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Outsourced Offshore Software Testing Challenges and Mitigations

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ABSTRACT

Context. Software development comprises of different phases like requirements, analysis, design coding and testing. In this contemporary world of software development, development of software in globalized scenarios is prevalent and prominent. As part of different globalized scenarios this thesis magnifies the scenario of software product transfer which deals with the testing of software in the offshore location.

Objectives. The prime objective of our research is to find out the challenges and their mitigations by performing Systematic Literature Review (SLR) specifically in both offshore and onshore scenarios. We have conducted surveys which focuses on the validating the challenges and mitigations identified. The study mainly focuses on how effective is the process of carrying out the outsourcing software testing activities to offshore.

Methods. In order to meet the purpose of the research, we had performed systematic literature review and industrial surveys based on questionnaire to get the relevant information. From our SLR we obtained 28 articles which answered our study criteria. We obtained primary studies based on performing two phase search strategy which includes both manual and electronic search. As a part of electronic search, we used electronic databases like IEEE, Engineering Village, ISI web of science, Science direct and Scopus. In the manual search, we targeted journals and conferences as a part of search venues. Some of them like International conference on Global Software Engineering. We conducted online survey where in we had 39 participants who contributed their knowledge by answering the questionnaire provided. For analyzing the data obtained we applied Grounded theory and Qualitative comparative analysis.

Results. We had found **93** challenges and **87** mitigations during systematic literature review. After conducting the survey for the industrial practitioners we made a comparison to explore similar and unique challenges and their mitigations.

Conclusions. In future, researches have to emphasis on personnel, project and product factors for effectively implementing the software testing activities both at offshore and onshore locations.

Keywords: Outsource, Offshore, Onshore, Challenges, Mitigations, Client and Vendor.

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CHAPTER 1
INTRODUCTION

Introduction

Throwing light into the globalization of software development it is prevalent that different teams from different locations get involved in the development of a software product during its evolution [1]. Software development cycle under goes different phases like requirements gathering, designing, developing, testing and maintenance. There are certain benefits when the work is distributed to multiple locations across the world like reducing the development costs, skilled employees, best innovation etc. In recent days globalization of software development involves either outsourcing the complete software product development or a particular software development phase to the remote locations (offshore). As a part of outsourcing the work to offshore, plethora of offshore vendors has emerged in the countries like India, china and South America. Among all the development phases, testing is the final phase that determines quality of software, which satisfies the end-user requirements. Software testing a process, or a series of processes, designed to make sure computer code does what it was actually designed to do and that it doesn't do anything unintended [2]. Software that was developed must be predictable and consistent always, offering no surprises to users. In the goal of achieving time to market development from small scale to large scale has started outsourcing the testing activities to offshore vendor organizations. Testing is one of the entities that companies are willing to outsource since there are a large range of offshore subcontractors specialized in software testing; outsourced offshore software testing is fast growing industry. It had perceived benefits of reduction in costs, access to skilled resources, effective time zone utilization and improved quality of work. Even though it became a common practice but there are some challenges which always hinder the software testing activities that are being carried out at both offshore and onshore. In this thesis we aimed to get an insight in both the literature and industrial practice. We have conducted systematic literature review to get the knowledge contributed by the researchers so far. We then conducted an industrial survey, which was a questionnaire format. Questionnaire was prepared based on the challenges that were obtained during systematic literature review. We have included papers from the year 1999 up to the year 2012. We have performed the data analysis both qualitatively and quantitatively. We used Grounded theory with Glaser and Strauss [27] flavor for quantitative analysis. We have framed the questionnaire for survey with the challenges that we have observed from both client and vendor side. We have separate survey forms for both onshore and offshore vendor employees.

1.1 Aims and Objectives

The main aim of this research is to identify the prominent challenges that occurred in outsourced offshore software testing and to find out their cope up strategies. In order to validate the observed challenges and their cope up strategies survey based on questionnaire was performed to know how effective is the process of outsourced offshore software testing and also to know if there are any other new challenges and their cope up strategies that are not captured in the literature.

1. Identify all the challenges that were present in the literature about outsourced offshore software testing.
2. Identification of any mitigation strategies that were addressed in the literature for the challenges identified.

3. In quest for challenges of outsourced offshore software testing by the industry practitioners.
4. In addition to the challenges from the industrial practitioners mitigation strategies are also included.
5. Comparing both the challenges and mitigation strategies of systematic literature review and industrial practice.
6. Based on the comparison, the effectiveness of OOST process is determined.

1.2 Research Question

Research Questions plays an important role to give the complete meaning to the research. These questions drives the complete thesis, an entire work is well motivated and frequently highlighted in the form of specific research questions. In our research we have formulated three research questions.

1. What are the challenges/ problems encountered in outsourced offshore testing?
2. What are the solutions/mitigation strategies for the identified challenges/problems in outsourced offshore testing?
3. How effective is outsourced offshore software testing based on literature and expert opinion?

To answers these research questions we had followed some research methods. First and second research questions are answered by performing the Systematic Literature Review. And the third research question is answered by data analysis done by SLR and Survey.

1.3 Study Area

1.3.1 Global Software Development

The drift of globalization of business has changed the traditional way of developing the software. The development of software has taken a new form of distributing the development task to team of people working at various sites across the globe rather being developed at collocated site [1]. In recent days global software development is a phenomenon of increasing importance in which the development of software was distributed across the geographically separated sites with different time zones and different organizational cultures. In the present days most of the companies are building or contracting globally distributed teams from India and China where there is an abundant availability of skilled manual resources with reduced cost compared to United States and Western Europe [2]. Organizations are increasingly moving to the model of global of software development to reap up the benefits like Cost savings, access to large skilled labor pool, reduced time to market, proximity to market and customer etc. [2] [3] [4] [5].

Nevertheless benefits come together with challenges, due to the aspects like Geographical, temporal and socio-cultural distances that affects communication, coordination and control [6]. Due to the challenges in globalization of software developed the efficiency of software developed is reduced. To overcome these scenarios additional effort is required. Some time software projects that are globalized may fail even though additional effort is applied. From the research article [7] the probability of fully distributed projects outcome is very low. In comparison to collocated software development, distributed projects throws plethora of challenges that inhibits the development of software at geographically distributed sites [8] [9].

1.3.2 Characteristics of Global Software Development Scenarios

Globalizing the software development had brought several changes in business strategies in the recent past. Main reason that motivates the transfer of software product development is reduction of development cost. Although there are other presumed benefits that were not clear and not guaranteed [10]. In the urge of achieving high returns on investments, organizations often failed to distinguish the settings present in global software engineering. Each setting or scenario comprised of its own challenges and advantages. Till now from the

review of literature it was found that there are some characteristics like each scenario that differ from one another, approach, location, organizational relationship and type of work. From the research article [11] different scenarios with its unique attributes are given below in the table1-1. Table given below provides a clear description about different settings that enables the global software development.

Scenario Characteristic	**Options**	**Examples**
Approach	Transfer	This approach aims at relocation of development activities from one site to another and it ends up with distributed development or single site execution at a different site.
	Distributed Development	Development activities that were distributed will be shared among the two or more sites.
	Single Site execution	Development is initiated and undertaken in different locations across the globe
Location	Onsite	Execution of work at a single site
	Domestic offsite	Sharing of work within the national boundaries
	Near shore	Sharing of work with nearby countries
	Offshore	Sharing of work with a far location
Organizational relationship	Insourcing	In this scenario collaboration is done within the organization. It is referred as an offshore in sourcing when development sites are located in different countries. Onshore insourcing is when the sites are located within the national borders.
	Outsourcing	It involves in subcontracting all the development activities to a third party vendors. Referred to as offshore outsourcing when the main contractor is located in one country and the third party vendor is in another country, Onshore outsourcing is the collaboration that takes place within the national frontiers.
Type of work	Entire project or product	New development, customization, or maintenance project.
	Selected functionality	Subsystem, module or

		component development
	Selected development phase	Coding, testing or other software life cycle phases.

Table1-1: Global Software development and its different scenarios

From the above diagram, global software development involves in many development scenarios in which, this thesis deals with outsourcing of selected development phase. Considering the conventional waterfall model there are development phases like gathering the requirements, designing of architecture of software, building (Coding), testing and integration of software modules. Among these phases outsourcing of software testing is become very famous in this advanced technological era of software development. Testing of heterogeneous business software systems is one of the most important tasks in the process of software quality improvement and reduction of operational costs. To guarantee competitiveness and reduced costs we benefit from relocating parts of the software testing process to offshore vendors. In this thesis authors have covered the perspectives of software testing from both onshore and offshore which are having Client and Vendor organization respectively. At initial stages authors of this have started only with onshore perspective, which has significance on onshore client organizations. Considering only this, it didn't align the research gap and did not stretch over the entire area of outsourced offshore software testing. So, authors found some other important research articles, that focused on offshore vendor organizations which performs software testing process onshore on client organization that are outsourced. Hence authors have included both onshore and offshore perspectives to make this thesis complete and consistent. When only specific articles on onshore or offshore were taken into consideration, it ended up with a very small set of articles. So, to overcome and make the research more effective authors choose to consider the articles on both onshore and offshore.

1.3.3 Definitions of Outsource Offshore

1. Offshore outsourcing means that the subcontractor or subsidiary that is in a foreign country, implying difference in language, culture, education and business background [S12].
2. Offshore outsourcing is a specific type of outsourcing where firm's contract for services with external firms located in remote destinations other than a country where the hiring firm is located.
3. Offshore information systems (IS) outsourcing is a contractual agreement involving transferring IS development and related services to overseas vendors.
4. It is an actual transfer of work from one site of a company to the third party vendor [11].

1.3.4 Outsourced Offshore Software Testing

In some companies, offshoring is already adopted as one of the primary approach, when the companies require handling huge projects. Companies are looking to outsource the projects as the time to market increases and also the competition within the information technology area increased, which always ensure that new offshoring projects are launched regularly. The process of outsourcing software testing to offshore software companies has grown prominently to avoid the inefficiencies and delays observed in multisite development. Organizations found an optimized solution of outsourcing the complete project to offshore [11]. Some of the development phases like coding, testing has started outsourcing to third party offshore vendor. Fixing the bugs in software is still a time consuming process and efficiency of using the available resources is to be increased. A software team tries to detect the defects in software before shipping it for commercial use; otherwise the cost of errors in software increase manifolds. In recent years, outsourcing the testing activities to the offshore vendors has become a frequently used approach for developing the software with high

quality [12]. Outsourced offshore testing in software is replacing the traditional methods in the field of software development [12]. Outsourced, offshore software testing industry is the second largest industry next to coding and still it is expected to grow [13]. Nevertheless outsourced offshored software testing industry is currently a large industry and it is growing to a annual rate of over 20% [14]. The presumed benefits for outsourcing the software testing activities to a third party offshore vendor is low development costs, access to high skilled resources, effective utilization of time zone effectiveness and an optimized quality [15]. According to another study [40], certain measures were given for software development process in which, 41% was given for testing and it also says that 41% of the project effort was spent in testing.

However it is known from the literature review that, along with the advantages in the outsourced projects challenges also prevails, that hinders the work at offshore location and it highly affects the productivity and quality of testing. A research survey in the year 2003 reported that 46% of the survey respondents had considered that the work done by the offshore team employees are of poor quality. In addition to that another research results had claimed that the executives were reluctant to outsource their work to offshore because of the quality issues associated with the work of offshore team employees. Offshore outsourcing is widely used in software-centric projects, especially in the development phases of software. Using the offshoring approach of blended resources, which involves in combining the onsite local staff and remote offshore staff in business centric projects still it, is rarely adapted and often not successful. Business centric projects such as business consulting, eliciting requirements, but also function testing, throws several challenges to offshore personnel like lack of business knowledge and knowledge of local laws and regulations, non-English communication, specific knowledge of legacy systems, and client specific knowledge of business processes. Hence, despite the increased popularity of OOST practice, there are concerns about the quality of work and ineffectiveness of this process. This research aims to explore the challenges and its coping strategies to overcome the identified challenges for the smooth flow of performing the software testing activities at the vendor site which is in offshore.

S.no	Role	Job Responsibility
CLIENT SIDE		
1	Managing Director	Supervises testing managers
2	Contract Development manager	Supervises and coordinates all the managed resources services
3	Principal	Evaluates business requirements against deliverables
4	Client Test Managing Director	Oversees testing managers
5	Client Manager	Supervises full time employees and vendors. Responsible for overall development management of major corporate projects across multiple workgroups.
6	Client Test Lead	Who leads the team at onshore, responsible for test plan, test scenarios, test cases, test data etc..,
VENDOR SIDE		
7	Vendor Delivery Manager	Project manager for the testing engagement of onshore testing resources and deliverables.

8	Vendor Team Leader	Who involves in coordinating offshore work activities like test planning and analysis, test design, test execution and status reporting.

Table: 1-2 Roles and responsibilities of client and vendor employees

The above table:1-2 is taken from [S18] and [S25] which contains information about roles and their responsibilities of employees who works at both onshore and offshore.

1.3.5 Software Testing and Its activities in OOST

According to [41] [53] there are two types of testing they are 1.Manual Testing and 2. Automated Testing. Whole process of testing is structured in three high-level phases they are Test-preparation phase, Execution phase and Client Management phase.

Test-preparation phase: When the project starts it starts with gathering of requirements based on which the whole project is developed. During this phase, functional requirements are gathered and assessment of the feasibility of completing the tasks in the stipulated amount of time, this is considered as one of the main activities. In this phase, negotiations are possible and can be performed by discussing task feasibility, requesting more knowledge transfer, reallocating the tasks, or requesting additional resources. The preparation phase of software testing overlaps with development phase [S2].

Execution phase: This phase begins as soon as the developer team deploys the software to the test engineers. After the release of stable software by the developers test team starts execution phase [S2][44].

Client management phase: This phase is referred to as warranty period, here the testers approve the product based on the satisfactory test results [S2][44].

In Manual Testing Test preparation phase is small compared to the Test preparation phase in Automated Testing. But the execution phase is considerably longer. However, for automated test engineers the preparation phase is longer since it demands considerable effort to create the automated test scripts from the manual tests stated in natural language, but the execution phase is relatively shorter [S2][44].

1.3.6 Test Quadrants

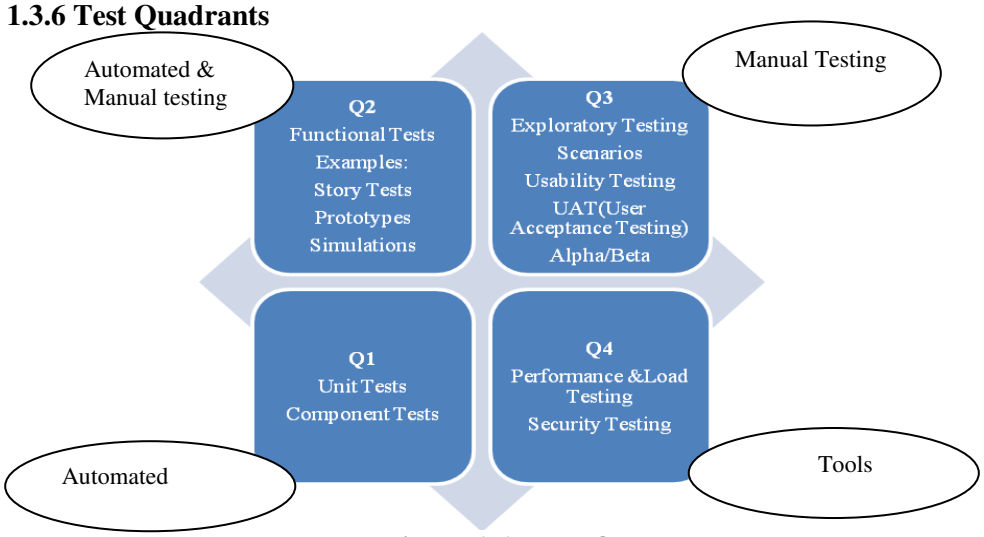

Figure 1-1: Test Quadrants

According to [44] application of different tests have different purposes, hence a diagram of different testing quadrants of Agile software testing is presented in Figure 1. This figure describes how each quadrant reflects different tests to test.

Q1: This test in support of programming. This will be done for Technical requirements testing (Does this method do what the developer intended?)[44]

Q2: This also tests in support of programming. This will be done for Business requirements tests. (Does the code do what it should?) [44]
Q3: This is called Business defect testing. This is to check whether there are any missing requirements. (Does the code do something it shouldn't?)[44]
Q4: This is called Technical defect testing; this is to criticize the product in terms of technological aspects. (Are there any leaks in your software? Can it handle a load? Is your software fast enough?) [44]

1.4 Thesis Outline

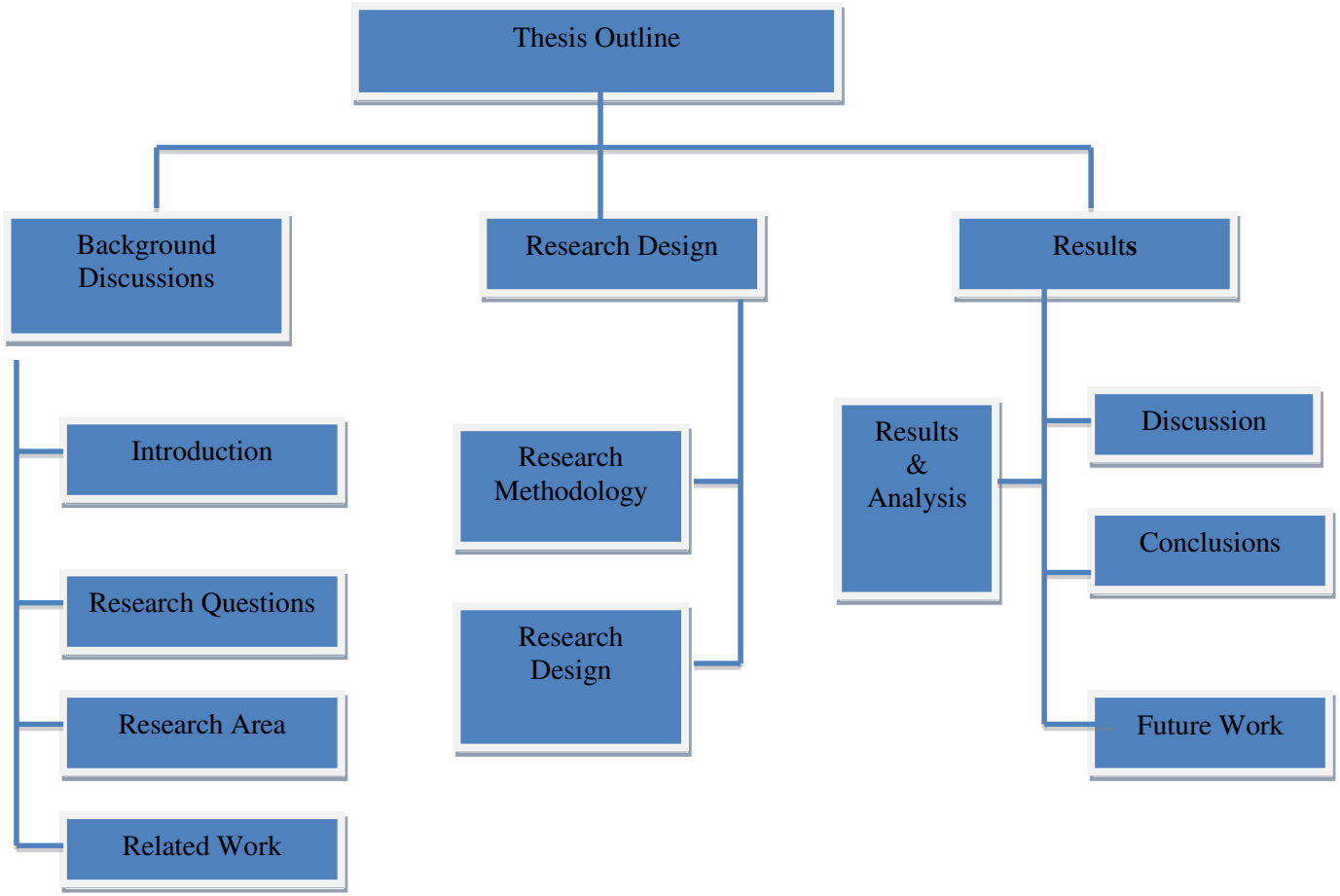

Figure1-2 : Diagrammatic representation of Thesis outline

Structure of the thesis mainly focuses on followings parts namely Introduction, Application of Research Methodology, Results and Analysis and Discussions. First part of thesis covers Introduction part mainly covers chapter-1 i.e., the introduction of thesis, the aims and objectives of the thesis, detailed discussion of study area. In second part of the thesis chapter-2, mainly focused on Research Methodology used i.e., Systematic Literature Review (SLR) which covers how the SLR is conducted and application of qualitative analysis for the results obtained in SLR. Third part consists of Surveys and Analysis of its results. Final part includes discussion and analysis, future work and conclusion.

1.5 Glossary

Acronym	Description
OOST	Outsourced Offshore Software Testing
GSD	Global Software Development
GSE	Global Software Engineering
SLR	Systematic Literature Review
GT	Grounded Theory
IS	Information System
CM's	Client Managers
S.no	Serial Number
ICGSE	Internet conference on Global Software Engineering
QA	Quality Assurance
CMM	Capability Maturity Model
VnV	Verification and Validation
UAT	User Acceptance Test
US	United States(formally called as United states of America)
KT	Knowledge Transfer

Table 1-3: Glossary

Chapter 2
SLR

2. Systematic Literature Review

A systematic literature review is a means of evaluating and interpreting all available research that is relevant to a particular research question, topic area, or phenomenon of interest [18]. Systematic literature review is the process of identifying, evaluating and interpreting all available research that is relevant to answer the research question [18]. There could be several numbers of reasons for performing systematic literature review depending on the research and research questions. Following are some of the reasons that motivate the researcher to perform systematic literature review.

1. To sum up all the existing evidence concerning a treatment or technology.
2. To identify the existing gaps in relevant research filed for conducting further investigation.
3. To come up with a new framework or background in order to appropriately position new research activities.

Systematic review involves three discrete activities. They are planning, conducting and reporting the review.

1. Planning the review
2. Conducting the review
3. Reporting the review

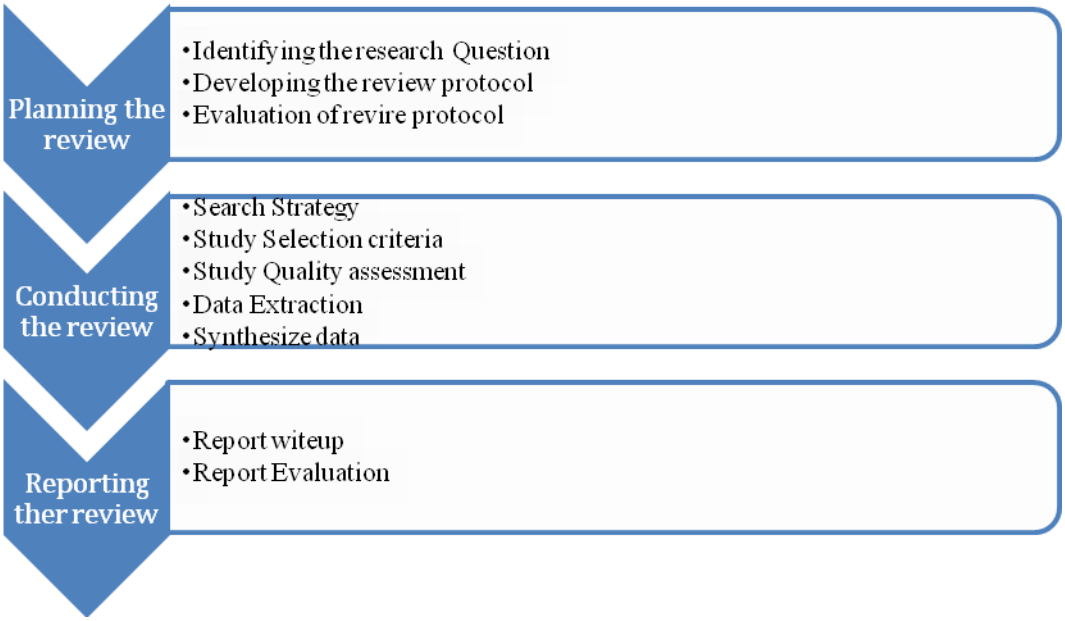

Figure 2-1: Diagrammatic representation of Systematic literature review process

The Diagrammatic representation of Systematic literature and the concerned steps that are followed are presented in the above Figure 2-1 and description about the Figure 2-1 is given below.

1. Identification of the need for conducting systematic literature review: what are the main motivations that are required to conduct systematic literature review.

2. Specifying the Research questions: This is the most esteemed part of systematic literature review. Defining these research questions gives the complete systematic review methodology.

A) Identification of primary studies for addressing the research questions is must by the search process.

