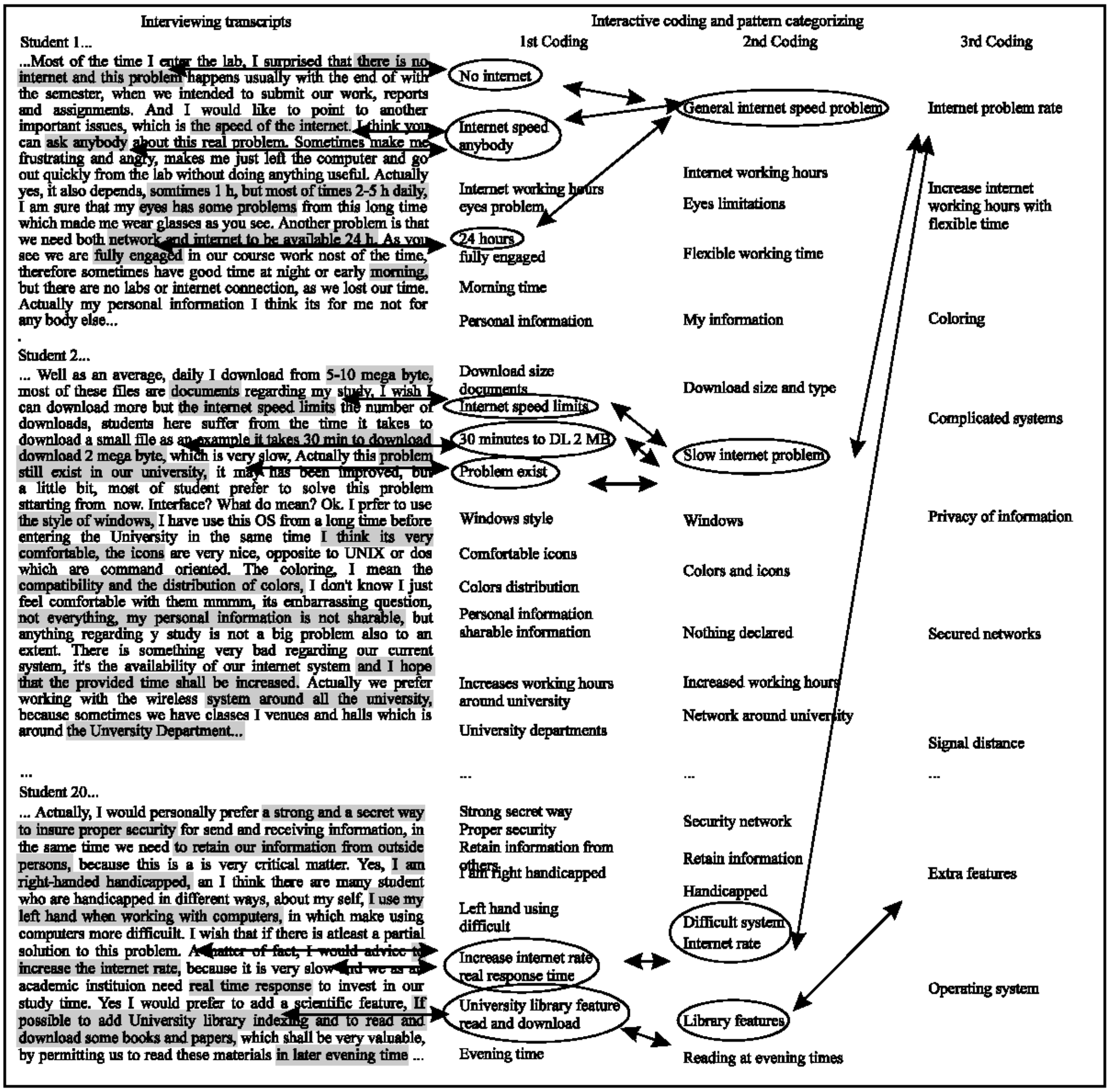
Table 3: Step 4: Requirements mapping and classification, Step 5: Requirements generation

	No. of	Interviewee	Interviewer	Transcription	Counted	Approximately
No.	questions	name	name	media	time	no. of words and lines
1	20	X1	Y1	Note Taking	30 Minutes	Words:640 Lines: 50
2	17	X2	Y2	Note Taking	28 Minutes	Words:561 Lines: 41
…	…	…	…	…	…	…
20	13	X3	Y3	Note Taking	25 Minutes	Words:443 Lines: 37

RESULTS AND DISCUSSION

In this study we offered a detailed discussion regarding the conducted case study UWNS. Step 2 has been shown below Table 2, which explain the organizing and identifying of the collected data from interviews.