B) Extraction of data items is done by the data extraction process which answers the research questions.

C) Data analysis method synthesizes the data in such a way that the questions are answered.

3. Search Strategy for primary studies: It includes designing the search terms, framing the search query, quest of primary studies by electronic search and manual search, snowball sampling, scanning authors personal web-pages.

4. Study Selection criteria: It aids in assessing the quality of primary studies obtained.

5. Data Extraction: It involves in extraction of data from the primary studies obtained according to the predefined data extraction form designed.
6. Synthesization of extracted data: It helps to perform meta-analysis of data. It also helps the researches to determine an appropriate data synthesizing technique that fits the data.

2.1.1 Specifying the Research Questions

Research questions drives the complete thesis, complete research is motivated and very often highlighted in the form of specific research questions [16]. We have formulated three research questions to address our concerns in the research. The first two research questions are answered by doing systematic literature review. The third research question is answered by data analysis of SLR and survey.
We have formulated the following research questions they are as follows:
1. What are the challenges/ problems encountered in outsourced offshore testing?
2. What are the solutions/mitigation strategies for the identified challenges/problems in outsourced offshore testing?
3. How effective is outsourced offshore software testing based on literature and expert opinion?

Research Question	Description	Research Methodology
What are the challenges/ problems encountered in outsourced offshore testing?	This research question emphasizes on what are the challenges that hampers the software testing activities that were outsourced to offshore location.	Systematic literature review
What are the solutions/mitigation strategies for the identified challenges/problems in outsourced offshore testing? How effective is software testing in offshore context?	This research question investigates the mitigation strategies that were proposed for the identified challenges during systematic literature review. Conducting survey base on questionnaire further validates them.	Systematic literature review
How effective is outsourced offshore software testing based on literature and expert opinion?	This research question focuses on how effectively the outsourcing activities are being carried out at offshore vendor location and onshore client location.	Systematic literature review& Survey based on questionnaire

Table 2-1: Research Questions and its methodology

2.2 Conducting the Systematic review

2.2.1 Defining the Keywords for the research questions

During the earlier stages we have tried so many search strings we further underwent modifying the search string which yields the better results which are capable of providing the required results. We have tried some search strings, we later realized that still two important primary studies were found missing.
As the search strategy commenced we piloted the search string thrice. We have included some keywords and acronyms like GSD, GSE to search string but the search became broader, we were unable to find the right articles which are relevant to our scope. We have changed the search string for three iterations and finally we have ended up with the following search string by taking the librarians help.
We have followed the approached used by Mian et al [17] for elucidating specific aspects of the research questions. Along with Mian et al, we have implemented PICOC strategy for

breaking down the research question into individual components which mainly contains keywords for deriving search string which fits into every data bases for the quest of articles which falls under the relevant research gap.

2.3 Breaking down the Research Question into PICOC criteria

In order to make the search for articles in systematic review more comprehensive, we use the criteria of PICOC to manage the search string effectively in obtaining relevant articles.

2.3.1 Applying PICOC criteria

A PICOC criterion provides ease in managing the complex search string when it is used in different databases in pursuit of relevant articles. Here PICOC stands for Population, Intervention, Comparison, Outcome and context. Population in this study characterizes the domain in which the software project belongs.

Population	Software, Software projects
Intervention	Outsource, Offshore, Testing
Outcomes	Challenges, Mitigations

Table 2-2: Applying PICOC criteria

Keyword	Acronym/Synonym
Software	Application Product Project
Outsource	Outsourcing Outsource
Offshore	Offshore
Challenges	Threat, hurdle, difficulty, mitigation and solution
Testing	Software Testing

Table 2-3: Deriving of keywords for search string

Above table illustrates the major terms and their synonyms derived. The search string was established by combining the keyword list from the previous section through the logical connectors “AND” and “OR”. Hence leading to the following search string:

((Application OR Product OR Project OR Software) AND (testing) AND (outsource OR offshore OR global) AND (challenge OR threat OR hurdle OR difficulty OR mitigation OR solution))

We have employed the search string in different electronic databases in the quest of retrieving the primary studies. The quest for primary studies was kicked off in the Inspec and compendex databases since most of the research articles were indexed in these two databases and also these databases has top priority in systematic literature reviews.

Following table contains various electronic databases used for retrieving the primary studies.

Database	Type
IEEE Explorer	Digital
Engineering Village	Digital
Science Direct	Digital
ISI Web of Science	Digital
Scopus	Digital

Table 2-4: Databases used for retrieving Primary studies

Depending upon the database in which the search string is employed we have done slight modifications to fit the search string into the appropriate database. As the syntax of search string varies from one database to another and combination of cluster of keywords were modified in order to obtain a feasible number of articles. Total of 58,016 articles are obtained from all databases. When we employed the search string in Scopus database, we have got articles in large number of 48,014 inspecting all the articles became cumbersome but in the aim of finding any new articles which fits for the research gap has continued. We have underwent inspecting the title and abstract of articles nearly upto 3000 we did not found any article which at least focusing on the global software engineering or outsourcing of software projects. Later we have limited our search to subject area computer science to minimize and narrow the search. Even though we have searched in the subject area of computer science we did not found any paper which is having the research on outsourcing of software development activities to offshore. Since we have invested much time and effort in finding the articles in this database we did not discarded as we have performed thorough search to obtain the articles.

Venue for search	Search String	# articles obtained	Search fields
IEEE explorer	((Application OR Product OR Project OR Software) AND (testing) AND (outsource OR offshore OR global) AND (challenge OR threat OR hurdle OR difficulty OR mitigation OR solution))	1840	Metadata
Inspec&Compendex	((Application OR Product OR Project OR Software) AND (testing) AND (outsource OR offshore OR global) AND (challenge OR threat OR hurdle OR difficulty OR mitigation OR solution))	1705	Metadata
Scopus	((Application OR Product OR Project OR Software) AND (testing) AND (outsource OR offshore OR global) AND (challenge OR threat OR hurdle OR difficulty OR mitigation OR solution))	48,014	Metadata
ISI web of science	((Application OR Product OR Project OR Software) AND (testing) AND (outsource OR offshore OR global) AND (challenge OR threat OR hurdle OR difficulty OR mitigation OR solution))	2506	Metadata
Science Direct	((Application OR Product OR Project OR Software) AND (testing) AND (outsource OR offshore OR global) AND (challenge OR threat OR hurdle OR difficulty OR mitigation OR solution))	3951	Metadata

Table 2-5: Count of studies during automated search

2.4 Quest for Primary Studies

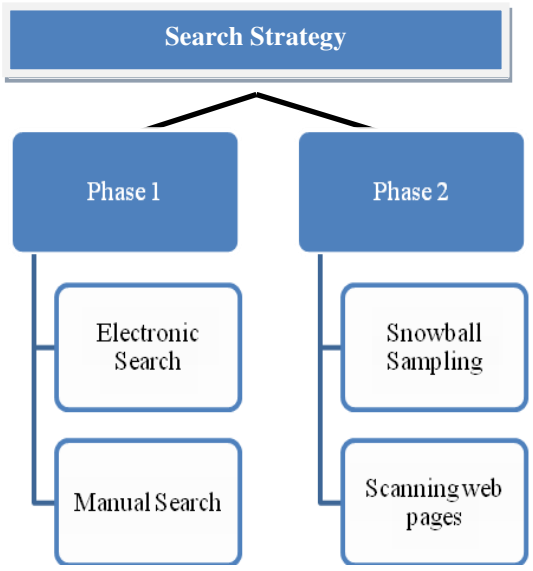

Figure 2-2: Two phase search strategy

We followed the tollgate approach for the selection of primary studies by implementing two-phase search strategy. It was clearly shown in the diagram above. In the first phase we performed a search in electronic databases and we manually searched for the conference proceedings and journals. In the prior stages of searching for the articles in digital libraries we thought that this wouldn't be sufficient for answering all the research questions. So we targeted for other sources of evidence that must also be searched (sometimes it should be manually) which includes Journals, conference proceedings and research registers etc. We have searched for articles in journals and conference proceeding to include as many papers which are relevant to our research questions. We have drawn a table which contains all the conference proceedings and journals in which we have performed our manual search. Second phase involves in scanning the reference list of articles, scanning the personal websites of authors and contacting the authors through emails for the articles which are not covered during the search in phase1.

S.no	Search Venue
1	International Conference on global software engineering
2	International Conference on global software engineering workshop
3	IEEE transactions on software engineering
4	Communications of the ACM
5	Empirical Software Engineering
6	IEEE Software
7	IEEE Computer
8	Information and Software Technology
9	Journal of Systems and Software

Table 2-6: Manual Search venues

2.5 Study Selection procedure

Study selection procedure will be performed based on Title and Abstract review, application of detailed exclusion criteria and finally reviewing the conclusion and full text of the article. Following constraints were chosen for the application of detailed exclusion criteria. Following tables gives a clear view of how the detailed inclusion and exclusion

criteria were accomplished. As a final refinement we have concluded primary studies after the thorough examination of conclusion and full text of an article.

#	Detailed Inclusion criteria
1	*Articles which are available in the full text format*
2	*Articles with language as English*
3	*Articles which belongs to software engineering*
4	*Articles which falls under the area of global software engineering or global software development*
5	*Articles which accentuates on outsourced offshore software testing*
6	*Articles which emphasizes on testing phase which is outsourced to offshore location/vendor*
7	*Articles which discusses challenges and mitigations in OOST*

Table 2-7: Inclusion Criteria

#	Detailed exclusion criteria
1	*Articles which are not available in English and full text*
2	*Articles were excluded which were published before 1999*
3	*Articles which discusses OR focuses on software development phases like requirements, analysis, design and coding.*

Table 2-8: Exclusion Criteria

Data Base	#Articles retrieved
Inspec and Compendex	1705
IEEE	1840
ISI WoS	2506
Scopus	48,014
Science Direct	3951

Table 2-9: Final set of studies in automated search

2.6 Results obtained after performing both Manual and Automated Search

We have first started with the automated search; in automated search we employed our search strategy in the databases like Inspec and Compendex, IEEE, ISI WoS, Scopus and Science Direct. After applying the search string in different bases, we have obtained different number of articles. Total number of articles obtained can be known from the table 2-9 , We have different levels of filtering for taking articles which addresses challenges and mitigations of OOST. There are three levels of filtering during the automated search they are scanning the documents based on Title & Abstract, implementing detailed exclusion criteria(refer table for detailed exclusion criteria) and finally scanning of articles based on Conclusions and full text of articles.

Databases	Number of articles found	Duplicates Removed	Title & Abstract	Detailed exclusion criteria	Conclusion& full text
IEEE	1840	456	141	13	2

Engineering Village	1705	563	210	19	2
ISI WoS	2506	816	313	3	1
Science Direct	3951	1126	326	11	3
Scopus	6113	225	113	39	4
Total	10002	2961	990	46	12

Table 2-10 : Final set of Primary Studies obtained during Electronic Search

After performing the Automated search, we searched for the articles manually by inspecting conferences, journals and workshops. We have contacted our thesis supervisor and Darja smite, associate professor who deals with GSE subject in BTH to know the popular avenues in which GSE articles are published. We considered five conferences, four journals and one workshop to search for articles. We got total number of ten articles during manual search, count of articles were presented in table 2-11. We applied thorough process of filtration of articles in manual search also, like automated search we applied three levels of filtering of articles they are scanning of articles based on Title & Abstract, executing detailed exclusion criteria and removal of articles by reading of conclusion and full text of articles.

Search Venue	Number of articles found	Title & Abstract	Detailed exclusion criteria	Conclusion	full text
IEEE Transaction's on Software Engineering	1166	99	26	2	0
Communication of the ACM	786	74	11	0	0
Empirical Software Engineering	3399	168	33	24	1
IEEE Software	1169	256	76	0	0
IEEE Computer	1069	311	59	9	0
Information and Software technology	698	196	51	16	0
Journals of System & Software	2665	263	176	32	0
IEEE transactions on Engineering Management	345	117	42	31	1
International Conference on Global Software Engineering(ICGSE)	631	459	231	49	6
International Conference on Global Software Engineering Workshop(ICGSEW)	125	66	46	29	1
Total	**12053**	**2009**	**751**	**192**	**9**

Table 2-11: Final Set of primary studies obtained during Manual Search

After the above discussed phases, Later our search continued to snowball sampling, scanning references, scanning author's personal webpage's and contacting authors. We have presented four tables to show the count of articles obtained at different phases of search strategy.

1. Table 2-12, shows the count of articles obtained in Electronic search, it contains details about the title of article, database in which that particle is obtained and article Id.
2. Table 2-13, shows the count of articles obtained in Manual search, it contains details about the title of article, search venue in which that particle is obtained and article Id.
3. Table 2-14, shows the count of articles obtained in Snowball sampling, it contains details about the title of article and Article ID.

Table 2-15, shows the count of articles obtained in scanning authors Webpage's, it contains details about the title of article and Article ID.

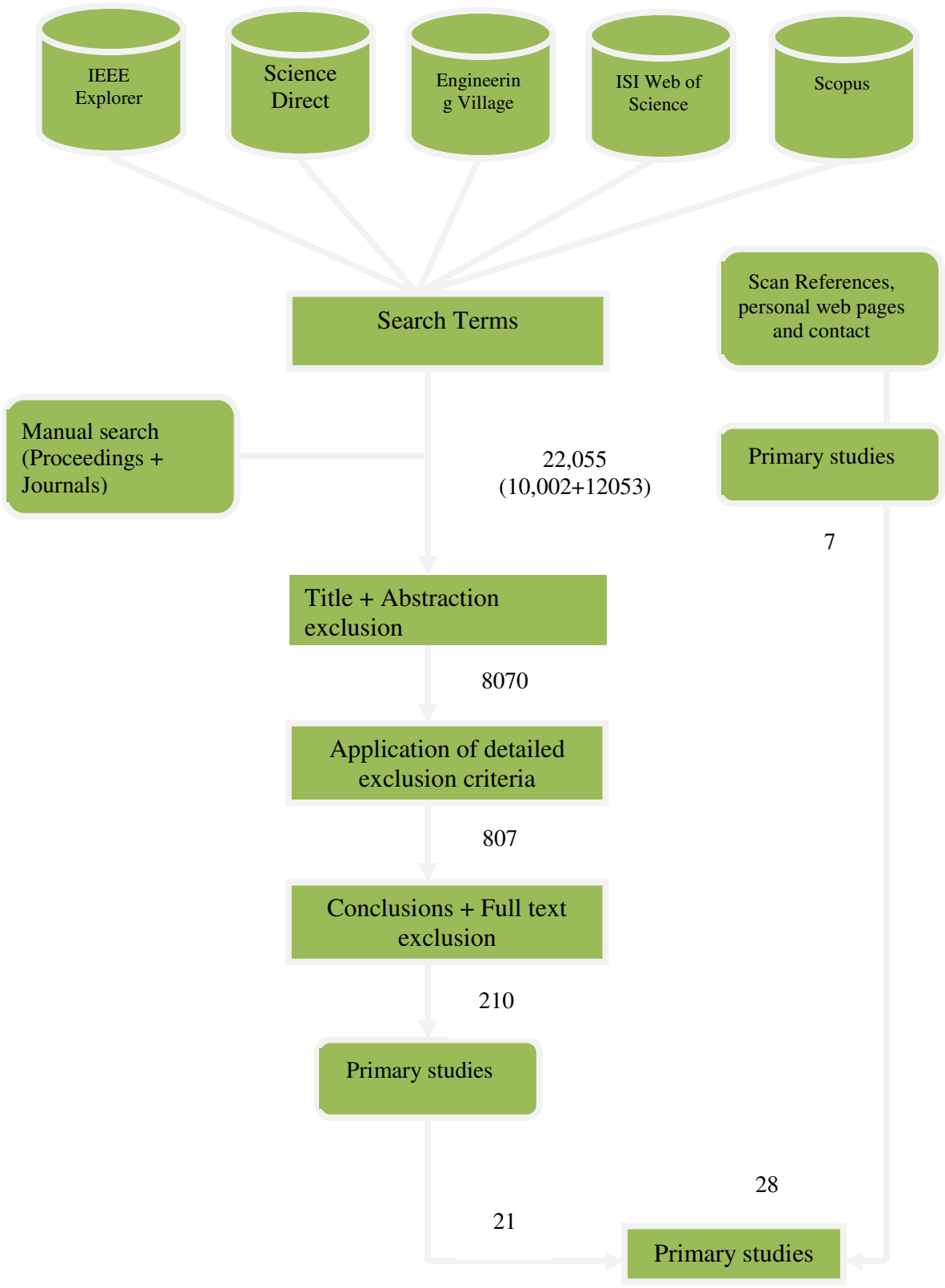

Figure 2-3: Tollgate Approach

Above figure gives diagrammatic representation of whole toll gate approach followed in systematic literature review. Total count of articles and the process followed in every phase were presented at different sections in systematic literature review.

2.6.1 Electronic Search

S.no	Title	Database	Id
1	Knowledge transfer in global software development: leveraging acceptance test case specifications	IEEE	S1
2	Outsourced offshore software testing: vendor side experiences	IEEE	S2
3	Efficient maintenance support in offshore software development: a case study on a global e-commerce project	Inspec & Compendex	S3
4	Leveraging global talent for effective test agility	Inspec & Compendex	S4
5	Determinants of software quality in offshore development-an empirical study of an Indian vendor	Science Direct	S5
6	Test strategies in distributed software development environments	Science Direct	S6
7	Exploring defect causes in products developed by virtual teams.	Science Direct	S7
8	Off shoring test automation observations and lessons learned	ISI WoS	S8
9	Culture and testing: What is the relationship?	Scopus	S9
10	Outsourcing software testing- A case study in Oulu Area	Scopus	S10
11	Information Bridging in a global organization	Scopus	S11
12	Enabling offshore software Testing: A Case study	Scopus	S28

Table 2-12: Final set of primary studies from electronic search

2.6.2 Manual Search

S.no	Year	Title	Conference	Id
1	2011	Outsourced offshore software-testing: vendor-side experiences	ICGSE/duplicate	
2	2011	Studying the influence of culture on Outsourced offshore software testing	ICGSE	S12
3	2009	Offshoring test automation observations and lessons learned	ICGSE/duplicate	
4	2009	Experience with a remotely located performance test team in quasi-agile global environment	ICGSE	S13
5	2007	Building effective global software test teams through training	ICGSE	S14
6	2006	Test community of practice in brazil	ICGSE	S15
7	2006	Collaborative international usability	ICGSE	S16

		testing: moving from document based reporting to information object sharing		
8	2006	A test specification method for interoperability tests in offshore scenarios: A case study	ICGSE	S17
9	2011	An Empirical investigation of client managers responsibilities in managing outsourced offshore software testing	IEEE transactions on Engineering management	S18
10	2009	An empirical approach for the assessment of scheduling risk in a large globally distributed industrial software project	Empirical software engineering	S19
12	2011	Integrating early VnV support to a GSE tool integration platform	ICGSEW	S20

Table 2-13: Final set of primary studies from Manual Search

2.6.3 Snowball Sampling

S.no	Title	Id
1	Test driven global software development	S21
2	Patterns for testing in global software development	S22
3	V.Casey. software testing and global industry: Future paradigms. Cambridge scholar paradigms. Cambridge scholars publishing, 2009	S23
4	B. Copstein and F.M. de Oliveira. Management of a Distributed Testing Process using Workflow technologies: A Case Study. In Seventh Workshop on Empirical Studies of Software Maintenance, pages 62–64, 2001.	S24
5	Global software test automation	S26
6	Case study: Testing for the utilities sector	S27

Table 2-14: Final set of primary studies from snowball sampling

2.6.4 Scanning Authors Web Pages

S.no	Title	Id
1	*Client communication practices in managing relationships with offshore vendors of software testing services.*	S25

Table 2-15: Final set of primary studies from Authors web pages

Following pie-diagram depicts the counts of articles obtained during different types of search.

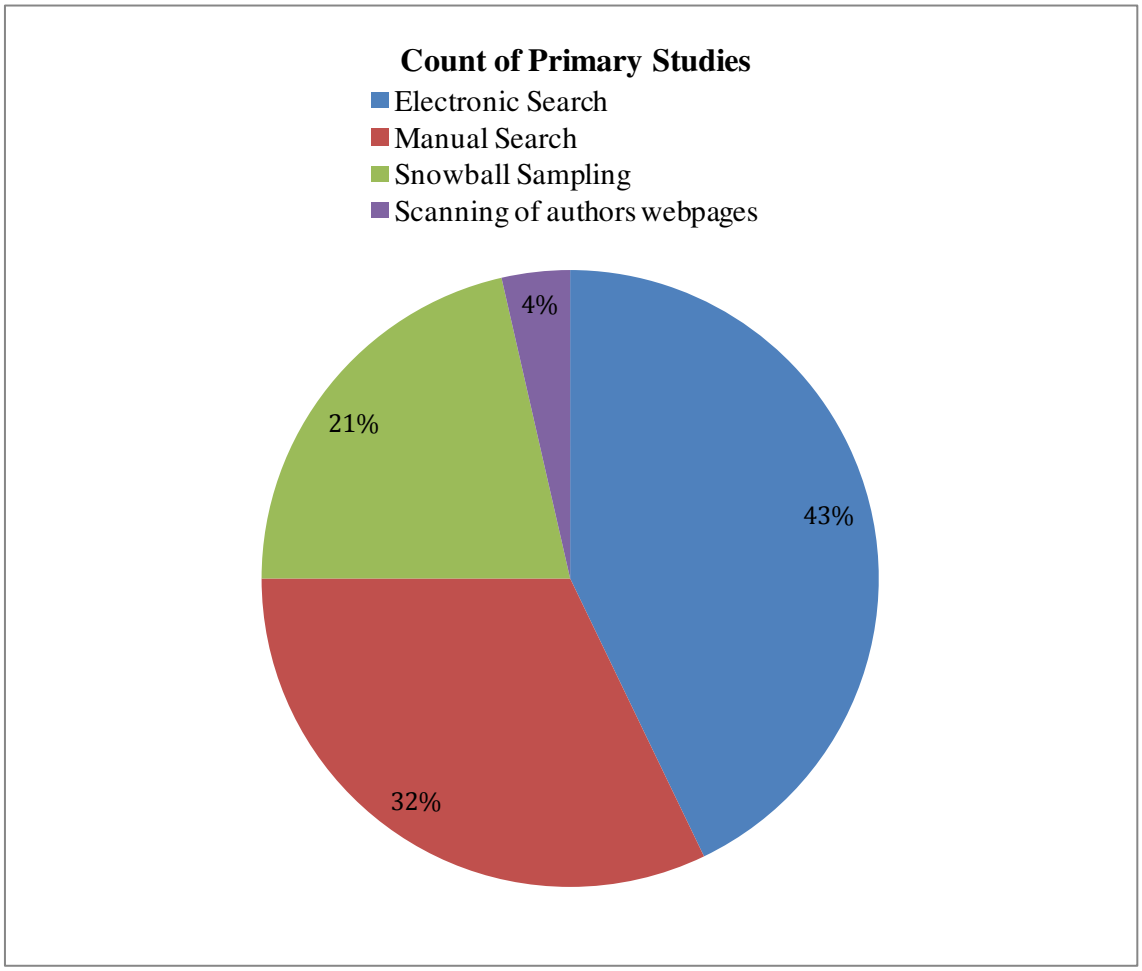

Figure 2-4: Statistical representation of primary studies

2.7 Study Quality Assessment Checklists and Procedures

Quality of the obtained primary studies were assessed based on the following questions and it was rated against the scale Yes, No and partially. Questions are furnished below.

Q1. Are the aims of the study clearly explained?
Q2. Are the findings of the research clearly described?
Q3. Is the research methodology appropriate to answer the aims of the study?
Q4. Are the challenges identified clearly explained?
Q5 Are the solutions/mitigations proposed fit for identified challenges and OOST scenario

Sid	*Are the aims of the study clearly explained?*	*Are the findings of the research clearly described?*	*Is the research methodology appropriate to answer the aims of the study?*	*Are the challenges identified clearly explained?*	*Are the solutions/ mitigations proposed fit for identified challenges and OOST scenario*
S1	*Yes*	*Yes*	*Yes*	*No*	*No*
S2	*yes*	*yes*	*yes*	*yes*	*Yes*
S3	*no*	*yes*	*yes*	*yes*	*Yes*

S4	*yes*	*yes*	*yes*	*yes*	*No*
S5	*Yes*	*Yes*	*Yes*	*No*	*No*
S6	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
S7	*yes*	*yes*	*yes*	*no*	*Yes*
S8	*Yes*	*yes*	*yes*	*yes*	*yes*
S9	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
S10	*yes*	*yes*	*yes*	*yes*	*yes*
S11	*No*	*Yes*	*No*	*Yes*	*No*
S12	*Yes*	*No*	*No*	*No*	*No*
S13	*yes*	*no*	*yes*	*yes*	*yes*
S14	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
S15	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
S16	*yes*	*yes*	*yes*	*yes*	*yes*
S17	*yes*	*yes*	*yes*	*yes*	*Yes*
S18	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
S19	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
S20	*yes*	*yes*	*yes*	*yes*	*Yes*
S21	*yes*	*yes*	*yes*	*yes*	*Yes*
S22	*yes*	*yes*	*yes*	*no*	*yes*
S23	*yes*	*yes*	*yes*	*no*	*yes*
S24	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
S25	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
S26	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
S27	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
S28	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*

Table 2-16: Quality Assessment of primary studies

2.8 Data Extraction Strategy

Data extraction form was designed in order to find an appropriate data which is essential to drive the complete research and to answer the research questions which involves in finding the challenges in Outsourced Offshore Software Testing. Data extraction form was designed based upon the research question that was framed in this thesis. Data extraction form comprises of Data item and its values which were given below in the table.

Data Item	**Value**
Article ID	
Article Name	
Literature Type	
Authors	
Article Type	1. Journal 2.Conference 3.Book Chapter 4. Workshop Book
Publication Date	

Source of Publication	
Source Database	
Study aims	
Methodology of study	
Challenges discussed	
Mitigations proposed	
Lessons learned/Recommendations	

Table 2-17: Checklist of items of data extraction strategy

2.9 Data Analysis

2.9.1 Quantitative Observations of Systematic Literature review

After the successful collection of data from systematic literature review conducted a data must be analyzed quantitatively [1]. A quantitative data analysis doesn't focus much on interviews, observations and focus groups where as its prime objective is to gathering and close examination of statistical and numerical information. This research mainly depends on case studies and interviews.

2.9.2 Characteristics of primary studies

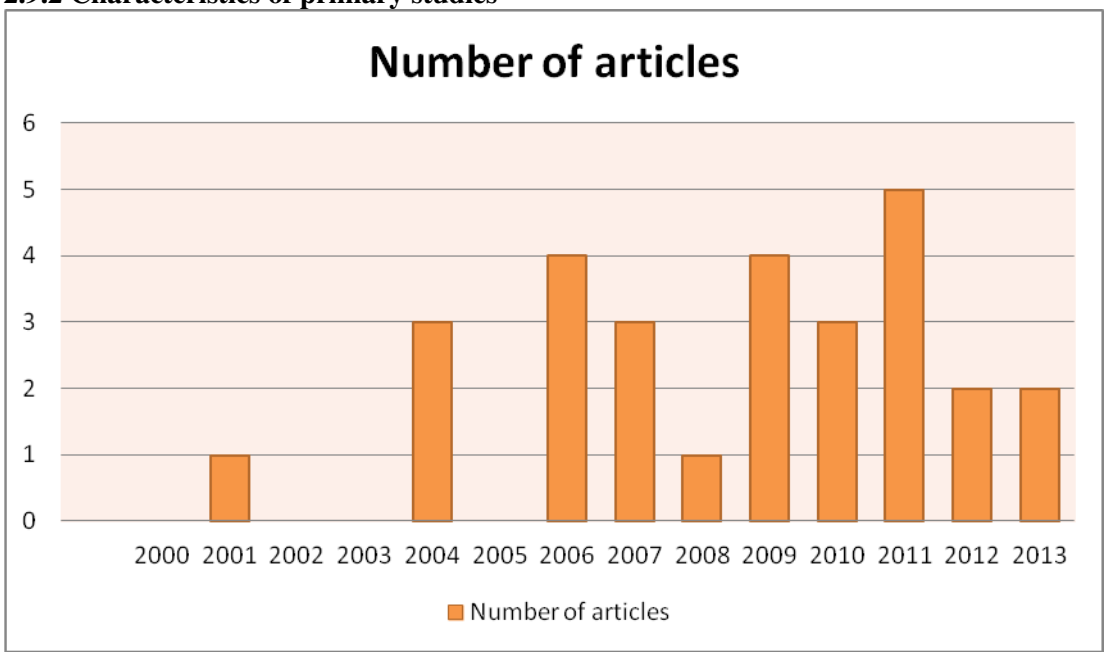

Figure 2-5 : Count of articles related to OOST published during 2000-13

We have got the articles from the year 200 since in order to accept the wide collection of data which maximizes our research. There is no proper research done at the earlier stages, even there are no articles published in the year 2000, 2002, 2003 and 2005. There is a continuity in pace in the expansion of research in the relevant field. From the year 2006 availability of articles' increased gradually, main articles of this thesis are obtained from the years 2009, 2010 and 2011. Only in the year 2011 total number of articles obtained was 5 which is a huge count compared to the others. Nearly 12 articles are obtained between 2009 and 2011. We felt that articles which are published during the years 2009-11 having more number of challenges and mitigations which helped us to carry our thesis with more qualitative data and also 2010 and 2011 which is very critical for our thesis which had given a clear view about how the outsourced offshore software testing is being carried out between client and vendor organizations. Our search string was finalized in the month of September 2012, so we have restricted our search between the years 2000 and 2012, there are two articles which were discovered during our search in 2012 but they have got published in the

year 2013, we have included those two articles as a result of our search performed in the year 2012. We got total of 2 articles in 2012 and 2013. It had seemed that research was continuous and there will be a wide range of scope to perform our research. Even though article count which refers to the vendor side and client side doesn't have the same amount of research, it had provided us to look depth into the challenges that are being existed at both client and vendor side. So in our thesis we have explored the challenges and mitigation as generalized one rather as specific for both client and vendor side. Even there is a chance to increase the in-depth knowledge in this research area in forth coming years.

2.9.3 Research Methodology

As we have further went deep into the research we came to a conclusion that all the studies that were obtained during systematic literature review are exploratory in nature. Research methodologies like Case study, Surveys, interviews, experiments and industrial experience reports are widely used in the aim of providing empirical evidences.

- **Case study**

  In this study approach assignments, activities or projects are supervised which are done in real time environment. Here, in this study approach when it undergoes these activities collection of data process is done continuously for some specific reasons. Then it undergoes some statistical analyses. This is an observational study approach which has least control when compared to experiments.

- **Surveys**

  This study approach is a retrospect of analyzing and gathering the relevant data by conducting interviews or by providing questionnaires. Here, a piece of population is gathered which represents the entire population and then the results are analyzed which gives explanatory and descriptive reasons or clarifications.

- **Experiments**

  This study approach is formal, rigorous and controlled kind of investigation. These experiments are performed in laboratory kind of environment which has high level of control. Here, objects are provided with different type of treatments. The variables obtained are observed and then statistical analysis is done which gives conclusion to the study.

- **Industrial Experience Reports**

This Industrial experience reports mainly rely on the industrial or regional experiences.

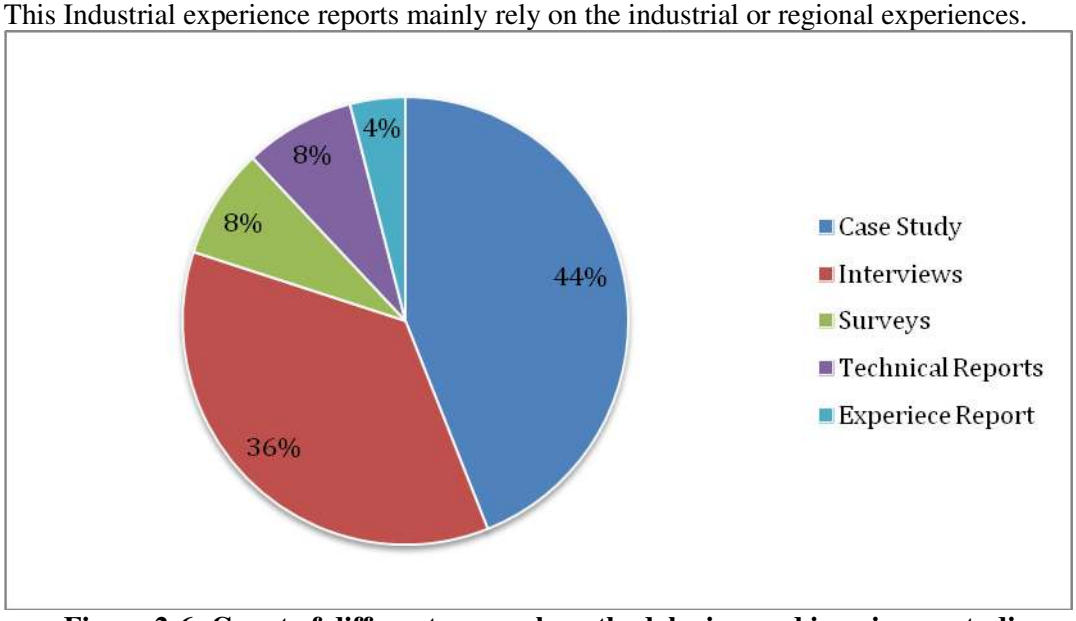

Figure 2-6: Count of different research methodologies used in primary studies

In our thesis, after observing the research methodologies that were used by authors, case studies were conducted with a highest percentage of 44, in the next place interviews are conducted with 36% and surveys, technical reports and experience reports have got very little proportions of 8%, 8% and 4% respectively.

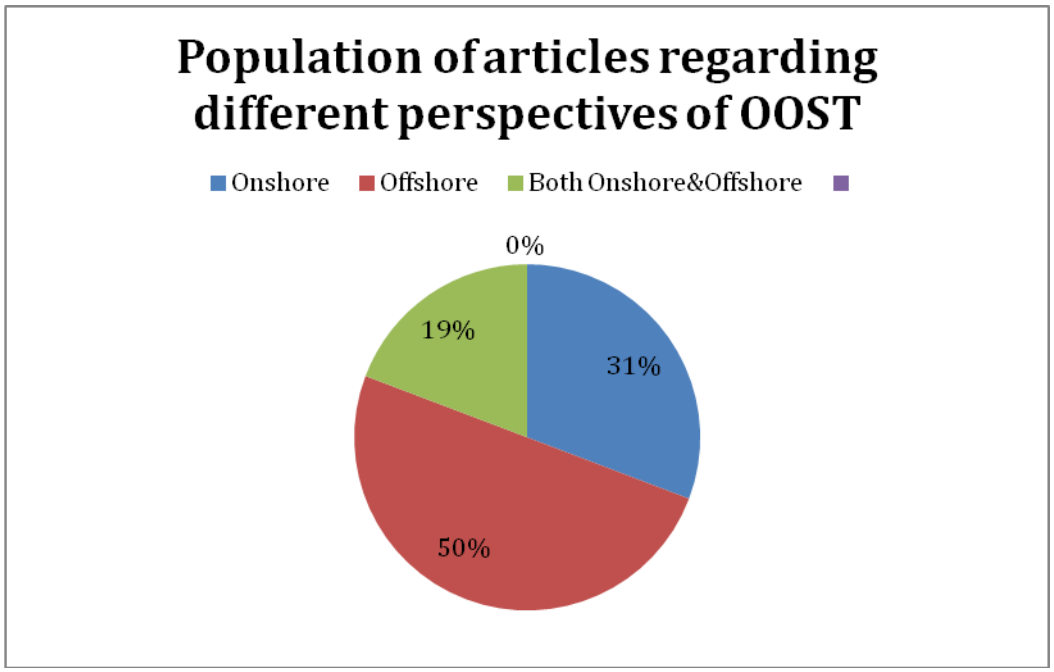

Figure 2-7: Count of articles related to onshore, offshore and both Onshore Offshore specific.

After performing the systematic literature, selection of type of articles were made basing upon Onshore, offshore and both offshore and onshore together. We found 28 articles which were relevant to conduct our master thesis, out of which 8 are specific to onshore, 13 are specific to offshore and rest of the 7 discusses about the software testing activities that were conducted at both onshore and offshore location. We have selected the papers in which challenges and mitigations are described and discussed specific to onshore, offshore and both onshore and offshore. Onshore is the client organization which has outsourced to offshore where Vendor organization resides. To get the clear view of article and its highlighting perspective of OOST, we have provided table which contains article title with its targeted area.

S.no	Article Title	Research Methodology	Year of Publication	Search Venue	Targeted area
S1	Knowledge transfer in global software development: leveraging acceptance test case specifications	Case study	2010	IEEE	Onshore & Offshore
S2	Outsourced offshore software testing: vendor	Interviews	2011	IEEE	Offshore

	side experiences				
S3	Efficient maintenance support in offshore software development: a case study on a global e-commerce project	Case study	2004	Inspec &Compendex	Offshore
S4	Levaraging global talent for effective test agility	Industrial Experience Report	2012	Inspec &Compendex	Onshore
S5	Determinants of software quality in offshore development - an empirical study of an Indian vendor	Case study	2011	Science Direct	Offshore
S6	Test strategies in distributed software development environments	Case study	2012	Science Direct	Offshore
S7	Exploring defect causes in products developed by virtual teams.	Case study	2004	Science Direct	Offshore
S8	Off shoring test automation observations and lessons learned	Interviews	2009	ISI WoS	Onshore & Offshore
S9	Culture and testing: What is the relationship?	Interviews	2013	Scopus	Onshore
S10	Outsourcing	Interviews	2013	Scopu	Offshore

	software testing- A case study in Oulu Area			s	
S11	Information Bridging in a global organization	Interviews	2007	Scopus	Onshore & Offshore
S12	Studying the influence of culture on Outsourced offshore software testing	Interviews	2011	ICGSE	Onshore & Offshore
S13	Experience with training a remotely located performance test team in quasi-agile global environment	Interviews	2009	ICGSE	Offshore
S14	Building effective global software test teams through training	Industrial Experience report	2007	ICGSE	Offshore
S15	Test community of practice in brazil	Surveys	2006	ICGSE	Offshore
S16	Collaborative international usability testing : moving from document based reporting to information object sharing	Technical report	2006	ICGSE	Offshore
S17	A test specification method for interoperability tests in	Case study	2006	ICGSE	Offshore

	offshore scenarios: A case study				
S18	An Empirical investigation of client managers responsibilities in managing outsourced offshore software testing	Case study	2011	IEEE transactions on Engineering management	Onshore
S19	An empirical approach for the assessment of scheduling risk in a large globally distributed industrial software project.	Interviews	2009	Empirical software engineering	Onshore&Offshore
S20	Integrating early VnV support to a GSE tool integration platform	Experiment	2011	ICGSEW	Onshore
S21	Test Driven global software development	Technical report	2004	IEEE (Snowball Sampling)	Onshore
S22	Patterns for testing in global software development	Case study	2010	IEEE (Snowball Sampling)	Onshore
S23	V.Casey. software testing and global industry :Future paradigms. Cambridge scholar paradigms.	Interviews & Surveys	2009	IEEE (Snowball Sampling)	Onshore Offshore

	Cambridge scholars publishing, 2009				
S24	B. Copstein and F.M. de Oliveira. Management of a Distributed Testing Process using Workflow technologies: A Case Study. In Seventh Workshop on Empirical Studies of Software Maintenance, pages 62–64, 2001.	Case study	2001	IEEE	Onshore
S25	Client communication practices in managing relationships with offshore vendors of software testing services	Case study	2010	IEEE (scanning authors web page)	Onshore
S26	Global software test automation	Case study	2006	Snowball sampling	Offshore
S27	Case study: Testing for the utilities sector	Case study	2008	Snowball sampling	Offshore
S28	Enabling offshore software Testing:A Case study	Case study	2007	Scopus	Offshore-Onshore

Table 2-18: Details of primary studies

2.10 Qualitative Results

2.10.1 Critical factors in Software product transfers

As from the context of product development, software transfer can involve in complete product development, a module, a component, or a piece of functionality. There are some critical factors which always play key role in deciding which phase or which part of the product development is to be distributed or outsourced they are Technological/Infrastructural , Process and Personnel. After performing the data analysis using grounded theory we found the challenges and their relevant challenges from the literature we have organized all the data into three categories product, process and personnel.

Categorization of Factors

In this thesis, data extracted from the systematic literature review is categorized into three main factors which are likely as Personnel factors, Project factors and Product factors.

- **Personnel factors**

  The software development projects success mainly depends on the personnel factors [56] [1]. This factor manifests on individual employees who are involved in global software development activities and it mainly focuses on the capabilities of an individual and person associated challenges [30] . Maximum personal factors are related to human skills and their inherent talents [31]. For any kind of success having individual skill is very important. Challenges that relates to human capabilities and in person behavior like language as challenge, trust between employees, personal attributes etc fall under personal factors.

- **Project factors**

  According to the research by Ebert[32], he stated that knowledge about the project is all about understanding the project requirements, budget of the project, resources of project, project task, milestones and delivering the right project in specified time [32]. This factor gives description about the characteristics of a project like the working conditions, organization and project management, turnover of the staff, development constraints, status, tasks, quality and the environmental conditions where the execution of the project takes place [30][33]. The success of project mainly rely upon proper project requirements, having good infrastructure, appropriate team size, consistency of team members in the project, better communication skills, stability in the organization, change in the management and cooperation among them[34][35][36].

  For successful development of projects in global software development (GSD), the values of project are determined in beginning of the project or while executing the project [33].

- **Technological/ Infrastructural factors**

  In this scenario the product a factor means it is about technological factors that affect the testing process in OOST. When we go deep into this, it is about infra structure that is being built and used to perform the software testing activities at both onshore and offshore. In offshore employees use both automated tools and manual testing, we have discussed more on the testing tools and testing infra structure under this area [11].

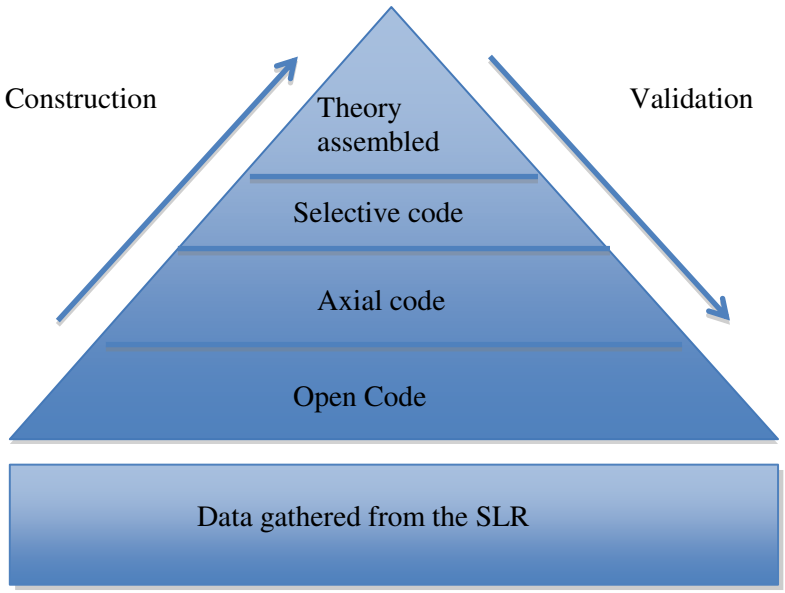

Figure2-8 : Organization of codes in Grounded Theory

2.10.2 Open Code

Open code mainly deals with identifying, categorizing, naming and describing the actions that are found in the text. This is also part of the data analysis. Open codes are similar to the raw data and Researchers formulates the information about study or about the required actions to be performed in the study by gathering the required data [27][37][38]. In this thesis, we got 57 open codes from the systematic literature review that related to the challenges and mitigation of outsourced offshore software testing.

Code stage	Total number of codes obtained
Open code	58
Axial code	23
Selective code	3

Table 2-19: The table above gives the data analysis codes obtained from our SLR

2.10.3 Axial code

Axial code is the method of relating codes i.e., properties and groups to each other using grouping of deductive and inductive thinking. Gathering of open codes together is done by the axial code that which constrain of similar open codes into the respective axial codes. This kind of coding is very much useful for shortening up the process instead of looking for entire relations [27][37][38]. The main motive of axial goals tells about the current scenario more accurately and completely. We have classified the open codes into 22 axial codes. Hence, axial codes are also called as the concepts.

2.10.4 Selective code

The process of selecting one important category of group and relating all other further groups to the same category is the selective code i.e., the combination of the group which is emerged from the axial code[27][37][38]. In figure 9 which was taken from [21] was presented to show how the whole data is organized using codes in Grounded Theory.
Once an analysis of 22 axial codes is done, we had grouped them into three main categories. Those categories are personnel factor, project factor and product factor. Using these three codes open, Axial and selective we build theories with the data gathered from SLR, this was shown in the figure 2-8 taken from [21].

2.10.5 Subsequent Category

After finding all the three codes explained in the above sections 2.10.2, 2.10.3 and 2.10.4 we again thought of categorizing the data, we have created subsequent categories to keep all similar categories of challenges under one tag. So that theory generation becomes more meaningful.

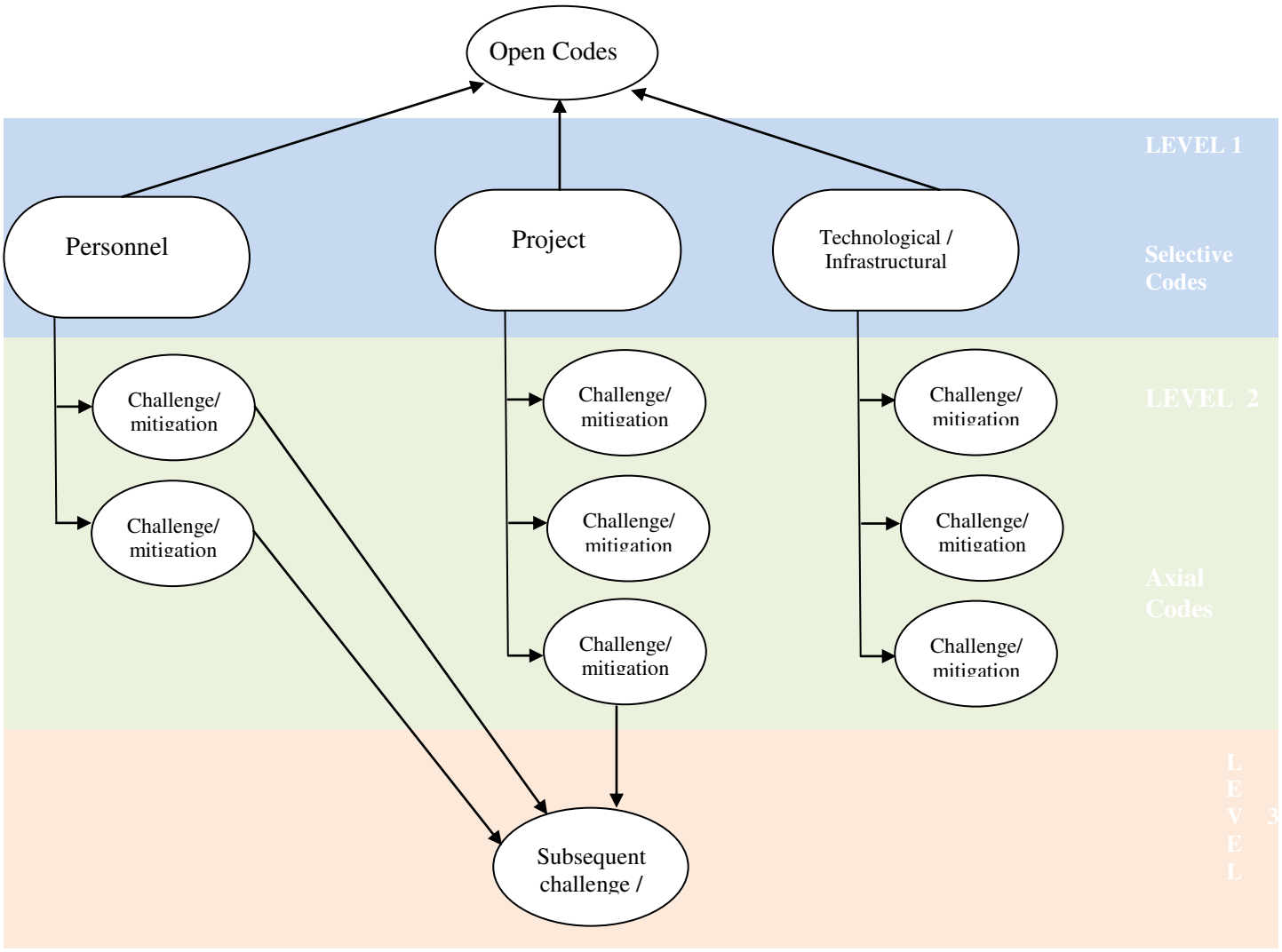

Fig 2-9: Different levels of coding strategy in Grounded Theory

Following sections to come contains new challenges and mitigations that were obtained after performing Grounded theory on primary studies obtained. Explanations of challenge and mitigation categories were given clearly to give subtle understanding. If we consider challenges from C1 to C11, some of these challenges are independent in nature and some of the challenges have overlap, from these challenges ranging from c1 to c11 C2 and C8 share a overlap. C2 says that both onshore and offshore shares a different perception about productivity and C8 says that onshore and offshore doesn't have a same perception about quality. Both C2 and C8 emphasize on perception, how onshore and offshore possess different thoughts about the attributes of testing. So we have mapped C2 and C8 into another subsequent category called difference in perceptions.