Now we can move into step 3, which is responsible for Coding and Categorizing of the data that has been organized and identified from step 2, as shown in Fig. 4. After coming up with a good coding and categorizing information, we can move into step 4 and step 5, to map and classify the codes to requirements types and then


Interviewing transcripts

Student 1...

...Most of the time I enter the lab, I surprised that there is no internet and this problem happens usually with the end of with the semester, when we intended to submit our work, reports and assignments. And I would like to point to another important issues, which is the speed of the internet. I think you can ask anybody about this real problem. Sometimes make me frustrating and angry, makes me just left the computer and go out quickly from the lab without doing anything useful. Actually yes, it also depends, somtimes 1 h, but most of times 2-5 h daily, I am sure that my eyes has some problems from this long time which made me wear glasses as you see. Another problem is that we need both network and internet to be available 24 h. As you see we are fully engaged in our course work nost of the time, therefore sometimes have good time at night or early morning, but there are no labs or internet connection, as we lost our time. Actually my personal information I think its for me not for any body else...

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Student 2...

... Well as an average, daily I download from 5-10 mega byte, most of these files are documents regarding my study, I wish I can download more but the internet speed limits the number of downloads, students here suffer from the time it takes to download a small file as an example it takes 30 min to download download 2 mega byte, which is very slow, Actually this problem still exist in our university, it may has been improved, but a little bit, most of student prefer to solve this problem sttarting from now. Interface? What do mean? Ok. I prfer to use the style of windows, I have use this OS from a long time before entering the University in the same time I think its very comfortable, the icons are very nice, opposite to UNIX or dos which are command oriented. The coloring, I mean the compatibility and the distribution of colors, I don't know I just feel comfortable with them mmmm, its embarrassing question, not everything, my personal information is not sharable, but anything regarding y study is not a big problem also to an extent. There is something very bad regarding our current system, it's the availability of our internet system and I hope that the provided time shall be increased. Actually we prefer working with the wireless system around all the university, because sometimes we have classes I venues and halls which is around the Unversity Department...

...

Student 20...

... Actually, I would personally prefer a strong and a secret way to insure proper security for send and receiving information, in the same time we need to retain our information from outside persons, because this is a is very critical matter. Yes, I am right-handed handicapped, an I think there are many student who are handicapped in different ways, about my self, I use my left hand when working with computers, in which make using computers more difficuilt. I wish that if there is atleast a partial solution to this problem. As matter of fact, I would advice to increase the internet rate, because it is very slow and we as an academic instituion need real time response to invest in our study time. Yes I would prefer to add a scientific feature, If possible to add University library indexing and to read and download some books and papers, which shall be very valuable, by permitting us to read these materials in later evening time ...

Fig. 4: Step3 iterative coding and pattern categorizing

generating the requirements based on the collected data from unstructured interviews.

CONCLUSION

Most of detailed and critical software requirements are elicited during unstructured (open-ended) interviews. This nature of interviews, frequently results in large amount of data that is intricate to read, analyze and consequently interpret to software requirements. Therefore, we argue that working with data analysis is rich and enlightening experience. The more practice, the easier and more rewarding it will become. As both a science and art, it involves critical, analytical thinking and creative and innovative perspectives. We argue that existing models almost focus on technology and have forgotten the human dimension. Human is a core part of the analysis process and hence cannot be exempted. In this study, we have proposed a BUQAM for analyzing software requirements driven by interviews. In the same time we have illustrated the BUQAM against a case study for developing a UWNS.

However, by including the Human element in BUQAM we have brought the factors such as quality of questions in the interview, structuring of the questions based on the context of use of the product, expertise level of the interviewer and the interviewee and the problems related to understanding the responses into the ambit of the analysis. The study reported is the core of the BUQAM model.

Both research and case study results are evidence for that there is high necessitating to apply qualitative analysis models for interviews. Considerable work still remains to be carried out in this area of converting the above method into a quantifiable one, that give us a measurable feel of the collected data; we suggest potential research work focusing on: More theoretical work on the analysis of qualitative models, Improved methods to identify relationships among qualitative data, Focusing on transforming the current model (BUQAM) into a quantifying model that can be verified and validated. We hope that our study analysis and discussions will help learning researchers and developers of better situate their research work and problems to focus on better methods to integrate human into the analysis process.

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