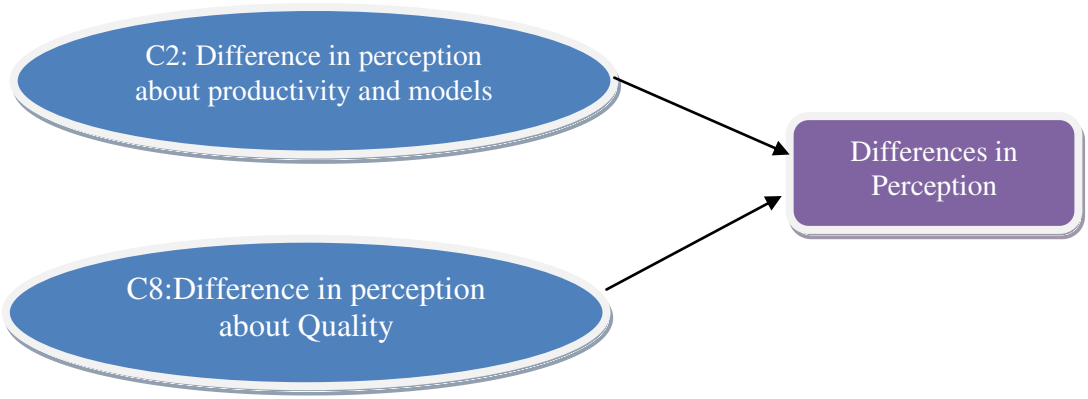

Figure 2-10: Mapping of challenges to subsequent categories

Above figure 2-10 represents mapping of challenges to subsequent categories, these subsequent categories altogether make up a third level of coding strategy. First level of coding consists of all Selective codes they are personnel, project and Technological/ Infrastructural factors, Second level of coding contains a layer of all axial codes derived from Open codes. Some of the axial codes like Culture, languages, information gaps these are the axial codes we referred these axial codes as challenge or mitigation Categories. These challenge and mitigation categories in turn consist of elementary data which are nothing but issues pertaining to particular challenge categories. Different levels of coding strategies were diagrammatic representation in Fig 2-9.

Chapter-3

Applying Grounded Theory

3 Finding Challenges and Mitigations during SLR using Grounded Theory

In previous sections making of different coding strategies were given explanation. We have gathered all required Challenge and mitigation categories. All challenges and mitigations were distributed among three important categories they are Personnel, project and Technological/ infrastructural. Beginning with section 3.1 and their following sections explains all the challenges and mitigations that were identified in Systematic Literature Review.

3.1 Challenges that were obtained under Personnel factors

These personnel factors are associated with the employees who are working for offshore software testing projects. In specific project managers who are responsible for managing offshoring activities and significantly offshore test employees. Most often language issues, cultural influence on offshore team, how pressure situations impacting the productivity of offshore team, legal sanctions and work delays caused by developers are widely discussed challenges on personnel involved in OOST.

		Personnel Factors		
S.no	**Subsequent Category**	**Challenge Categories**	**Challenges identified**	**Article Reference**
C1	Cultural influence	Culture	Lack of cultural compatibility between vendor and client	S12
C2	Cultural influence		Different perception of productivity and its models	S2, S12
C3	Cultural influence		Employees at offshore unwilling to admit their mistakes	S25
C4	Cultural influence		Lack of initiative in problem resolution	S13, S23
C5	Cultural influence		Different in level of thought	S9
C6	Cultural influence		Different trust levels on offshore team testing skills	S9
C7	Cultural influence		Differences in UAI	S9
C8	Cultural influence		Difference in perception about Quality	S9
C9	Cultural influence		Difference in Expectations	S9
C10	Cultural influence		Difference in approaching details during testing	S9, S11
C11	Cultural influence		Misunderstanding between staff	S10
C12		Language	Usage of different languages at vendor and client	S18
C13			Offshore team hardly talk english	S8
C14		Pressure	Employee working under high pressure	S2
C15		Work delays	Delay of work by developers	S2
C16		Decision making	Improper decision making by client managers	S2
C17		Training	Extra effort in training and investing on human effort	S2
C18			Lack of trained employees	S5
C19		Language	Multiple languages in communication	S18
C20	Building mutual trust	Trust	Lack of trust to share business and intellectual knowledge	S18
C21	Building mutual trust		Lack of trust by onsite employees to share their intellectual property	S6
C22	Building mutual trust		Unwilling to share the information	S2
C23		Legal Sanctions	Unable to build cohesive teams	S18
C24		Roles and responsibilities	Poorly defining roles and responsibilities	S10
C25		Common goals and categories	Grudge between onshore and offshore employees	S10

Table 2-20: Challengers that were obtained under personnel categories

3.1.1 Cultural Influence (C1-C11)

Lack of cultural compatibility between Vendor and Client

It is important for offshore vendor employees to think in the perspective of client/users. In OOST usually software testing is performed by the offshore vendor employees who don't have culture compatibility with the end users or clients who outsourced the testing phase to offshore [S9].

Psychology, is considered as a keen factor that brings the difference how employee perceives the testing activity. Culture influences mainly the psychology of humans. Hence culture is the factor that mainly dominates the way testing activities are performed [S9].

Culture influence on the perception of productivity

In OOST, both vendor and client have different perceptions in productivity. Their perceptions are often conflicting during the test case design and test case execution. Due to lack of prior communication and negotiation between the client and vendor this problem of dissimilar perception was aroused because of cultural incompatibility between the cultures of client and vendor. Throwing light on productivity, how the client team and vendor team measures the productivity changes. Productivity for the client team seemed to be measured in numbers; whereas productivity for the vendor team seemed to be measured in terms of tasks that were being sent to vendor team and number of tasks accomplished by vendor employee.

Difference in the level of thought

Culture has many influences in many ways on employees from different cultures who involves in OOST set up. Culture brings differences in how the people think, the way they perceive the things, peoples approach to problem solving, differences in the way how they utilize the resources (i.e., effort, time and money) for software testing. In OOST set up client and vendor organizations come from totally different cultural backgrounds, this brings the differences in their thoughts and thought patterns. From the [S9] Japanese customers[1] they will probably expect their vendors to test their software on success cases and normal conditions after they thoroughly tested the software with conditions, which are less likely to prevail. Thus, the scenarios with unexpected inputs, situations, and environments were emphasized over the expected scenarios for which the software was being built. They seem to be motivated to test their software in every worst case scenario in which software won't fail to run. If we consider U.S clients they seem to emphasize much on functionality of the software, whether software is having good functionality or not rather than considering the negative scenarios [S9]. Therefore perception behind the purpose of testing the software differs from Japan to U.S

Both Japanese and U.S client teams have *different trust levels*. Japanese client team would not trust others to perform their testing activities. It is very difficult to gain the trust from the Japanese team to perform testing. In contrast it is very easy to gain the trust from the U.S client team [S9][S27].

[1] In this article authors conducted interviews to Japanese and U.S client teams, to study the affect of culture on different clients, to understand how they perceive and expect their software to be tested by vendor.

There are also some considerable *differences in the expectations* of two client teams. Japanese client team expected their vendor test team to work late hours to finish their tasks to which they have committed. Interestingly, the U.S client team expected their vendor test team to be very "realistic" in their goals. This apparently tells us that they should not over commit to testing beyond what is possible to cover in the allotted time [S9].

Uncertainty avoidance, described by the Hofstede as a cultural dimension, is the "extent to which members of a culture feel threatened by ambiguous or unknown situations" [55].Testing can be viewed as mechanism for avoiding ambiguity of how the software will behave in uncertain situations and thus, it helps in avoiding uncertainty [S9]. Japanese client team significantly emphasized boundary conditions and negative scenarios, thus it is clear that the Japanese team wanted to ensure that their software could handle as many uncertain situations as possible. Depending upon the tolerance levels to ambiguity, Hofstede assigned different uncertainty avoidance index values to different nations; Japan is having UAI score of 92 which is the highest among all the nations. In contrast U.S is having an UAI score of 46, it shows that the U.S client team is realistic in nature towards the testing may be due to their lower levels of anxiety that result from uncertainty [S9].

Interestingly *perception about quality* changes from person to person, it is subjective in nature. One gets satisfied with the quality of software, but it wouldn't be same for the other person. The other person might not really be satisfied and happy. He may possess some kind of expectations, and might rate that as a low grade quality product. Japanese client team appeared to have a high software quality expectation from their vendor team than the U.S client team [S9].

Sometimes researchers found differences in the way both U.S and Japanese client teams extract the details of ongoing testing activities from their vendor teams. U.S client teams always concentrated on the end result. Japanese client team is very much focused in getting the right details related to testing. Japanese client team always used to ask some questions in common as a part of getting details, they includes *How did you reach that point[conclusion], how many issues did you face, how did you solve it[issue], what will you do that you will not face those issues..Everything"* [S9]. There is also another example from [S11] about Chinese and Indian teams; seeking information by asking questions is considered in a negative way in some cultures. Information seeker might be perceived as being less knowledgeable or less resourceful. Indian software engineers also have a high level of question asking behavior. The Chinese team was less interested in asking questions and getting information to perform their tasks [S11].

3.1.2 Language (C12, 13, C18)

Usage of different languages in client and vendor locations

Relation between client and vendor are mostly dependent on communication and importantly the language they use to communicate each other. In some scenarios even though they used English as a common language it had affected the interactions of both clients and vendors. It hampers the knowledge sharing between client and vendor employees during the execution of some critical tasks [S15]. Use of multiple languages has become a great problem in the offshore as it doesn't support the smooth communication channel when problem escalates during the test execution. Sometimes in some scenarios onshore employees hardly found people who can speak English fluently [S2].

3.1.3 C14: Perception of pressure at vendor site

During all the phases of product evolvement in software engineering the testing team has higher deadlines to meet, they have certain objectives to accomplish like delivering the test cases, problem escalation, project status and troubleshooting the problems. Employees at the vendor location were subjected to extreme pressure conditions as they were asked to submit

the project status to the client organization. They were supposed to work under the severe pressure conditions. Some other employees of vendor organizations claimed that they have to work for the deadlines set by the client company this has created more pressure and affected the working efficiency. Employees has shared different perceptions about the pressure, the pressure is a demotivating factor as they did not appreciate unnecessary pressure. When the light was thrown on other employees they have revealed that the pressure is the factor which measures the capability of an employee in meeting the deadline. Pressure was stated as bad at times and good at others. Sudden increase of allocated tasks to vendor employees and reduction of time given to meet the deadlines are one of the primary reasons for increase of pressure in vendor employees. Other reasons for extreme pressure conditions include incorrect time estimation, sudden shortage of resources, impromptu requests and preponement of deadlines [S2].

3.1.4 C15: Work Delays

Delay of work by developers also increases pressure in the testers as they have to manage the time for fast approaching new version release of software. As the time to meet the deadline declines quality of work at vendor location also reduces. A developer might take a twenty days to develop the code which is comparatively very much less to the developer and also test engineers must have to test the entire code within the given time period they are not supposed to demand an extra time. Developers may miss the deadline but it wouldn't be possible with the test engineers. For test engineers meeting the deadline is the major challenge. Thus, delay created by the developers highly affects the test engineers working efficiency because of approaching deadlines with great swift [S2].

3.1.5 C16: Decision making

As from the literature most of the test engineers mentioned that it is very challenging when they are managing with the issues for which they don't have an authority to take a decision. In this context managers at client location are highly responsible for making the decisions which are very critical for carrying the work at offshore. However managers in most often put off the process of decision meaning, they may be reluctant or genuinely not in a position to make a decision. Hence it leads to delay in work at offshore [S2].

3.1.6 C17: Training test engineers for the test automation

New technologies, products, tools and techniques caused certain new challenges in the offshore. As the result of this, new training sessions are conducted for the offshore employees to make them aware of new tools and techniques [S2].

3.1.7 C18: Lack of trained employees

Some of the researchers raised the problem of finding trained professionals in testing domain, availability of trained manpower is a big challenge, and this challenge was spotted in Indian IT Industry [S5].

3.1.8 C20, C21 and C22: Trust

There are some identified risks when sharing business knowledge during distributed development and when the project was shared among the internationally distributed teams. There are some negative impacts in this globally distributed software development settings which are like an opportunistic behavior by offsite teams, public relation mishaps, loss of control over intellectual property and having to deal with legal systems [S18][S6]. In some other cases, even though if the right person who will provide the information is known still getting the information from the available source is challenging. Some people from the literature yelled that people from development organizations showed the resentment by closing the chat window when they need information urgently [S2].

3.1.9 C24: Roles and responsibilities

In study [S10] [S26] stated that roles and responsibilities were not properly defined in the initial stage, where the offshore location had to increase the number of testers. Once the coordination responsibilities were given clearly, then the roles and responsibilities were defined little more clearly.

3.1.10 C25: Common goals and objectives

This is one of the important factors. In some cases in [S10] it was noticed that employees of onshore and offshore had some kind of slight grudge between them. Thus it reported that them-and-us culture was adapted, which lead to lack of sharing the information and visibility of offshore location's work among them [S10] [S26]. This was happened because there are no common goals and objectives which increases team cohesiveness.

3.2 Challenges that were obtained under Project factors

Project Factors				
S.no	**Subsequent Category**	**Challenge Categories**	**Challenges identified**	**Article Reference**
C26		Process transparency	Lack of visibility	S18
C27			Lack of process transparency	S2
C28	Building effective communication channels	Communication gaps	Lack of knowledge and documentation	S2, S23,S28
C29	Building effective communication channels		Geographical Distances	S25
C30	Building effective communication channels		Less synchronous communication	S10
C31		Temporal difference	Project schedules	S18
C32			Less shared time window	S11
C33		Geo political	Political unrest at vendor location	S18, S25
C34			Unstable political situation	S8
C35		Extra costs	High fees for new services	S8, S25
C36		Coordination	Geographical Distance	S25
C37			Presence of multiple vendor employees at onshore	S18
C38			High coordination cost	S10
C39		Knowledge Transfer	Diplomatic knowledge sharing	S18
C40			Insufficient K.T	S18
C41			Lack o f K.T on automated testing	S2, S8
C42			Employees refuse to share knowledge	S10
C43		Requirement specification	Requirements uncertainty	S10
C44			Changing requirements	S10

C45			Lack of informal meetings	S1
C46		Geographical distance	Team spirit not built	S10
C47		Turnover rates	High turnover rates in offshore	S10
C48	Building effective communication channels	Information Gaps	Difficulty in information gathering	S11,S2
C49	Building effective communication channels		Difficulty to find appropriate people	S11,S2
C50	Building effective communication channels		Hurdles in exchanging accurate information	S27

Table 2-21: Challenges obtained under project categories

3.2.1 C26, C27: Process Transparency

The vendor employees can further define process transparency and visibility issues in terms of clarity and understanding of the testing activities. This is the most commonly identified challenge by the testing teams which hinders the smooth functioning of testing activities. This had created problem in two ways both from vendor side and client side [S18] [S2].

Circumstances that demonstrates the given challenge:

During the testing, development teams are fixing high severity bugs that are to be tested within the short period of time given to the vendor employees. They perform testing for the bug fixes; client employees lack visibility into the types of bugs and types of fixes that were being performed. There are also certain challenges that were acknowledged by the participants in the earlier research. They are data-setup problems, delayed delivery of code by the development team, and the lack of required information encountered by the testing teams were not made visible to the clients [S18],[S2].

3.2.2 C28, C29 and C30: Communication problem

This was highlighted as prominent challenge in global software engineering. Delays and improper communications patters often hampers the work at vendor site. In specific when the test-execution phase as the deadline for vendor employee fast approaching necessity of information from Client Company for performing activities at vendor site is indispensable. In the critical situation code developers are often showed the lack of interest and irresponsibility by closing the chat window and by not answering some important phone call from the test engineers working at offshore [S2].

C30: Less Synchronous Communication

If distributed teams are working in different time zones say like U.S and India there will be very much less or no shared time window. In this scenario team members must rely on asynchronous communication. This makes the complete testing activity late [S10].

3.2.3 C31 and C32: Temporal Difference

A temporal difference also impedes the aggressive testing schedules, as Client Managers were unknown of the working schedule of the vendor employees, holidays and local events.

Particularly when working with remote team members due to the lack of unavailable working hours of employees it has caused misunderstanding in distributed teams [S18].

In offshoring software testing activities to vendor organization has associated with the challenge of time zone differences. In some scenarios there would be less shared time windows, which means that there will be very few hours in which employees from both offshore and onshore can hardly work together. If the testing activity was outsourced to India from U.S, shared time window is almost zero. In India if the test engineer starts work at 9.00 AM (IST), local time of Newyork (U.S) is, finding right person, and problem escalation will become difficult. Employees in offshore has to wait even in late hours until the right person from onshore employee come and coordinate the work [S11].

3.2.4 C33 and C34: Geo Political

Political unrest caused at some offshore locations hampered testing activities which were scheduled to meet some important deadlines. Unstable political situations and riots caused a huge delay in supply of shipments to clients which made the employees of client organization to work on their holidays. [S18][S25][S8].

3.2.5 C35: Extra Costs

In outsourcing of testing projects to the offshore vendor employees, vendor organizations offer their services at the low cost in the beginning but the contract terminates with unexpected costs charged because of wrong estimation of cost for the service given and the other costs beside salaries. Vendors are trying to getting as many clients as possible with low cost at the start up but there is always a risk of unexpected huge investments which is needed at the middle [s8]. There are some other activities that demanded the extra costs like restructuring development and testing processes to fit vendor needs, supporting changes in technology and connectivity with the vendor, transferring knowledge about the business context, travelling to the vendor location, allocating overhead for governance activities, and mitigating risks through disaster recovery for vendor activities [S25][S8].

3.2.6 C36, C37 and C38: Coordination

High coordination cost resulted in temporal resources and monetary resources [S10][S26], where monetary resources consists of communication tools that are used to support for development, access control, inter-site travel cost and delivery of systems to foreign locations. And for controlling the offshore locations, the original site required temporal resources [S10].

3.2.7 C39, C40, C41 and C42: KT

The original site employees were not willing to share the knowledge to the new site, since they thought that their jobs were on the line. But the company had set some expectations that the knowledge gained in two years would be shared or transferred to the new site and expected that company at new site would start up and would be running at required capacity [S10][S26].

3.2.8 C43, C44 and C45: Requirements specification

Changing of requirements is identified as most common problem that is faced. The requirements used in projects were of cheap quality standards. These cheap quality resources were collected from previous materials that are stored in multiple locations, which resulted in adverse requirements. Using of changed requirement as a part of software development activity has become very much problematic [S10] [S26].

3.2.9 C46: Geographical distance

Considering the geographical distances in mind it has become impossible to have trust and build up friendship between the employees. Due to lack of trust and friendship among the

employees, team sprit cannot be built. This geographical distance has damaged the formation and maintenance of team sprit [S10] [S26].

3.2.10 C47: Turnover rates

From the article [S10] [S26], says that in most the cases projects are affected by the turnover rates. Since the turnover rates are very high in offshore location retaining of staff and work relocation during the project is become a great challenge. In countries like Asia, staff turnover rate has been a problem where it has become a habit for most of the individuals to attain good amount of experience and expertise at one company and then quickly resign and move on to another company.

3.2.11 C48, C49 and C50: Information gaps

In global software testing, testing teams are separated across many continents with different time zones which make availability of information very much less. It becomes very difficult to get right information from the right contact person (e.g someone involved in fixing a bug). Information seeking and sharing are communication activities that are critical for successful software engineering, design, development and testing. Information is exchanged either synchronously or asynchronously. Software teams working under same time zones can get the information synchronously which is an interactive way, but in different time zones ability to get correct information becomes very difficult. Most of the research was claiming that vendor team was facing lot of troubles in obtaining information relevant to how to produce a bug, how a bug is fixed(according to that fix can be tested approximately), and what is the priority given to test that particular module. Employees have to wait until the right person comes and send the information. This is considered to be a great hindrance which makes the delivery of the shipments late [S10][S27][S2].

3.3 Challenges that were obtained under Product factors

Technological/Infrastructural Factors				
S.no	**Subsequent Category**	**Challenge Categories**	**Challenges identified**	**Article Reference**
C51	Infrastructural bottlenecks	Test Environment	Challenges in setting environment for the testing	S2
C52	Infrastructural bottlenecks	Test Environment	Remote access to test environment	S27
C53	Infrastructural bottlenecks	Infrastructural bottlenecks	Dearth in sophisticated working technology	S25
C54	Infrastructural bottlenecks	Infrastructural bottlenecks	Differences in infrastructure	S11
C55	Infrastructural bottlenecks	Infrastructural bottlenecks	Networking issues	S8
C56	Automation Testing	Testing Tools	Lack of reliability on test tools by onsite employees	S2
C57	Automation Testing	Testing Tools	Lack of testing tools	S8
C58		Technological issues	No standard reporting format	S16
C59	Infrastructural bottlenecks	Infrastructural bottlenecks	No shared system database	S3
C60	Automation Testing	Testing Tools	Usage of expensive tools	S10
C61		Capability & maturity	Differences in capability maturity in both client and	S18

			vendor organizations	
C62		Capability & maturity	Lower organizational maturity level	S7
C63		Domain knowledge	Lack of domain knowledge at offshore to perform test	S4, S19
C64		Resource management	Shortage of human and technical resources	S17
C65		Information Security	Lack of security for confidential information	S25
C66		Information Security	Lack of availability of information	S2
C67		Information Security	Firewall and Permission rules	S25

Table 2-22: challenges obtained under Technological/Infrastructural Categories

3.3.1 C51-C55: Infrastructural bottlenecks

Infrastructural issues aroused during the test automation, setting up a new testing environment that supports automated testing becomes challenging. Transformation of manual testing to automation testing and lack of availability of sophisticated tools also implied the investment in training and buying the necessary tools [S2] [S25]. In some scenarios like when the test environment was located in U.S, access to remote environment and solving any related issue becomes more difficult for the vendor team [S27].

A difference in infrastructural setting always hampers the testing activities. This reduces the speed of whole testing activity [S11].

C52: Remote access to test environment

In some projects test environments are located in U.S when the vendor team is located in India. It becomes so problematic to access the test environment located remotely, some specific hardware which is required for testing also available in U.S. At later stages offshore staff relied on simulators to replace this dependency. 24X7 onsite support was required for the environment.[S27]

3.3.2 C56-60: Affect of Tools and Technology on Test Automation

When the manual testing is replaced by the automated testing, automated test tools depending upon the code and environment, in this critical situations lack of availability of the appropriate tools has created some problems has made the shipments to be delivered late to the offshore [s8]. In OOST setup most of the vendor companies are trying to make use of the tolls that test the software code. But client organizations are not reliable on the tools that are used to test the software which were already being coded by someone [S2].

According to study [S10][S26], some tools are considered to be very expensive. There are some situations where the license of tool's cost may not be covered by the benefits of the projects, especially when the products were given to less economic countries. Some of the most expensive tools can be replaced with cheaper tools [S10].

3.3.3 C61, C62: Capability and Maturity

At the beginning of any relationship between client and vendor, Client Managers must look forward whether the vendor has more standards, trends and best practices in testing. Client Managers must bring them along and improve how they operate. Most commonly Client Managers doesn't have the standards which are at least as equal to the client companies which are outsourcing their projects. Client Managers speculated whether to sign that particular contract with the Vendor which doesn't have good CMMI levels for the company

to maintain certain standards in the process of software testing. It would result in the wastage of money, time and effort [S7] [S18].

3.3.4 C63: Domain Knowledge

Domain knowledge of offshore employees also plays a vital role in the outsourcing projects. It highly affects the productivity of the employees. Employees with less domain knowledge must be given training to make them enlightened about the testing task they have to deal with [S4],[S19]. As it was said in [S19] communication delay and domain knowledge are some of the factors that could explain well in the observed differences in site productivity.

3.3.5 C65, C66 and C67: Information Security

It is very important to provide high level of security for the information that will be exchanged between the clients and vendors. Test managers highly reported that security is the primary concern for confidential information that is to be exchanged between onshore and offshore. Client and vendor as they are supposed to work together the client need to transfer information to and from the vendors. They have to exchange the emails back and forth and sometimes they need to provide access to the vendors on secure FTP sites. However there are many information security requirements that are to be well established to govern these information exchanges, making it difficult to work efficiently and effectively. It's the major role that is to be taken by the administrative time and immense face-to-face communication to iron out these issues [S25] [S2].

3.4 Mitigations that were obtained under Personnel factors

List of Mitigations

Personnel factors				
S.no	**Subsequent Category**	**Challenge Categories**	**Mitigations identified**	**Article reference**
M1	Building mutual trust	Trust	Selective dissemination of knowledge	S6
M2		Training	Good experience in testing	S5
M3		Training	Skill road mapping	S10
M4		Roles and responsibilities	Following gatekeeper strategy	S10
M5		Roles and responsibilities	Sharing responsibility	S27
M6	Cultural influence	Culture	Create cross channel awareness	S9
M7	Cultural influence	Culture	Evaluate cross-culture initiatives	S9
M8	Cultural influence	Culture	Manage culture knowledge	S9
M9	Cultural influence	Culture	Employees of similar culture	S11

Table 2-23: Mitigations obtained under personnel Categories

3.4.1 M1: Selective of knowledge

In distributed and multi vendor software testing there is always a sense of optimistic behavior of both intellectual property and business knowledge. But in order to continue the contract in further both client and vendor organization can't skip out of uncovering some confidential data. In this scenarios selective dissemination of knowledge, risk of opportunistic behavior from offsite business partners is reduced. However it also very

helpful in integrating the software artifacts that were being built in different development domains [S6].

3.4.2 M2 and M3: Training (Skill road mapping)

Some studies conducted skill road mapping in training process. Skill road mapping is used in the employees hiring phase, which maps the amount of training that is required for the staff that are located offshore. This approach is believed to be an effective method [S10][S26].

Onshore client organizations always gave priority for the well trained and experienced personnel in hiring for performing testing activities. Experienced personnel are more skilled to handle testing and defect prevention activities, which will result in better quality and more productive use of resources [S5].

3.4.5 M4 and M5: Roles and responsibilities

Clearly defined roles and responsibilities are noticed to have great importance since the employees in the offsite may not be aware of the distinct organizational hierarchy [S26].
According to a case in study [S10], their projects used a strategy called gatekeeper strategy where all the team leaders worked as proxy information flow to and from the team [S10][26]. The main use of gatekeeper is for sharing the data between the sites [S10].

3.4.6 Shared Responsibilities

It is really important for offshore team to come up voluntarily to take responsibility for the tasks and deliverables assigned to them. It will create a strong feeling among offshore employees to create a feeling of shared responsibility but also it makes the distributed teams responsible and accountable for their deliverables [S27].

3.4.7 M6-M9: Culture

Create cross-cultural awareness

There are so many negative consequences for having different cultural backgrounds; there is a need to invest effort in creating cross-cultural awareness. This brings the understanding of cultures of vendor as well as the client team. Because it will have some benefits like (1) minimized confusion/ delays among delivery teams due to miss-communication (2) can form cohesiveness with global team members(3) better understanding of expectations across teams (4) reduced costs by achieving projective objects(5) enhanced experiences resulting in better productivity and quality. It will help to predict potential client's behavior like UAI which makes better effort estimations [S9].

Evaluate cross-cultural initiatives

Even though organizations conduct training programs which bring cultural sensitivity they don't affect much, they mostly focus on high-level concepts of culture like handshaking style and business etiquette. It is almost necessary they should change their programs to demonstrate the deeper impact that culture has on their way of executing their practice. Such kind of effort can enhance the business value of testing, which brings both the client and vendor together [S9].

Manage cultural knowledge

Large vendors will always work with multiple clients from different countries. Such organizations must acknowledge and support customized ways of working based on client's preferences. There is a need for such vendors to build some strategies for understanding and synthesizing the cultural learning and knowledge gained from working with various clients. It will make vendor organizations to offer better services to their clients [S9].

It is better to chose offshore vendors from same culture, from [S11] it was said that vendors from Far East feel very comfortable to communicate other vendor employees who are from near Asian countries. Because they have the same accent in their language with which they

communicate easily and get the proper information, they will also have less culture differences compared to western countries.

3.5 Mitigations that were obtained under Project factors

		Project Factors		
S.no	**Subsequent Category**	**Challenge Categories**	**Mitigations identified**	**Article Reference**
M10		Temporal	Making phone calls	S18
M11			Follow the sun	S2, S22
M12			High speed data links	S2
M13			Round-the-clock work	S10
M14			Adjusting employees work schedule	S11
M15	Building effective communication channels	Communication gap	Daily status reports	S25
M16	Building effective communication channels	Communication gap	Weekly phone calls and discussions	S25
M17	Building effective communication channels	Communication gap	Employee must have good communication tactics	S2
M18	Building effective communication channels	Communication gap	Groupware and communication technologies	S18
M19	Building effective communication channels	Communication gap	Offshore coordinators and improved test specification	S28
M20	Building effective communication channels	Communication gap	Voice and Video chat	S20
M21	Building effective communication channels	Communication gap	Iterative development	S21
M22	Building effective communication channels	Communication gap	Proper Training	S14
M23	Building effective communication channels	Communication gap	Use of wiki	S13
M24	Building effective communication	Communication gap	Instant messaging	S10

	channels			
M25	Building effective communication channels	Communication gap	Similar and effective communication methods	S10
M26		Knowledge Transfer	Presence of offshore vendor employee	S25
M27			Frequent training of offshore employee	S15
M28			Frequent visit to onsite	S25
M29		Coordination	Onsite presence of vendor employee	S18
M30		Resource utilization	Allocation additional resources, prioritize tasks	S2
M31		Project status update	Prioritize work	S18
M32		Extra cost	Prioritize task	S8
M33		Resource management	Limited personnel resources	S10
M34		Bridging	Selecting bridging countries	S11
M35			Technical training	S11
M36	Communication gap	Information gaps	Appoint onsite test coordinator	S27

Table 2-24: Mitigations obtained under project Categories

3.5.1 M10-M14: Temporal differences

Another issue in working with offshore vendors is temporal differences. Organizing work among different vendor organizations is very challenging with different time zones. It has become difficult to reach the people to communicate when they are dispersed globally. For smooth work transitions and to properly coordinate the works, phone calls are made every day and night [S25]. There are some other strategies that are being implemented for smooth work transitions are follow the sun approach, and high speed data links [S20] [S22].

One strategy commonly adapted to overcome this challenge is, the employees have to adjust their work schedules according to the availability of the shore team [S10].

Round-the- clock (temporal)

In some scenarios [S10], round-the-clock work had given outstanding results. This is accomplished in such a way that, the outsourced location would perform the testing activities during the evening hours of on-site location. Then the test results would be ready by the start of on-site location's workday. Many organizations realized the advantages of performing testing activities while the original site doesn't work. This round-the clock word approach helps in saving the time and work is distributed properly [S10] [S26].

3.5.2 M15 to M25: Building effective communication channels and relationships between offshore and onshore employees

Several managers adopted status reporting, making weekly phone calls and discussions with vendor staff has filled the communication gaps up to large extent for the testing activities to be done at good pace [S25].

As far from the participants in the most of the empirical studies reveals that having good communication tactics helped them better in high-pressure situations. They also claimed that spending extra effort in maintaining good relationships with the clients and onshore employees reduced information gaps and communication breakdowns [S2]. While advanced groupware and communication technologies may help minimize geographic distances, they

may strengthen the cultural and power differences rather than promote team building through the development of shared identity and context [S15]. There are some other practices like communication tools, voice and video chat, iterative development, proper training of employees and use of wiki are better used to reinforce the relationships and communication patterns between the onshore and offshore employees [S18], [S19], [S11], [S10].

3.5.3 M26, M27 and M28: Knowledge Transfer

There are always been a coordination challenges to organize the work between the Vendor and Client employees who are from different regional and cultural back grounds. The offshore vendor delivery manager explained that another important factor that ramp up knowledge transfer and adequate communication is to have full time client employee presence at the vendor location. There are some other benefits beside knowledge transfer is to see the morale, conditions, and other issues. The practice of doing site visits routinely could be informative if full time presence is not possible at often. Some knowledge transfer may include a list of activities like understanding the client's execution process, validation methods, measure systems, and technical tools [S25] [S12].

3.5.4 M17: Coordination

Client Managers always expressed dissatisfaction about the coordination challenges that were aroused. To coordinate the work properly and to get the in-depth details of offshore work there is always a client employee was being sent to offshore to coordinate the work. There are some shadowing employees were sent which were followed by the old one who cannot stay beyond the given time limit at offshore [S18].

3.5.5 M30: Resource Utilization

Shortage of resources hampered the testing activities at offshore, vendor teams have shortage of infrastructural and human resources. In this scenarios offshore vendor teams gave prioritized the testing activities and assigned additional resources to complete the work in time [S2].

3.5.6 M31: Project Status update

Receiving project status update found to be a great catalyst in fastening the activities at offshore. Project status reporting is one of the most important areas in the project management. It is very difficult to get accurate project status updates. Cultural values brought some unique challenges in problem escalation and status reporting. Most of the Client Managers expressed that reporting of project status was one of their primary concerns in working with offshore vendors. In order to obtain accurate project status CM's have followed the approach of prioritizing the work for vendors on a dynamic basis[S18]. By prioritizing the software testing activity it had helped the CM's to induce vendors to escalate problems more often and immediately. Without this prioritizations CM's noted that offshore vendor employees spending disproportionate time amount of time trying to solve problems on their own in a vain [S18].

3.5.7 M32: Extra Costs

Some of the corrective actions that were proposed for get rid of these extra costs.

- Proper planning of resources, allocation of resources as planned for supporting activities [S8].
- Being secured about belated deliveries will not have significant impact on project progress [S8].

3.5.8 M33: Resource Management

In most of the cases personal resources are sufficient. In some cases [S10][S26], there were very limited personnel resources at offshore site. These inadequate resources will affect the

onsite employees by having enormous workload that can be mitigated by information requests and coordination [S10] [S26].

3.5.9 M34 and M35: Bridging

Selecting bridging organization is the best approach to overcome the information seeking problems. Bridging the organizations from different time zones will smoothen the information flow complete and consistent. In this article author's conducted research on global setting which was distributed across the sites U.S, Ireland, India and Chinese. India and Chinese share a huge time window as they are from the Asian continent, it is very difficult to get information from the U.S team because both U.S and Asia will have a completely different time zones. In this scenario Ireland (Dublin) has served as a bridging organization which bridged the gaps in information seeking and time zone differences. Thus, bridging provided the opportunity for increased information seeking from knowledgeable resources as well as the opportunity for self promotion [S10].

In some projects onshore client organizations have assigned onsite coordinators to facilitate the exchange of information between the cross border teams. In the same way offshore team appointed test lead as a single point of contact. Test lead has to bridge the information gap by communicating with the onsite coordinator to facilitate discussions with other teams on topics like business, data, infrastructure etc..,[S27]

3.6 Mitigations that were obtained under Technological/Infrastructural factors

Technological/Infrastructural factors				
S.no	**Subsequent Category**	**Challenge Categories**	**Mitigations identified**	**Article Reference**
M37		Capability maturity	Substantial technical knowledge	S18
M38	Automation Testing	Testing Tools	Early integration of tools	S20
M39		Technological	Use of formal language	S24
M40	Infrastructural Bottlenecks	Infrastructural Bottlenecks	Establish right tool infrastructure	S10
M41	Infrastructural Bottlenecks	Test Environment	24x7 onsite support	S27
M42	Infrastructural Bottlenecks	Infrastructural Bottlenecks	Usage of same tools in client and vendor	S10,S26

Table 2-25: Mitigations obtained under Technological/Infrastructural Categories

3.6.1 M37: Capability and Maturity

When engaging with the new offshore vendor, Client Managers specified that it was very important to work in association with the offshore vendors not only for business domain knowledge transfer but also to strengthen up offshore vendors software testing process maturity, developing vendors skills on advanced test design and development to meet clients quality expectation. Literature is suggesting that Client Managers managing outsourced offshore software testing projects need to be closely involved in building vendors capability not only to transfer business and system knowledge but also to build and strengthen vendor's software process maturity especially in early stages of relationship. There are some scenarios where offshore vendor employees are not as mature and experienced in software testing as Client organization employees. This led to an initial dilemma which was faced by the Client organization employees in the beginning of the contract whether to invest in building up vendor's software testing processes and practices along with business and domain knowledge transfer. As a result of this Client Managers has followed the strategy of "sub

categorization approach, where both client and vendors recognize and value their differences in a cooperative spirit and see these differences as a potential source of advantage for the group as a whole [S18].

3.6.2 M38, M39, M40 and M41: Infrastructural Bottlenecks and Issues in Test Automation

In software testing that is carried out at offshore early integration of tools which performs verification and validation activities right from the early stages of software development life cycle results in higher quality and more reliable programs, and also that ideally V&V parallels software development [S20]. Going to some deep in order to execute the testing process that supports architecture along with formal language, to describe the test plans and reports which describes test execution results, users create these documents with a set of form oriented editors, the test plan editors, the Test report editors and the Bug report editors [S24] [S10].

The differences between the tool infrastructure is noticed as a hurdle, where in some instance the tool may not be present or the tool which is present is completely a different tool. To avoid these situations, occurrence of the tool was noticed well in advance and required actions were considered to establish the right tool infrastructure so that desired performance can be obtained in the original location [S10][S26].

In some projects test environments are located in U.S when the vendor team is located team in located in India. It becomes so problematic to access the test environment located remotely, some specific hardware which is required for testing also available in U.S. At later stages offshore staff relied on simulators to replace this dependency. 24X7 onsite support was required for the environment [S27].

3.6.3 M42: Infrastructural

According to the study [S10], it says that infrastructure must be addressed in a proper order for outsourcing of the work correctly and effectively. Usage of the same tools at different locations and also between the customer and service provider are identified as an important way for reducing the issues that are caused by infrastructural problems [S10] [S26].

Chapter 4
SURVEYS

4 Surveys

The main motive of conducting survey is to examine the experiences and practices in industry that relates the associated threats and practices, challenges in coordination in Global software development. For this thesis conducting surveys would good option when compared to other methods like case studies or experiments. Case studies will be helpful to investigate for how and why things are done [38]. In the similar way, experiments are controlled studies where the situations are controlled and manipulation in behavior is done precisely, systematically and directly. Hence, having case study or experiment is not appropriate for this study. In our thesis, we need to get correct and appropriate knowledge from different industries. Survey is capable to present huge number of variables for evolution [37]. The main purpose of surveys is, they can gather information across the globe, since it is not influenced by any kind of geographical distance and temporal distance. Taking time and budget into consideration surveys are advantageous and beneficial.

In our study we conducted survey based on questionnaire. We designed our questionnaire on the data gather and identified from systematic literature review.

After designing the survey questionnaire, we distributed the questionnaire for experienced industrial practitioners, which helped us in identifying the differences and similarities obtained between literature review and the present industrial experience that helps to meet the challenges and practices to mitigate them. The main goal of surveys answers the research questions.

4.1 Information regarding the Questionnaire design and Questionnaire distribution

4.1.1 Questionnaire Design

For designing the survey questionnaire we intensively reviewed the literature that we got from systematic literature review. We designed the questionnaire in such a way that we could extract lot of data from the industrial practitioners. Our survey form used in this study was self-monitored and surveys were disturbed online using Internet. We used survey monkey as a tool for conducting online survey (http://www.surveymonkey.com). As it is not easy to gather people across the globe and make them to sit under one roof and conduct survey so we have conducted it online.

Our survey questions are divided into two sections.

- Demographic information
- Open ended questions

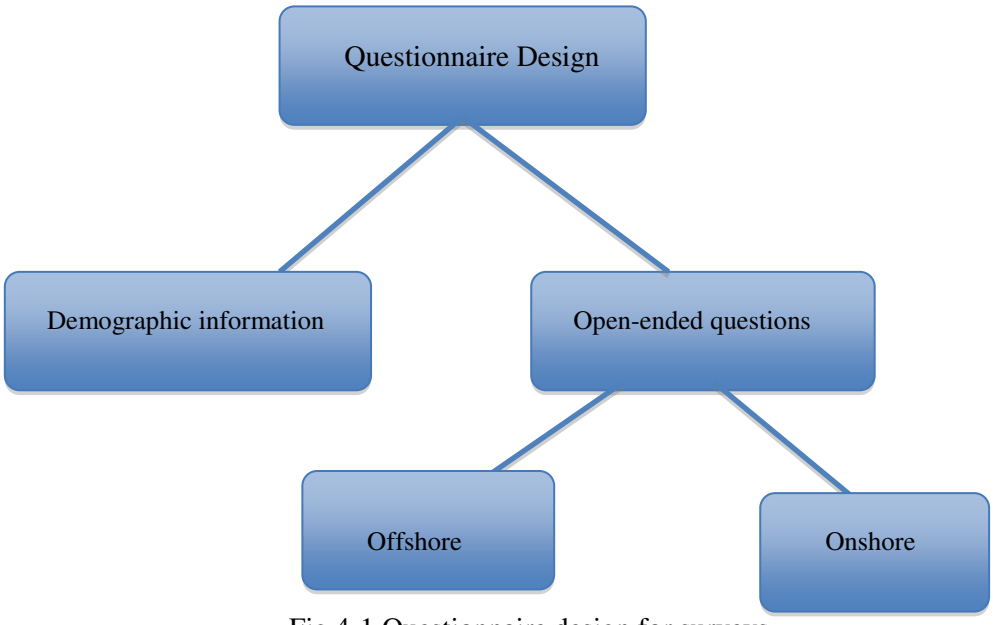

Fig 4-1 Questionnaire design for surveys

- Demographic Information

  Demographic information gives assistance to the researcher about the practitioner's roles and responsibilities in their organization. In our survey, we raised certain set of questions to the industrial practitioners like,

  - Name of the organization they are for?
  - How many years of experience in that organization?
  - What is their current designation in the organization?

- Survey Questions

  The entire survey questionnaire is divided into two sections basing onshore and offshore challenges and their mitigations obtained by systematic literature review. We have divided our questions into two sections i.e., Questionnaire-A and Questionnaire-B. Questionnaire-A was filled by the participants who worked or working offshore. Questionnaire-B was filled by the participants who worked or working onshore. Main aim of the two sections is to validate all the challenges and mitigations that were found during the systematic literature review and to make findings about the similarities and differences in challenges and mitigations found both in systematic literature review and surveys conducted for industrial practitioners.

4.2 Distribution of survey questionnaire

We have sent the web reference link of survey questionnaire to the industrial experts whom we have contacted prior to the kickoff. We have chosen the participants based on their project (offshore-onshore) they are working for. We have incorporated most of the answers from the high level management employees like project managers and test leads. Since they had worked for both onshore and offshore they can provide valuable data for the challenges that exists both at offshore and onshore. Depends upon the experience participants having either they had answered the questionnaire A and questionnaire B. If participants are having experience both at offshore and onshore they had answered both the questionnaires.

4.3 Survey Piloting

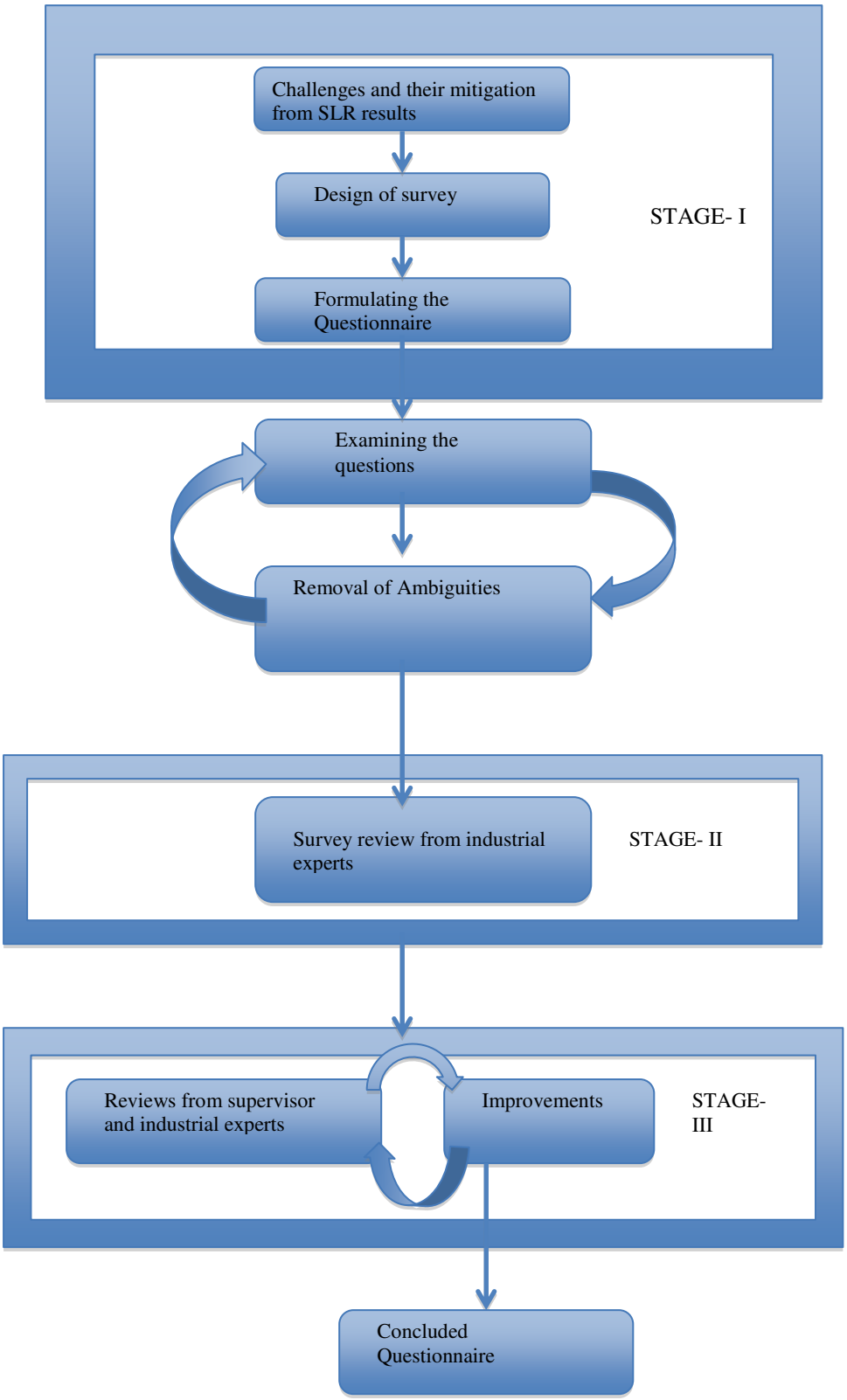

Fig 4-2: Process of survey Piloting

Chapter 5
SURVEYS AND DATA ANALYSIS

5.1 Data Analysis

We have applied grounded theory to analyze the data obtained during surveys conducted to industrial practitioners. In surveys we have provided open ended questions for the survey practitioners to express their experiences; they have given answers in the form of statements. We gathered all those data which contains challenges or relevant mitigations. In order to analyze the data we applied grounded theory, "A grounded theory is one that is inductively derived from the study of the phenomena it represents" [37, p.23] Key focus is the reflective reading of text and the application of codes. GT is about focusing on generating theoretical ideas (or hypotheses) from the data. Grounded theory involves in sequential series of stages, they are Open coding, Axial coding and Selective coding.

Open coding: During open coding the data that was collected during the surveys were broken down into discrete parts, closely examined, and compared for similarities and differences and questions were asked among the thesis authors about the phenomena as reflected in the data [37] [54].

Axial coding: It involves re-building the survey data (which was broken down to open codes) in order to establish relationships between categories and subcategories [37] [54].

Selective coding: In selective coding we refine and integrate all the categories into theories, which accounts for the phenomenon being investigated thoroughly and to validate the statements of relationships among concepts [37] [54].

In this process after applying the grounded theory we have obtained 26 open codes for challenges and 60 open codes for mitigations, and finally three Selective codes, results are displayed in the table: 5-1.

The process of how we have applied the grounded theory applied is illustrated using some of the responses from survey practitioners. When we have asked survey participants what are the mitigating factors to get more transparency at offshore two of the participants has answered in below statements.

Participant1: *Documentation of every activity and recording all results in time. Frequent connect with the team on progress and pain points.*

Participant2: *Proper documentation, regular reviews and regular follow up on the deliverables.*

We fractured above statements into open codes, when we compare those two open codes, documentation of every activity was common in both statements, there are some other mitigations which are different in both statements, they are frequent connect with the team mate to discuss about the progress and critical points. The second mitigation which was covered in the second statement, it is regular reviews and regular follow up on the deliverables which was developed by offshore team is the second mitigation strategy. We have categorized these two open codes under process transparency; we again reassigned this category of process transparency for Project selective code. Since onshore team expecting all the software testing project activities to be transparent to keep track of every deliverable and to maintain the trust on offshore team mates.

S.no	Coding stages	Total number of codes
1	Open code	86
2	Axial Code	10
3	Selective Code	3

Table 5-1: Results of grounded theory applied to survey data

5.2 Observation of Survey Results

We have collected both challenges and mitigations during surveys as it was already mentioned, this section starts with the new challenges that were collected, they are categorized into personnel, project and technological/infrastructural factors. Table 5-2 contains all the challenges that were gathered under the personnel factors and also clear explanations were provided depending upon the data provided by survey practitioners.

5.2.1 Challenges that were obtained under Personnel factors

S.no	Subsequent Category	Challenge Category	Challenge
C69		Delay of work	When there are complex topics
C70		Delay of work	Requirement Freeze delay
C71		Delay of work	Unavailability of Business Analyst on time
C72		Delay of work	Support from Build Teams
C73		Delay of work	Change in requirements
C74		Delay of work	Usage of Agile methodology
C75		Delay of work	Difficulties in process understanding
C76		Delay of work	Lack of expertise
C77		Delay of work	Geographical issues causing unplanned absenteeism by offshore employees
C78		Legal Sanctions	VISA issues
C79		Legal Sanctions	Delay in getting the SSN in US
C80		Legal Sanctions	Delays in getting H1B visa's and limitations on J1 Visa's
C81		Legal Sanctions	Restrictions for offshore employees who doesn't have citizenship
C82		Legal Sanctions	Work visa's with Limited Time stamps

Table 5-2: Challenges belonging to Personnel factors obtained during surveys

5.2.1.1 Legal Sanctions

The contractual nature of offshore outsourcing includes legal sanctions, this hinders in building the cohesive teams to work on projects, especially when the offshore vendor employees visit onshore client location. In some countries like united stated local country imposed several restrictions on vendor employees, onshore employees are not allowed to treat equally, onshore employees are not allowed to give any bribes for the excellence of

their work etc. These are some of the issues covered in the literature review, when we tried to include some more challenges in surveys; survey participants shared their experiences when they have to visit onshore location. Participants in the survey bemoaned as *"Sometimes associates stopped at immigration and sent back from port of entry. Delay in getting the SSN in US".*
In countries like United States of America employees who had visited Client organizations has taken time to settle in the working organization. There will be long time delay in getting efficient work output in such situations as they were not included legally as their organization employee. Even people were sent back to home country at immigration check itself, getting the social security number also cumbersome. Some survey participants also expressed that they have some visa issue's they were unable to get their visa's in correct time this had impacted on the service delivery, one of the participant expressed that *"Delays in getting H1B visas, limitations on J1 visas. Problem aggravated after 9/11 and the 2009 financial crisis. Off shore employees cannot work on Federal/Defense clients due to Citizen Ship and clearance requirements. Access to classified/confidential/restricted data for realistic testing of software code."*

We can understand from the above experience of survey practitioner is that, getting H1B visas got delayed for employees who visit onshore and also there are limitations on J1 visas. Imposing restrictions became more intense after the 9/11 attacks in America and the financial crisis in 2009. Offshore vendor clients are not allowed to work on clients who belong to Federal/Defense departments if an offshore employee doesn't have citizenship in Unites states. Even offshore employees are rarely having an access to confidential and restricted data to perform realistic testing of software code.

5.2.1.2 Work Delays

In recent days of software engineering, most of the product development and service oriented company's shifted from traditional software development to agile. In agile new executable piece of software code is developed and has to be tested with in short deadlines. If the developer delays the development, testing department has to wait to run their test cases. If there is any delay in work by developers testing activities will be slowed down at offshore. During complex topics, requirements freeze delay, unavailability of business analyst, agile methods and when there is a lack of process understanding and lack of expertise there are huge work delays
.

5.2.2 Challenges that were obtained under Project factors

Table 5-3 contains all the challenges that were gathered under the project factors and also clear explanations were provided depending upon the data provided by survey practitioners.

S.no	Subsequent Category	Challenge Category	Challenge
C83	Building effective communication channels	Information gaps	Lack of understanding functionality assumptions
C84	Building effective communication channels	Information gaps	Software coding differences
C85	Building effective communication channels	Information gaps	Misunderstanding between team mates

Table 5-3: Challenges belonging to Project factors obtained during surveys

5.2.2.1 Building effective communication channels using Information gaps

Problems in building effective communication channels still prevails in OOST, we came across some of the issues in surveys. There is no proper exchange of information when there is lack of understanding in functionality assumptions and software coding differences. Information gaps between onshore and offshore employees also created misunderstandings between teammates.

5.2.3 Challenges that were obtained under Technological/Infrastructural factors

Table 5-4 contains all the challenges that were gathered under the technological/ infrastructural factors and also clear explanations were provided depending upon the data provided by survey practitioners.

S.no	Subsequent Category	Challenge Category	Challenge
C86	Automation Testing	Testing Tools	Testing tools cannot test complex scenarios
C87	Automation Testing	Testing Tools	Testing is incomplete and issues at the UAT phase
C88	Infrastructural Bottlenecks	Test Environment	Test environments are slow
C89	Infrastructural Bottlenecks	Test Environment	Test environment issues to run automation suites
C90	Infrastructural Bottlenecks	Test Environment	Instable test environment
C91	Automation Testing	Testing Tools	Cost Overruns
C92	Automation Testing	Testing Tools	Mistrust in employees and employer
C93	Automation Testing	Testing Tools	Project Delays

Table 5-4: Challenges belonging to Technological/Infrastructural factors obtained during surveys

5.2.3.1 Testing tools and Test Environment

In recent trend of software testing, manual testing has transformed to automated testing which involves in testing the software code with testing tools. According to survey practitioners real time issues some testing tools cannot test complex scenarios, this leads to incomplete testing of software and issues prevailed at User Acceptance Test. There are also some issues with test environment are notices, like test environment issues to run automation suites and test environments are slow and instable. Testing tools and Test environments caused in project delays and mistrust in employees and employers.

5.2.4 Coping up strategies obtained under Personnel factors

Table 5-5 contains all the mitigating strategies that were gathered under the Personnel factors and also clear explanations were provided depending upon the data provided by survey practitioners.

S.no	Subsequent	Challenge	Mitigation

	Category	Category	
M43		Language	English as a common language
M44		Culture	Same language
M45		Culture	Organization style
M46		Culture	Hierarchies
M47		Culture	Team Structure
M48		Culture	Decision making
M49		Culture	Working Style
M50		Culture	Approach to Solution
M51		Work Delays	Extension of Testing sign-off
M52		Work Delays	Start testing from requirements gathering phase
M53		Work Delays	Proper planning assuring no delay for UAT
M54		Work Delays	Proper scheduling

Table 5-5: Mitigating strategies belonging to Technological/Infrastructural factors obtained during surveys

5.2.4.1 Language

Adapting for common language like English will reduce the language problems to most extent in OOST. Both onshore and offshore employees have to use single language for the better communication.

5.2.4.2 Culture

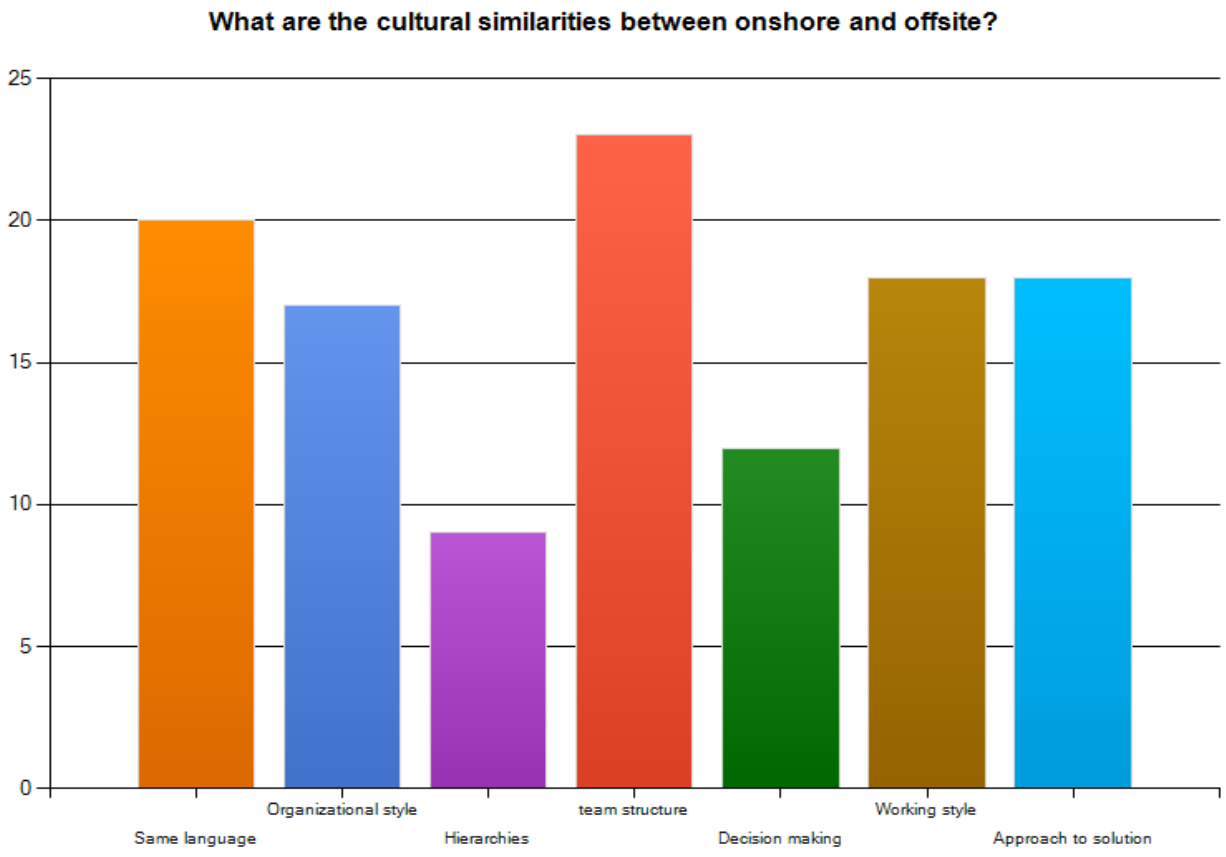

Fig 5-1: Cultural similarities between onshore and offshore employees

"Daily meetings to bring" these are the words said by one of the participants in the survey. To overcome the problems posed by dissimilar cultures followed at onshore and offshore personnel at both offshore and onshore had followed conducting the daily meeting to share and understand the work done by the offshore employees. In surveys we had allowed the participants to exhibit their cultural similarities that they had found in both onshore and offshore organizations. They had provided some of the similarities they found while they working in onshore offshore software testing project. They are following of same language, most of the participants said that their common language is English as their projects are mostly done in Multi National Companies they did not faced any language problems.

During literature review we mostly identified threat that caused due to the cultural incompatibility was admittance of mistake by the offshore employees. During our entire research most of the challenge of cultural compatibility was aroused with the Indian software employees as they are not willing to say "no" for anything that was asked by the onsite managers and employees during the problem escalation. We have planned to cover as many responses for this particular question from Indian employees. Below we presented graphical representation of responses of survey participants. Most of the participants bemoaned that there is only 50-75% (fig 5-2) genuineness in the admittance by the offshore employees which highly affects the trust, quality and productivity of the work. Nearly 5 to 6 employees expressed their grief as they are not having the genuine information from offshore. From fig 4-1 similar organizational styles, hierarchies, team structures, decision making by managers, working style of employees and approach to solutions also includes the list of cultural similarities that must be possessed by both onshore and offshore teams to cultural issues to some extent.

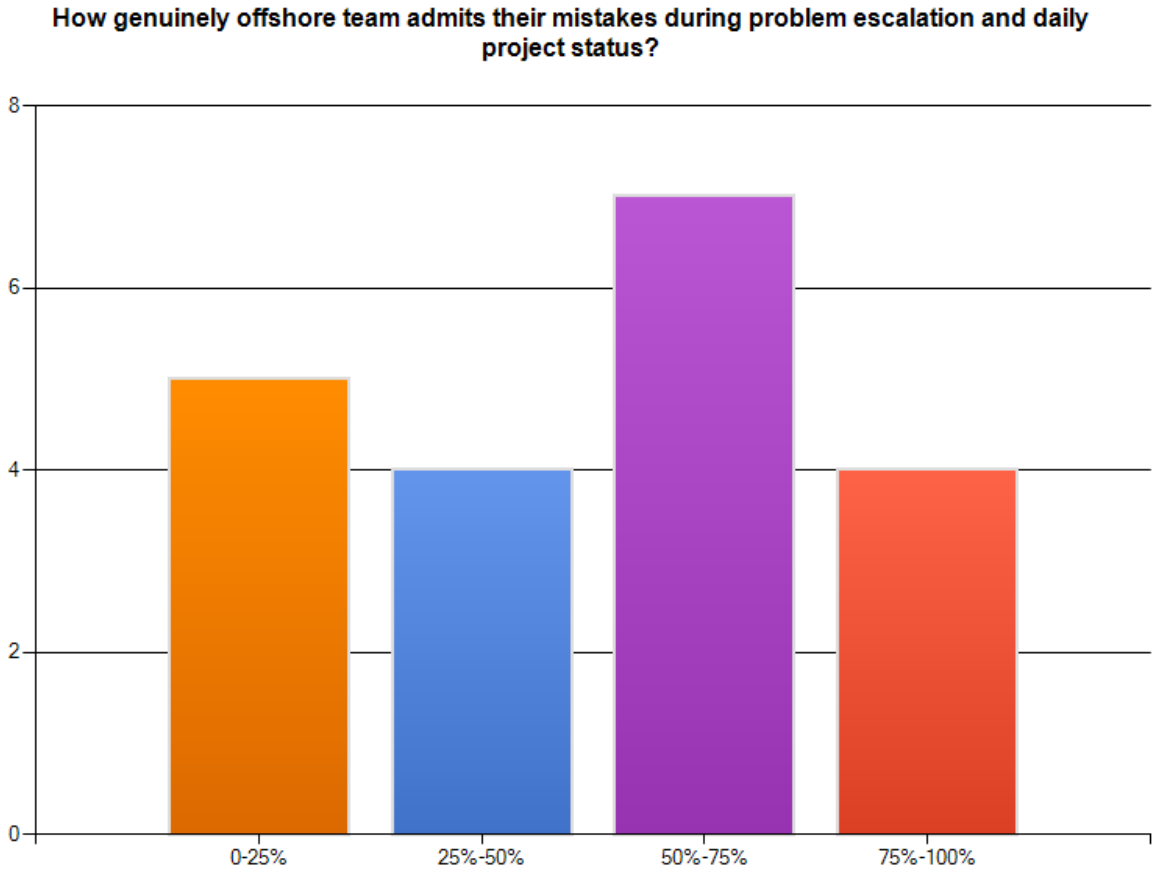

Fig 5-2: Graphical representation of survey respondents

5.2.5 Mitigating Strategies Obtained for Project Factors during Surveys

Table 5-6 contains all the Mitigating strategies that were gathered under the Project factors and also clear explanations were provided depending upon the data provided by survey practitioners.

S.no	Subsequent Category	Challenge Category	Mitigation
M55		Legal Sanctions	Home and Host country legal countries have to take care of such issues.
M56		Exchange of Information	Test cases and test environments are shared
M57		Exchange of Information	Maintaining shared directories
M58		Exchange of Information	Proper KT
M59		GeoPolitical	Start testing services at multiple locations
M60		GeoPolitical	Compensate using extra efforts
M61		GeoPolitical	Business Continuity Plans
M62		GeoPolitical	Working extra hours
M63		GeoPolitical	Deploying associates based on criticality
M64		GeoPolitical	Work on Weekends
M65		GeoPolitical	Daily meetings and working strategically
M66		GeoPolitical	Proper Planning
M67		GeoPolitical	Open new locations
M68		Process Transparency	Regular Reviews
M69		Process Transparency	Regular Follow-up
M70		Process Transparency	Common tool for recording the test results And micro Soft Project Plans
M71		Process Transparency	Keeping all documents in shared drive
M72			

		Process Transparency	Maintaining a issue log and discussions on daily basis
M73		Process Transparency	Status meeting
M74		Process Transparency	Daily Execution Reports
M75		Process Transparency	Daily Activity Reports
M76		Process Transparency	Involvement of Test Engineers in Quality Assurance
M77		Process Transparency	Shared testing tool and Defect tracking tool
M78		Process Transparency	Monitoring Quality Control on timely basis
M79		Process Transparency	Following the standard procedure provided to offshore employees
M80		Process Transparency	Documenting whole testing activity
M81		Process Transparency	Timely reporting on a hourly and daily basis
M82		Process Transparency	Close monitoring of Work progress
M83		Knowledge Transfer	Exchange of emails
M84		Knowledge Transfer	Live Meetings
M85		Knowledge Transfer	Video Conference

Table 5-6: Mitigating strategies belonging to Project factors obtained during surveys

5.2.5.1 Legal Sanctions

There are always such constraints from the contracts and legal departments on the length of the time that vendor team employee can be present onsite. These legal sanctions affected the

vendor team employees working attitude toward the work. As from both the surveys and literature we have identified the best coping strategy that is in practice is the Shadow the vendor employee who is going back to the offshore office. Following graphs from the Fig 5-3 reveals the count of applying the shadowing practice by the survey participants.

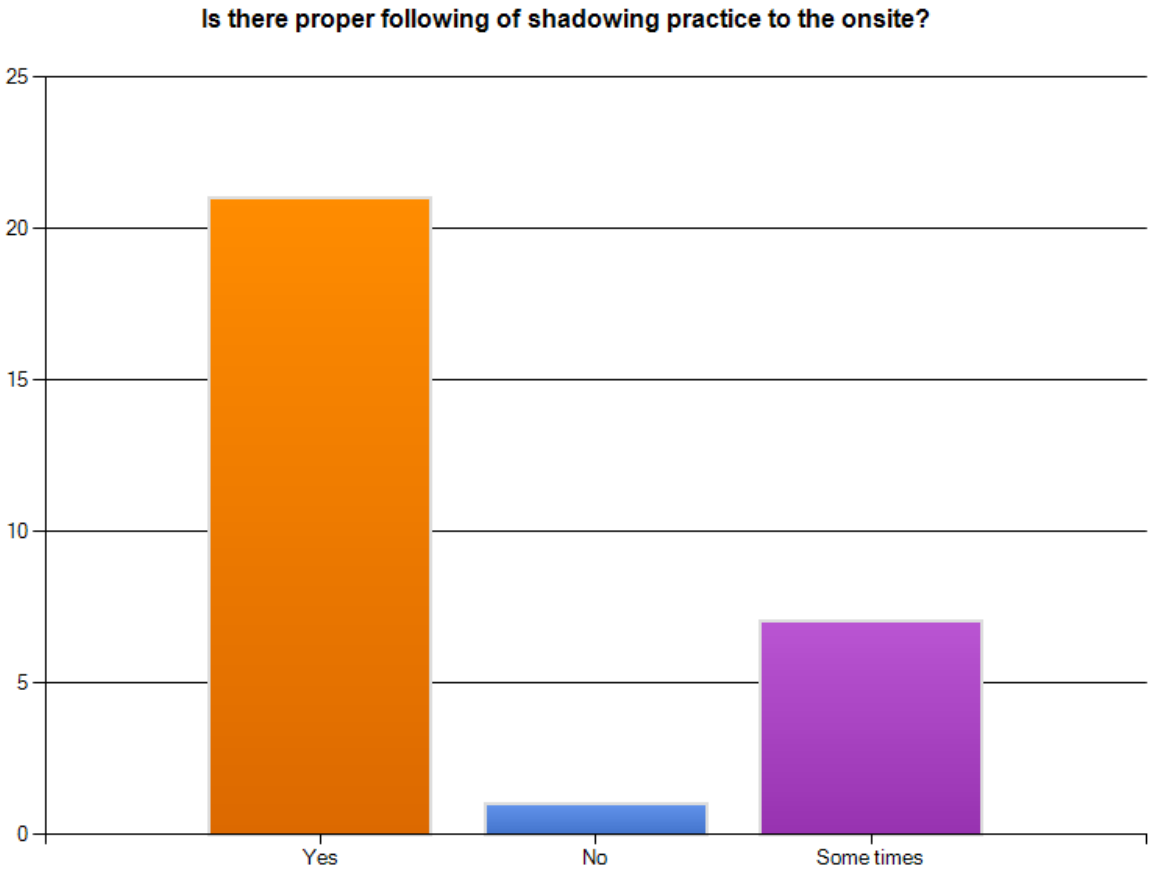

Fig 5-3: Trend of Shadow practice experienced by the practitioners

Most of the survey participants claimed that most of the organizations in which they are working followed the shadow practice.
"We will have fortnight calls with customer and weekly calls with onsite team"
In the above stated lines survey respondents expressed that they will have fortnight calls and weekly calls with onsite teams.
Some of the survey participants told that *"Normally home and host country legal departments take cares of such issues. No impact at resource level unless some unknown issue arises"*. In some organizations both client and vendor organizations are taken care about legal issue related to the stay of offshore vendor employees.

5.2.5.2 Geopolitical issues

Geopolitical issue's greatly hinders the testing activities which are proceeding on at offshore organizations. Following are some of the coping up strategies that were suggested by surveys practitioners that were being implemented by them to cope up some of the challenges caused by Geopolitical issue's.
"We worked on weekends also in order to deliver the work in time"
"Huge delay on delivery of results .Opened up new locations for"
"During New Resource Deployment time, delays happened on work. By having Daily meetings with offshore team to bring everyone on the same page we resolved issue strategically."

It signifies that work delay caused the employees to work for long hours to complete the work in deadlines. It had created many inconveniences for manage the work at both offshore and onshore. As a consequence there is always a delay caused deliverables which are to be sent onsite (Client organization). Some organizations had strictly confined to the practice of daily meetings. Starting work at multiple sites also considered as the best coping up strategy by industrial practitioners.

5.2.5.3 Knowledge Transfer

There are some of the mitigating strategies revealed by survey participants. Few of the participants expressed *"Expect them to know the industry and read the business process/requirements documents developed during the initial phase"* .One of the survey participant has expressed above lines. After extensive knowledge Transfer session is given, onshore employees expect the bare minimum things from offshore team to know what is going on in the industry, domain knowledge on which they are doing their testing project and to read the business process requirement documents developed during the initial phase.

"Most of the KT sessions will be online so i don't think there is much spent on KT sessions" These are some of the lines expressed by the survey practitioners. Most of the knowledge transfer sessions are carried out through online. They should be planned properly; software test teams must always have well trained employees to perform software testing activities since lack of expertise will always affect quality standards. There are some channels by which onshore employees used to transfer the knowledge from onshore to offshore they are presented in the Fig 5-4.

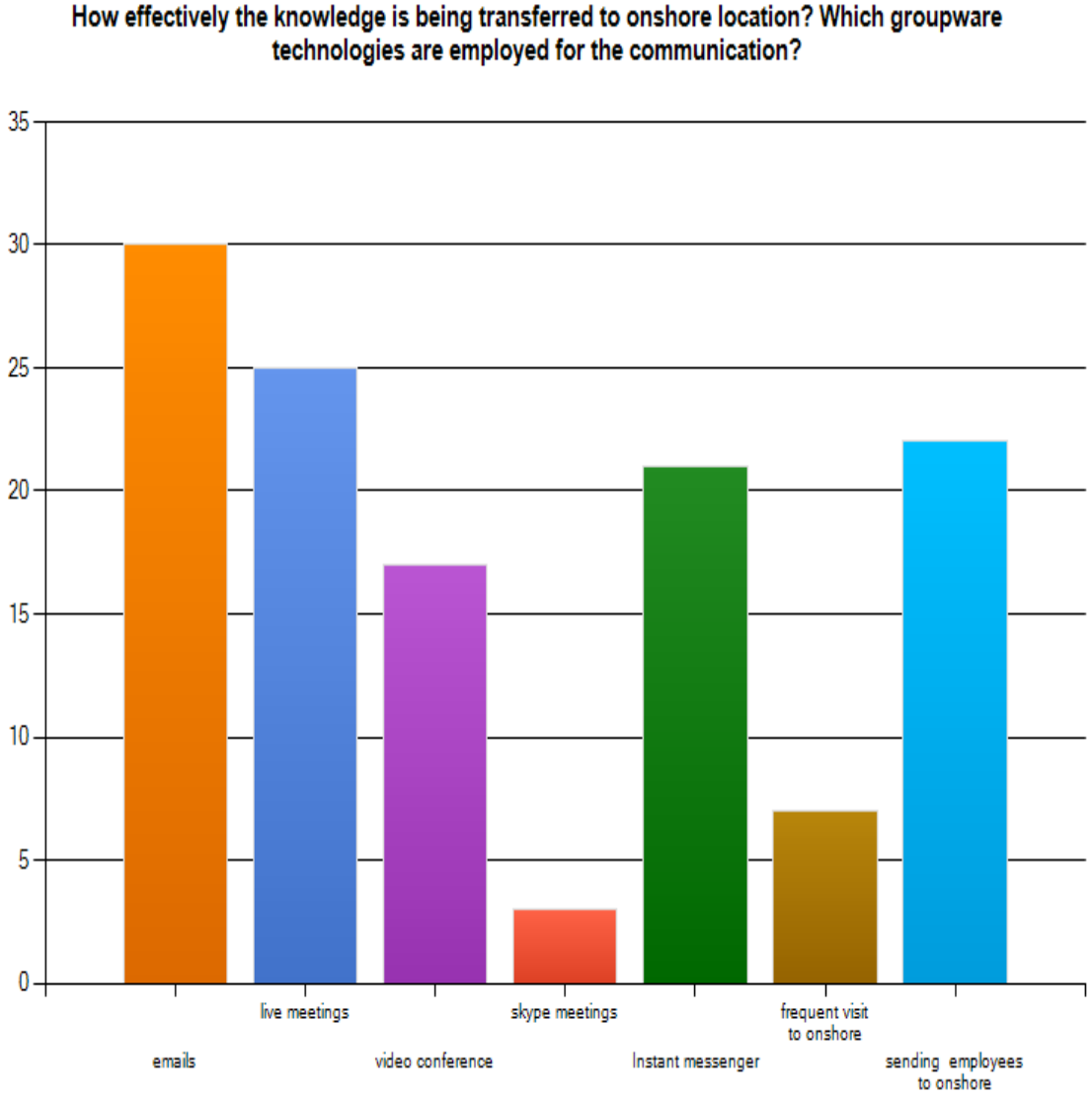

Fig 5-4: Different types of channels for Knowledge transfer by survey respondents

They above graph represent the mostly used approach for making a good communication channel with the onsite employees. Emails, live meetings, video conferences, Instant messengers, sending employees onshore has the most priority compared to the Skype meetings and frequent visit to onshore.

5.2.6 Mitigating Strategies Obtained for Technological/Infrastructural Factors during Surveys

Table 5-7 contains all the Mitigating strategies that were gathered under the Technological/Infrastructural factors and also clear explanations were provided depending upon the data provided by survey practitioners.

S.no	Subsequent Category	Challenge Category	Mitigation
M86	Infrastructural Bottlenecks	Test Environment	Take help from developers
M87	Automation Testing	Testing Tools	Usage of reliable and robust tool for test management and defect tracking

Table 5-7: Mitigating strategies belonging to Technological/Infrastructural obtained during surveys

5.2.6.1 Test Environment and Testing Tools

Some of the survey participants echoed that *"Not really in all scenarios. In case of complex scenarios manual testing will be better than automated.1.Complex scenarios were too many interfaces.2.Different sets of test data."*

"This differs from business to business. In case of automated scenarios large implementations Automation is a better solution and for small project the manual testing.1. Automated scenarios gives quick and accurate result.2.Result will be consistent."

Depends upon the scenarios and application size of the software the option of selecting whether automated or manual varies. Test automation can be confined to a certain tool, and usually the characteristics of the tested application or system.

"Testing tools are reliable but cannot test complex scenarios. The testing environment is quite good. Normally the defect tracking becomes very dif"

"This is normally ironed out during the scope and objectives prior to signing the contract"

Offshore team have good Test Automation Skills, sometimes we have test environment issues to run automation suites over nights which causes some delays on deliverable". Some of the other survey participants had bemoaned as above, these words has a lot of significance on the reliability of software test tools. It shows how far the onsite client employees reliant on the testing tools. They should be very efficient in producing the results, based on the scenarios in which the software testing tools are employed either they may be complex or easy they should not fail in producing effective results. Even the testing environment at vendor side must be sophisticated and updated according to the varying application scenarios. These conflicts should be better negotiated prior to the signing of the contract.

CHAPTER 6
EFFECTIVENESS IN OOST

6 Effectiveness in Outsourced offshore Software testing

We have taken cost effectiveness, Quality Standards, Productivity and Turnaround time as an instrument to quantify the effectiveness in outsourced offshore software testing. We have gathered the statistical information from the survey participants. As per the literature and based on contacting some industrial experts who have been working as Project Managers, Delivery Managers and some Company directors we have taken these attributes into consideration.

6.1 Innovation and shared best practices

As far from the below diagram, it was shown that innovation and shared best practices has given a highest priority. In software testing, it is the main aim to show that the software free of bugs and works according to the customers need, testing to be done on the complex codes in which developers always implements new technologies in the concern of robustness. Test Engineers should always keep in mind that they should always have a new technologies and best innovations, hence even the industrial experts voted much for the shared innovation and best practices. When we go for the next best attribute as per the industrial experts are improved resource allocation.

6.2 Improved resource allocation

In offshoring software testing activities it is more about giving services and providing resources to execute the testing activities mutually. In this setup it is more about emphasize the technological resource allocation. Some of them are below.

> ***1. Information security or firewall issues:*** *problems in setting up connectivity between vendor and client.*
> ***2. Infrastructure setup:*** *Differences in technology access requirements between onshore and offshore locations.*
> ***3. Employee presence:*** *Lack of employee presence at the client location for smooth flow of knowledge transfer and to iron out communication gaps*
> ***4. Testing tools:*** *Sometimes client manager relies on the testing tools that are implemented in the offshore location, at that times vendor employees have less knowledge about the testing tools and are incapable to implement them it has caused a very big problem.*
> ***5. Test Environment:*** *Test tools, software, licenses, hardware components and accessories that are essential to setup test environment.*
> ***6. Test Automation:*** *Documents which are necessary and all the tests, specifications and guidelines that were applicable to the test automation point of view.*

6.3 Access to large skilled labor pool

It is the one of the biggest motivating factor for most of the western mostly from United States of America and Europe to outsource the software testing activities to countries like India and China, where the software development and its related activities are cheap at cost. Expertise, skillfulness, good domain knowledge, communication skills, good team playing skills and trouble shooting skills are given high priority for the employees. There are some companies which always verifies the background and years of experience of employees when they are about to transfer the project to offshore.

6.4 Leveraging time zone effectiveness

Effective time zone always improves the quality of entire process of OOST setup. Before the contractual agreement it is always suggestible to look upon the convenient time zones, which enable smooth transition of work from onshore to offshore and vice versa.

6.5 Strategic Contractual Relation

This was placed last according to the expert's point of view but always beneficial in projects with long term duration. Reinforcement of contracts should be done often because client needs are always changing.

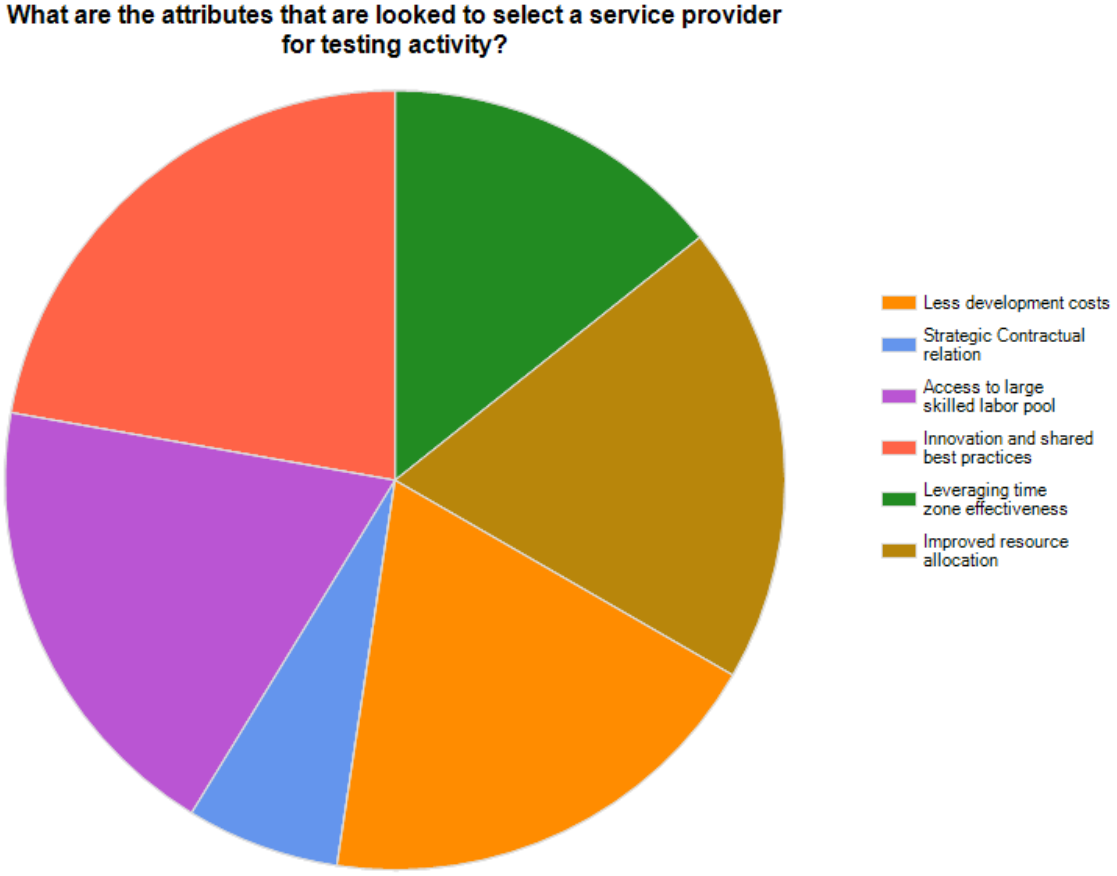

Fig 6-1 attributes of service provider

6.6 Perspective of Effectiveness in both Offshore and Onshore employees

Effective of outsourced offshore software testing from Vendor Organization employee		
Answer Options	**Response Percent**	**Response Count**
Cost effectiveness	96.6%	28
Quality Standards	100.0%	29
Productivity	100.0%	29
Turnaround time	93.1%	27

Table 6-1: Count of offshore vendor employee responses about effectiveness

As per the above table depicted we have asked the same question for both high level and low level employees of vendor organizations. We have asked them what is the percentage of following attributes have influenced them.

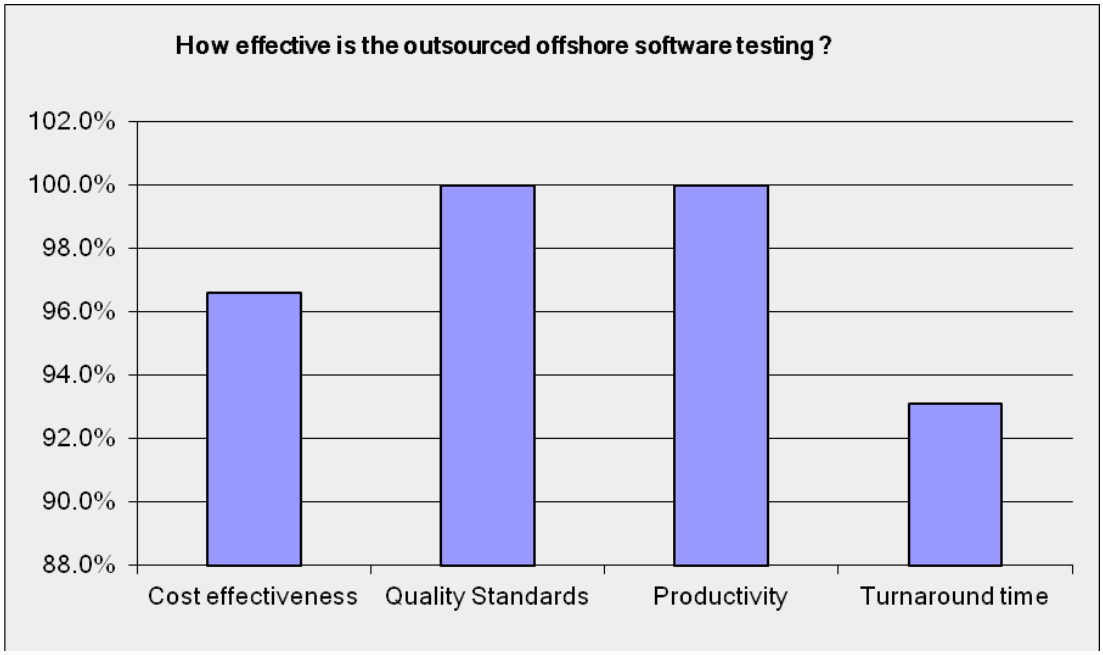

Fig 6-2: Count of offshore vendor employee responses about effectiveness

6.7 Perspective of Effectiveness in both Offshore and Onshore employees

Effectiveness of Outsourced offshore Software testing from Client Organization		
Answer Options	**Response Percent**	**Response Count**
Cost effectiveness	90.9%	10
Quality Standards	100.0%	11
Productivity	100.0%	11
Turnaround time	90.9%	10

Table 6-2: Count of onshore Client employee responses about effectiveness

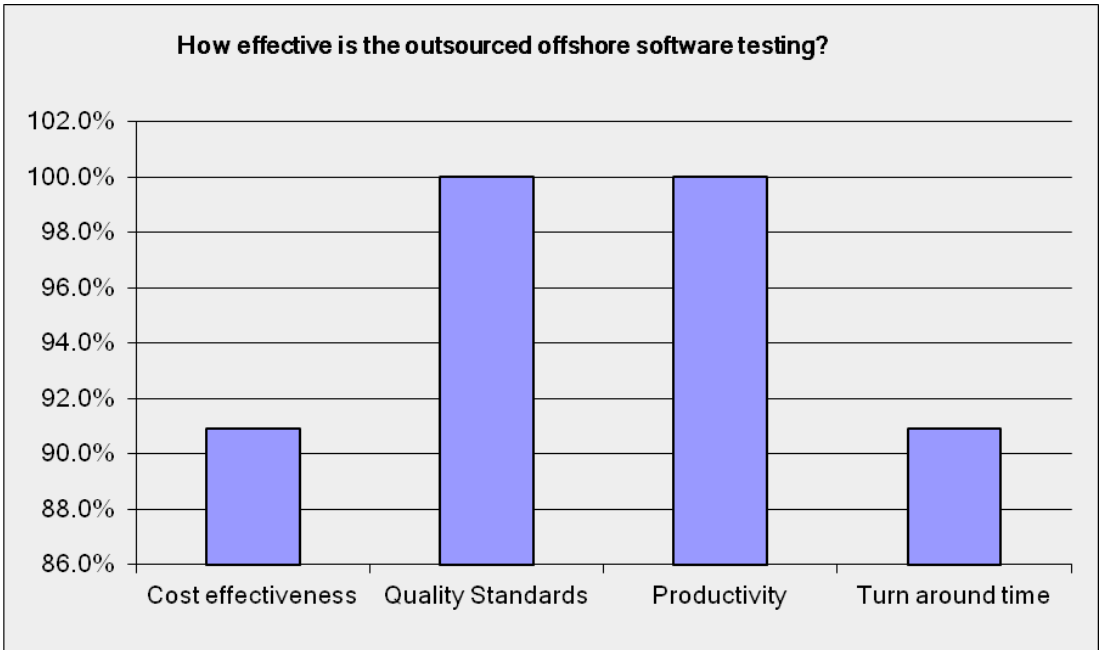

Fig 6-3: Count of onshore client employee responses about effectiveness

If we compare both the diagrams which reflect the opinions of both onshore and offshore employees, attention is paid much for quality standards and productivity of the software testing activity. We have thrown light on the concept of productivity in the above sections.

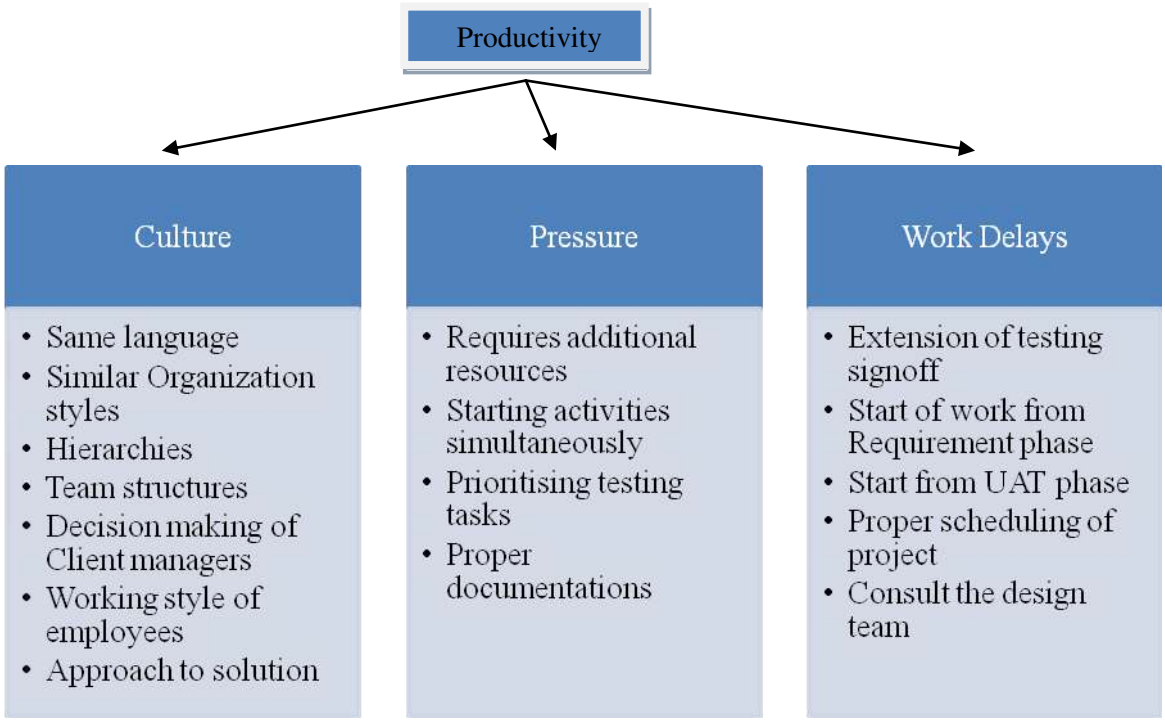

Figure 6-4: Description of productivity and its related attributes

As from the above diagram enlighten that productivity of software testing employees depends on some sub factors like Culture, pressure and work delays. Challenges and their corrective actions have provided in the below. Above challenges categories decreases the productiveness of the software employees which hinders them to perform up to their best productive levels. Corrective steps are taken based on the results of systematic literature review and experts opinion collected through the surveys.

6.8 Quality Standards

The whole discipline of research is meant to toughen the quality standards depending upon the concerned research area. Concept of quality occupied a very less space in the literature; it is not possible to cover the entire notion of quality in this thesis. Quality can be something illusive that is hard to define, as per the software testing we can improve the quality by means of product and process as well. If we consider this OOST set up and this thesis, there are some aspects which influence the quality of software testing.

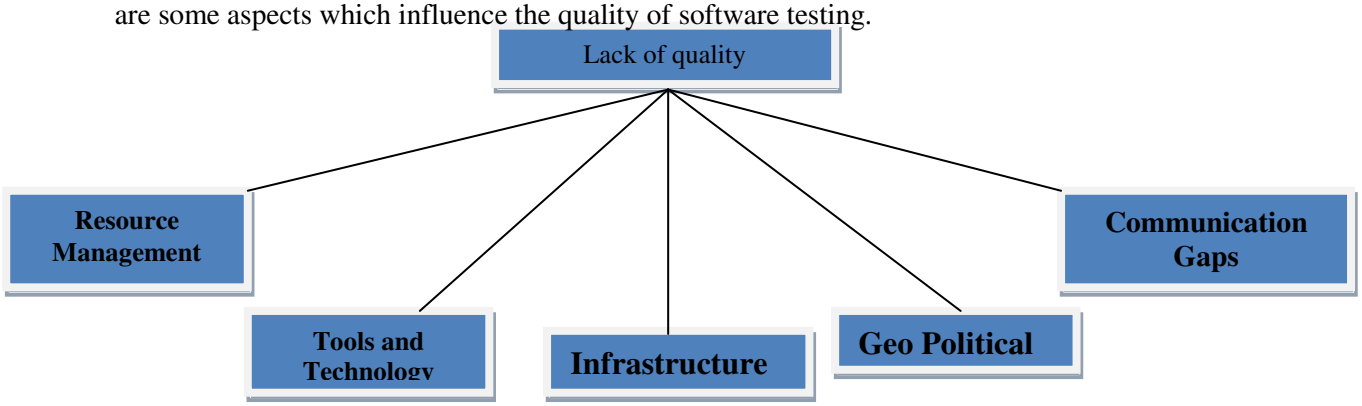

Figure 6-5: Quality and its related attributes

Above figure gives an idea that lack of quality arises due to issues life poor resource management, ineffective utilization of tools and technology, poor infrastructure available to perform the tests, unstable geopolitical situations and large communication gaps. We have stresses on these aspects while discussing the challenges and their mitigations in SLR part and survey results. Before the project kicks off both the parties' vendor and clients must sit together on these aspects which affect the quality of Software Testing activities.

CHAPTER 7
DISCUSSIONS

7.1 COMPARITIVE ANALYSIS

The primary reason behind conducting comparative analysis is the explanatory interest of obtaining a better understanding of the casual processes involved in the production of theory. We have performed comparative analysis to observe the challenge and mitigation strategies we have identified all through this thesis. We intended to observe similarities and differences among the challenges and mitigations of OOST. In Comparative analysis we have compared the cases (Open codes) through human analytical insight rather than using any software. There are two features that define comparative analysis 1. An interest in explanatory question of why the observed similarities and differences between cases (Open codes) exist. 2. Reliance on the collection of data on two or more cases available [51] [52]. We applied qualitative data analysis using grounded theory on the data obtained during SLR and surveys; we have organized entire data by categorizing into certain codes. In the objective to map challenges and their concerned mitigation strategies we have observed for similarities and differences in challenges and mitigation categories. After the deep analysis of comparing and finding differences among challenges and mitigations, we have mapped suitable mitigation strategies to challenges to overcome the issues in real time scenario [51] [52].

For analyzing the results obtained from SLR and Surveys we used Qualitative Comparative Analysis (QCA) method.

As from the Table 7-1, there are 109 Open codes in SLR and 86 Open codes in surveys during this research. Both SLR and Surveys have 12 common Open codes and 97, 74 uncommon Open codes respectively.

Research Methodology	Open Code	Open codes which are in Common	Open codes which are Uncommon
SLR	109	12	97
Surveys	86	12	74

Table 7-1: Count of Common and Uncommon Open codes from SLR and Surveys

Challenges

When we tried to find what are the similarities and variance in Challenges and mitigations in SLR and Surveys, we are able to find only two common challenges in SLR and Surveys, rest of the challenges that are identified during surveys are new. This reinforced our study in order to incorporate as many challenges and mitigations and this also helped us maximize the collection of data about current industry practice.

Mitigations

Surprisingly when we started finding the Common mitigation strategies which are in common in both SLR and Surveys also very much few, there are only ten common mitigations that are common in SLR and Surveys. These counts have given authors a great confidence, because it was seemed for the authors that coping strategies that were adapting by the practitioners were mostly new and contemporary to the industry

7.2 Distribution of overall Challenges and Mitigations in OOST

In this thesis as we have already proposed, whole set of data into Personnel, project and Technological/Infrastructural. This thesis was conducted around these factors, we have considered these three factors as a pillars on which the whole OOST setup runs. Dispensation of challenges and mitigations that were collected during this thesis was shown in the figure Fig 7-1.

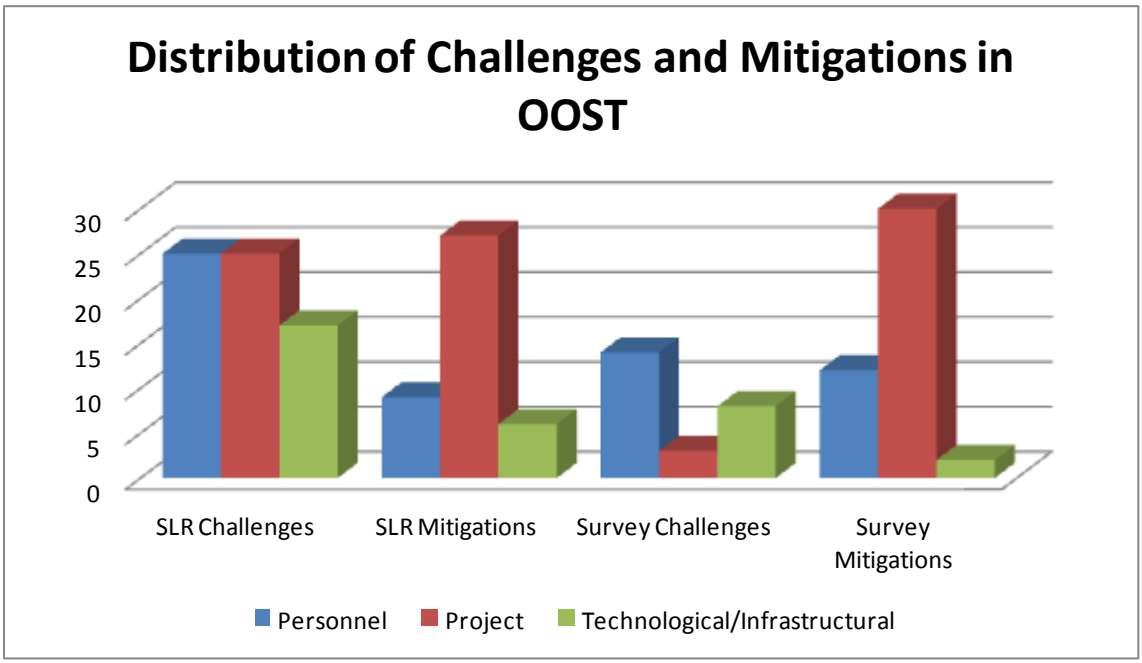

Fig 7-1: Distribution of Challenges and Mitigations in OOST

After conducting the surveys, we have mapped both Challenges and mitigation strategies. By considering the graph shown in Fig 7-1 ,we have observed that personnel and project factors affect most of the OOST setting. In personnel factors some of the challenges like culture adapted by the offshore employees, how the testers handle the pressure situations, efficient testing skills, trust to share the knowledge by onshore employees highly impedes the testing activities conducted at offshore. Project factor also got a greater proportion some of the challenge categories which fall under project factors like proper flow of knowledge transfer from onshore to offshore organization particularly while performing automated testing, coordination of work between offshore and onshore teams, communication patterns which build stronger relationships and process transparency of whole testing process at offshore are mostly challenging and discusses issues in SLR and surveys. Both onshore and offshore teams collectively focus on personnel and project factors for the smooth and better software testing activities. When Technological/Infrastructural issue's we have came across some challenges related to test environment and testing tools used in Automation testing. In surveys some of the employees suggested that testing tools are best when there is bulk of software to test and testing tools implemented also very sophisticated to bring the great results by offshore team. On the other side some of the survey practitioners are still facing some problems with the test tools and inactive test environments that are being used at offshore. We didn't find any relevant mitigation strategies in this thesis for those challenges and also when we analyze those responses from survey practitioners that still some of the companies unable to afford expenses to bring expensive and latest tools to implement in their testing projects. Onshore team must check CMMI levels of the vendor company to know whether they are having good testing tools and testing infrastructure, improvised testing process and software testing experts.

When we analyze the above graph in both challenges and mitigations there are enough number of mitigations to overcome the challenges related to Software Testing Projects.

7.3 Distribution of Challenges

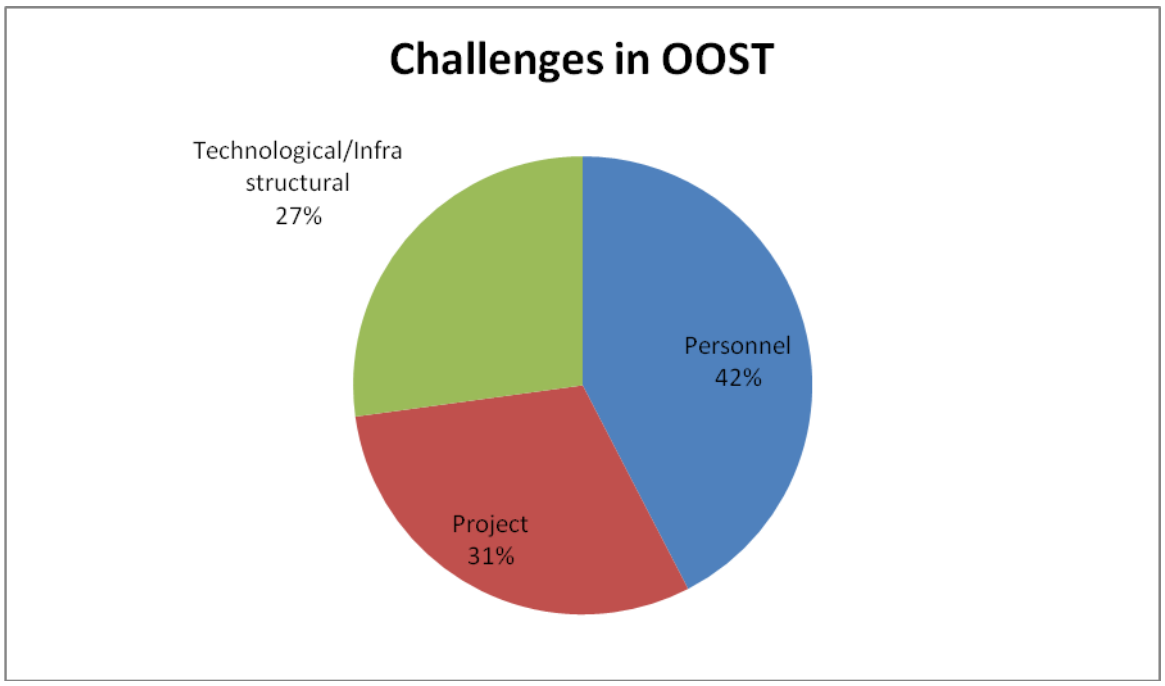

Fig 7-2: Distribution of Challenges in OOST

7.4 Distribution of Mitigation strategies

The below figure Fig 6-3 gives a statistical representation of how many mitigations this thesis could be helpful for industrial practitioners in solving out their challenges in OOST. There are 66% of mitigation strategies for project factors in a highest number, personnel and technological/Infrastructural factors comes in the next for personnel in its count.

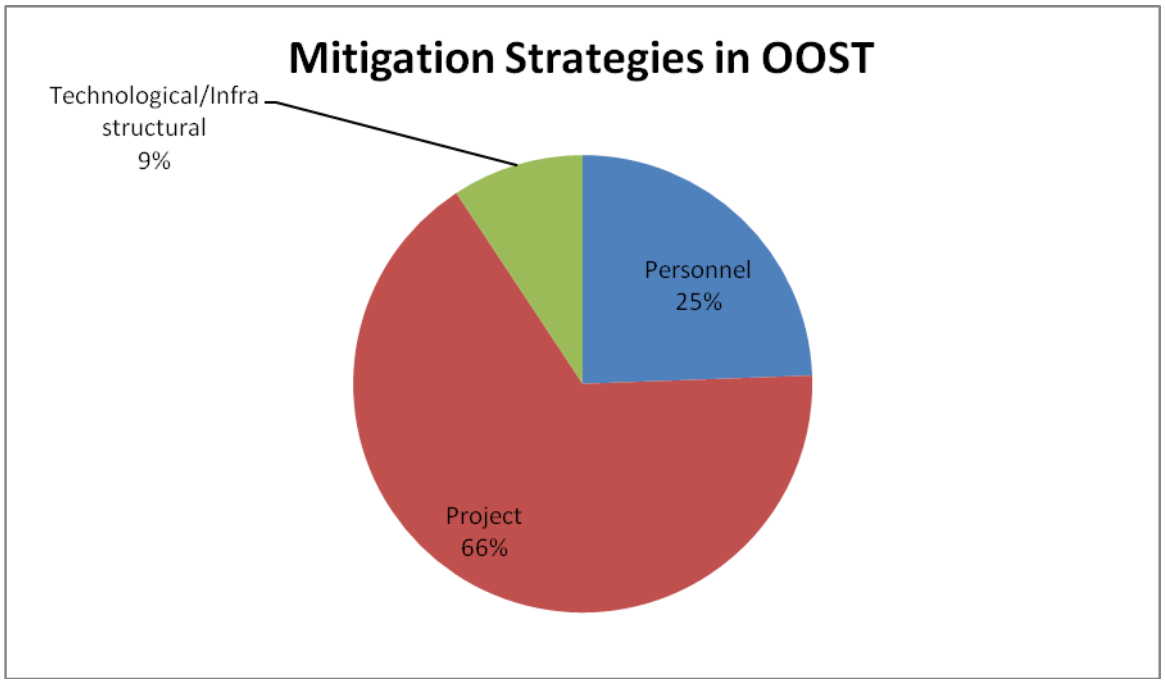

Fig 7-3: Distribution of Mitigating Strategies in OOST

7.5 Mapping of Challenges and Mitigation in OOST

As a part of Comparative analysis we have compared all the Open codes that are collected in both Challenges and Mitigations. The underlying goal of Comparative Analysis is to search for similarity and variances among the theories (Open codes) that were constructed using grounded theory. Those searches for similarity often apply on theories that were constructed during SLR and Surveys. At first we have combined all the open codes obtained in both SLR and Surveys, we have compared Open codes of both Challenges and Mitigation strategies gathered as a part of SLR and Surveys respectively, with our human insight we used to compare the Challenge Categories and Mitigation strategies. Later we have mapped relevant mitigating strategies for the challenges.

Associated Threats	Challenge	Coping Strategies adapted
Submission of code by developers.	Delay in work	***Extension of testing signoff***
Complex topics		***Start of work from requirement phase***
Requirements freeze delay		***Testing from UAT phase***
Unavailability of business analyst		***Proper scheduling of project***
Environmental support build teams.		***Consult the design team.***
Change in requirements		
Geographical Issues		
Lack of process understanding		
Lack of expertise		
Agile methods		

Table 7-2: Challenges and their mitigating strategies to overcome Work delays

We have taken an example to illustrate how we have performed mapping, if we take above table into consideration, it contains all the issues related to Work delays caused by the Software development team before code reaches to test team. There by it led to increase in pressure for testing team and there are unable to reach the deadlines imposed and high tension for the management to reach the market. In the third column from left we have given appropriate mitigating challenges for the Industry when its concerned issues are raised, as specified in the above table. Letters which are bold and italicized are the challenges and mitigations that are collected from Surveys.

We also felt that not only relevant challenge and mitigating strategies but also some of the other mitigations also seemed applicable for the other challenge categories. We have compared the also cross checked the mitigations with other challenge categories. For example "presence of Project manager or visit of project manager to Onshore Client organization" is the mitigation which is used to iron out the issues of project coordination, we have gathered the similar mitigation in the SLR that there should be at least one associate from Offshore as a Point of contact when offshore team is not available. Hence role of project manager has played a key role to address some of the challenges like proper communication to exchange or extract information, co ordination of work, decision making during critical issues and Knowledge transfer.

7.5.1 Mapping of Mitigations to Challenges

In the following tables 7-3, 7-4 and 7-5 mapping of mitigations to challenges, mapping of challenges to mitigations performed and challenges which doesn't have mitigations are presented respectively. We have taken Challenge right from Challenge Id1 from the SLR and we provided concerned mitigating strategy Id.

CID	Challenge	Mitigation ID	No of Mitigating Strategies
C1	Lack of Cultural compatibility between Vendor and Client	M44,M45,M46,M47,M48,M49 and M50	7
C3	Employees at onshore unwilling to admit their mistakes	M36,M19,M6 and M8	4
C5	Difference in Level of Thought	M50,M49 and M6	3
C9	Difference in Expectations	M6,M7,M8,M9	4
C10	Difference in approaching details during Testing	M6,M7,M8,M9	4
C11	Misunderstanding between staff	M6,M7,M8,M9	4
C12	Usage of different languages at vendor and Client	M43	1
C13	Offshore team hardly talk English	M22	1
C19	Multiple languages in communication	M43	1
C17	Extra effort in training and investing on human effort	M2,M3 and M32	3
C18	Lack of trained employees	M35,M2 and M3	3
C15	Delay of work by developers	M51,M52,M53 and M54	4
C20	Lack of trust to share business and intellectual knowledge	M1	1
C21	Lack of trust by onsite employees to share their intellectual property	M1	1
C22	Unwilling to share the information	M1	1
C23	Unable to build cohesive teams	M55	1

C24	Poorly defined roles and responsibilities	M4 and M5	2
C25	Grudge between onshore and offshore employees	M5,M36,M19,M15	4
C26	Lack of process transparency at offshore	M68,M69,M70,M71,M72,M73,M74 ,M75,M76,M77,M78,M79,M80,M81 and M82	15
C28	Communication gaps	M15,M16,M17,M18,M19,M20,M21, M22,M23,M24 and M25	11
C31	Temporal differences affecting on project schedules	M10,M11,M12,M13 and M14	5
C32	Less shared time Window	M10,M11,M12,M13 and M14	5
C33	Political unrest at vendor location	M59,M60,M61,M62,M63,M64,M65, M66 and M67	9
C34	Unstable political situation at offshore location	M59,M60,M61,M62,M63,M64,M65, M66 and M67	9
C35	Imposing High fees for new services offered by Vendors	M32	1
C36	Coordination issues because of Geographical distances	M29,M19,M36,M34	4
C37	Presence of multiple vendor employees	M27,M36	2
C38	High coordination cost	M29,M19,M32,M36,M73	5
C39	Diplomatic knowledge sharing	M26,M27,M28 and M36	4
C40	Insufficient Knowledge Transfer	M26,M27,M28 and M36	4
C41	Lack of Knowledge transfer on automation testing	M35	1
C42	Employees refuse to share knowledge	M26,M27,M28 and M36	4
C48	Difficulty in Information gathering	M36,M34,M56,M57 and M58	5
C49	Difficulty to find appropriate people to get correct information	M56,M57 and M58	3
C50	Hurdles in exchanging accurate information	M36, M56,M57 and M58	4
C51	Challenges in setting environment for testing	M41	1

C52	Remote access to test environment	M41	1
C54	Differences in Infrastructure	M42	1
C61	Differences in Capability maturity in both client and vendor organizations	M37,M2 and M35	3
C62	Lower organizational maturity	M2,M37 and M35	3
C69	Work delayed When there are complex topics	M51,M52,M53 and M54	4
C70	Work delayed when there is requirements freeze delay	M52 and M54	2
C71	Work delayed when unavailability of Business Requirements	M52 and M54	2
C72	Work delayed due to lack of Support from Build Teams	M51,M58 and M65	3
C73	Change in requirements	M54 and M52	2
C74	Usage of Agile methodology	M54 and M52	2
C75	Difficulties in Process Understanding	M34,M36,M35,M58	4
C76	Lack of expertise	M34,M36,M35,M27,M51,M52,M53 and M54	8
C77	Geographical issues causing unplanned absenteeism by offshore employees	M54 and M51	2
C78	VISA issues	M55	1
C79	Delays in getting the SSN in US	M55	1
C80	Delays in getting H1B visa's and limitations on J1 Visa's	M55	1
C81	Restrictions for offshore employees who doesn't have citizenship	M55	1
C82	Work Visa's with limited Time stamps	M55	1
C83	Lack of understanding functionality assumptions	M56,M57 and M58	3
C84	Software Coding	M56,M57 and M58	3

	differences		
C85	Misunderstanding between team mates	M56,M57 and M58	3
C88	Test environments are slow	M86 and M41	2

Table 7-3: Mapping of mitigation to challenges

7.5.2 Mapping challenges to mitigations

MID	Mitigation Strategy	CID	Total number of Challenges addressed
M1	Selective dissemination of knowledge	C22	1
M2	Recruit employees with good experience in testing	C6,C40,C41,C17 an C18	5
M3	Skill road mapping	C6,C40,C41	3
M4	Following gatekeeper strategy	C17 and C18	2
M5	Sharing responsibility	C17 and C18	2
M6	Create cross culture awareness	C1,C3,C9,C10 and C11	5
M7	Evaluate cross culture initiatives	C1,C3,C9,C10 and C11	5
M8	Manage culture knowledge	C1,C3,C9,C10 and C11	5
M9	Employees of similar culture	C1,C3,C9,C10 and C11	5
M10	Making phone calls	C29,C30,C31,C32,C33,C34,C36,C48 C49 and C50	10
M11	Follow the Sun	C36,C31 and C32	3
M12	High Speed data links	C29	1
M13	Round the clock work	C31,C32 and C36	3
M14	Adjusting employees work	C29,C31 and C32	3
M15	Daily status reports	C36,C48,C49,C50	4
M16	Weekly phone calls and discussions	C29,C30	2
M17	Employees must have good communication tactics	C14,C29,C31,C32,C42,C49,C50	7
M18	Groupware and	C29,C31,C32	3

	communication technologies		
M19	Offshore coordinators and improved test case specification	C29,C31,C32	3
M20	Voice and Video chat	C29,C31,C32	3
M21	Iterative development	C44	1
M22	Proper training	C17,C18	2
M23	Use of Wiki	C29,C31,C32	3
M24	Instant messaging	C29,C31,C32	3
M25	Similar and effective communicative methods	C29,C31,C32	3
M26	Presence of offshore vendor employee	C29,C31,C32,C36,C38	5
M27	Frequent training of offshore employee	C29,C31,C32	3
M28	Frequent visit to onsite	C29,C31,C32,C40	4
M29	Onsite presence of vendor employee	C36,C38	2
M30	Allocation of additional resources	C14	1
M31	Prioritize work	C36,C38	2
M32	prioritization of tasks	C64,C35	
M34	Selecting bridging countries	C48,C49,C50, C29,C31,C32	6
M35	Technical training	C39,C40,C41,C42,C61,C62	6
M36	Appoint onsite test coordinator	C36,C38,C48,C29,	4
M37	Substantial technical knowledge	C61,C62	2
M38	Early Integration of tools	C58,C53	2
M39	Use of formal language	C53,C58	2
M40	Establish right tool infrastructure	C54	1
M41	24X7 onsite support	C52	1
M42	Usage of same	C60	1

	tools in Client and vendor		
M44	Usage of Same language	C19	1
M43	English as a common language	C12 and C19	2
M45	Having same organization style	C9,C10,C11,C5,C1,C3	6
M46	Having same hierarchies in company	C9,C10,C11,C5,C1,C3	6
M47	Adapting same team structures	C9,C10,C11,C5,C1,C3	6
M48	Similar decision making by higher administration	C9,C10,C11,C5,C1,C3	6
M49	Same working styles	C9,C10,C11,C5,C1,C3	6
M50	Approach to solution	C9,C10,C11,C5,C1,C3	6
M51	Extension of testing sign-off	C15, C69,C70,C71,C72,C73,C74,C75,C76 and C77	10
M52	Start testing from requirements gathering	C69,C70,C71,C72,C73,C74,C75,C76 and C77	10
M53	Proper planning assuring no delay for UAT	C69,C70,C71,C72,C73,C74,C75,C76 and C77	10
M54	Proper scheduling	C15, C69,C70,C71,C72,C73,C74,C75,C76 and C77	10
M55	Home and Host country legal countries have to take care of such issues	C78,C79,C80,C81,C82 and C23	6
M56	Test Cases and environments are shared	C83,C84,C85,C48,C49 and C50	6
M57	Maintaining shared directories	C83,C84,C85,C48,C49 and C50	6
M58	Proper Knowledge Transfer	C83,C84,C85,C48,C49 and C50	6
M59	Start testing services at multiple locations	C33 and C34	2
M60	Compensate using extra hours	C33 and C34	2

M61	Business continuity plans	C33 and C34	2
M62	Working extra hours	C33 and C34	2
M63	Deploying associates based on criticality	C33 and C34	2
M64	Work on weekends	C33 and C34	2
M65	Daily meetings and working strategically	C33 and C34	2
M66	Proper planning	C33 and C34	2
M67	Open new locations	C33 and C34	2
M68	Regular reviews	C26,C27,C29,C36,C37,C38,C48,C49	8
M69	Regular follow-up	C26,C27, C29,C36,C37,C38,C48,C49	8
M70	Common tool for recording the test results and micro soft project plans	C26,C27, C29,C36,C37,C38,C48,C49	8
M71	Keeping all documents in a shared drive	C26,C27, C29,C36,C37,C38,C48,C49	8
M72	Maintaining a issue log and discussions on daily basis	C26,C27, C29,C36,C37,C38,C48,C49	8
M73	Status meetings	C26,C27, C29,C36,C37,C38,C48,C49	8
M74	Daily execution reports	C26,C27, C29,C36,C37,C38,C48,C49	8
M75	Daily activity reports	C26,C27, C29,C36,C37,C38,C48,C49	8
M76	Involvement of test engineers in Quality assurance	C26,C27, C29,C36,C37,C38,C48,C49	8
M77	Shared testing tool and defect tracking tool	C26,C27, C29,C36,C37,C38,C48,C49	8
M78	Monitoring Quality control on timely basis	C26,C27, C29,C36,C37,C38,C48,C49	8
M79	Following the standard procedure provided to offshore employees	C26,C27, C29,C36,C37,C38,C48,C49	8
M80	Documenting whole testing activity	C26,C27, C29,C36,C37,C38,C48,C49	8
M81	Timely reporting	C26,C27,	8

	on a daily and hourly basis	C29,C36,C37,C38,C48,C49	
M82	Close monitoring of work progress	C26,C27, C29,C36,C37,C38,C48,C49	8
M83	Exchange of emails	C39,C40,C41 and C42	4
M84	Live meetings	C39,C40,C41 and C42	4
M85	Video conference	C39,C40,C41 and C42	4
M86	Take help from developers	C51,C52	2
M87	Usage of reliable and robust tool for test management and defect tracking	C56 and C60	2

Table 7-4 Mapping of challenges to mitigations

7.5.3 Challenges without mitigation strategies

CID	Challenges	Mitigation strategy
C2	Different perception of productivity and its models	-
C4	Lack of initiative in problem resolution	-
C6	Different trust levels	-
C7	Differences in UAI	-
C8	Difference in perception about quality	-
C43	Requirements uncertainty	-
C47	High turnover rates in offshore	-
C55	Networking issues	-
C59	No shared system database	-
C65	Lack of security for confidential information	-
C67	Firewalls and permission rules	-
C86	Testing tools cannot test complex scenarios	-
C87	Testing is incomplete and issues at the UAT phase	-
C89	Test environment issues to run automation suites	-
C90	Instable test environment	-
C91	Cost overruns	-
C92	Mistrust in employees	-
C93	Project delays	-

Table 7-5 Challenges without mitigations

There are some challenges for which we didn't get any mitigation strategies. C2, C4, C6, C7 and C8 challenges falls under Culture challenges category, it is very important to throw light on these challenges. Culture is playing a vital role in whole globalised software development, if culture affects the way how offshore and onshore employees think and perceive everything in terms of quality and productivity about the testing also changes. Vendor organization may think that it is giving a quality of service to their clients, if Clients don't perceive like vendor they won't get satisfied and they still find some issues in the deliverables. There are some vast topics on which researchers have to carry out some

research on cultural influence on thought, perception about productivity and quality which will highly damage the onshore-offshore model of OOST. This may leads to mistrust and termination of strategically

7.6 Discussion on OOST

According to extant literature, the most popular offshoring destination within the software Industry has been India, but China, Singapore and Ireland have also become successful offshoring sites [45]. In global software engineering, outsourcing parts of software development process to offshore vendor had become a common industry practice. While software programming, support and maintenance related activities are being outsourced to offshored vendors, outsourcing of software testing activities to offshore vendors are becoming increasingly beneficial [40].Most of the areas of the software testing like unit testing, integration testing, functionality testing, system testing, acceptance testing, performance testing and regression testing are sent offshore [S10]. Testing phase in this context is not a widely researched subject. Realizing the importance of OOST, in this thesis we studied the outsourcing of software testing to offshore vendors which covers both offshore and onshore perspectives. We have considered challenges and their mitigations in OOST and efficiency of software testing process in OOST. We have made some discussions on the new challenges that were identified as a part of this thesis which would help industrial practitioners and researchers to use this thesis in real time scenario.

7.6.1 Why there is a huge impact of culture on OOST Practice?

In recent studies there is more importance on culture, since culture in OOST highly affects on Quality aspects and productivity. Client organization always expects vendor organization and its employees to have same perspective to carry out testing activities effectively. Both client and vendor organizations will have two different cultures and thus they may have different understanding and perspectives. Client and Vendor organizations hold two different cultural models of productivity, and thus they perceive productivity differently. Offshore vendor employees claim that from the perspective of their clients productivity can be seen in terms of number. For e.g., number of test cases created/tested during a given period of time. When we consider vendor employees perspective productivity is defined as accomplishing total number of test cases given by client organization. In U.S people are more open to report the mistakes but in the Indian culture people don't admit their mistakes; this was happened mostly with offshore vendor employees. They mostly say yes to everything when onshore client employees ask any question to them, they actually don't mean yes but they may not able to do that particular work [S12], [40], [S9], [S25], [S8], [S12]. This approach of responding to the client brought new issues to problem escalation and status reporting.

Hina Shah and Mary Jean Harrold argue conducted vast research in exploring the affects of culture difference on OOST practice, they have also observed that culture also affects the level of thought, no two vendor organizations will have the same level of thought about how and what to be tested. From [S9] it was asserted that Japanese always want their vendors to test their software in worst case scenarios. On the other way U.S team seem emphasized much on functionality of software testing. Japan has a unique culture and U.S has a totally different culture compared to Japan. Japanese team had chosen number of testcases as a basic resource to complete the testing, U.S team relied most on time, certain time in which the testing of software could be completed. Both Japanese and U.S have different patterns and approach of testing in other areas like the way how they perceive about the testing, differences in expectations, uncertainty avoidance and getting the details from offshore team. Researchers also came up with certain cope up strategies like creating cross cultural

awareness, evaluating cross cultural initiatives and managing cultural knowledge, but there were no clear evidence up to how long they have any practical findings. We have asked survey practitioners about how genuinely their offshore team admits their mistakes during problem escalation and daily project status; they have said that between 50-75% their offshore team admits their mistakes.

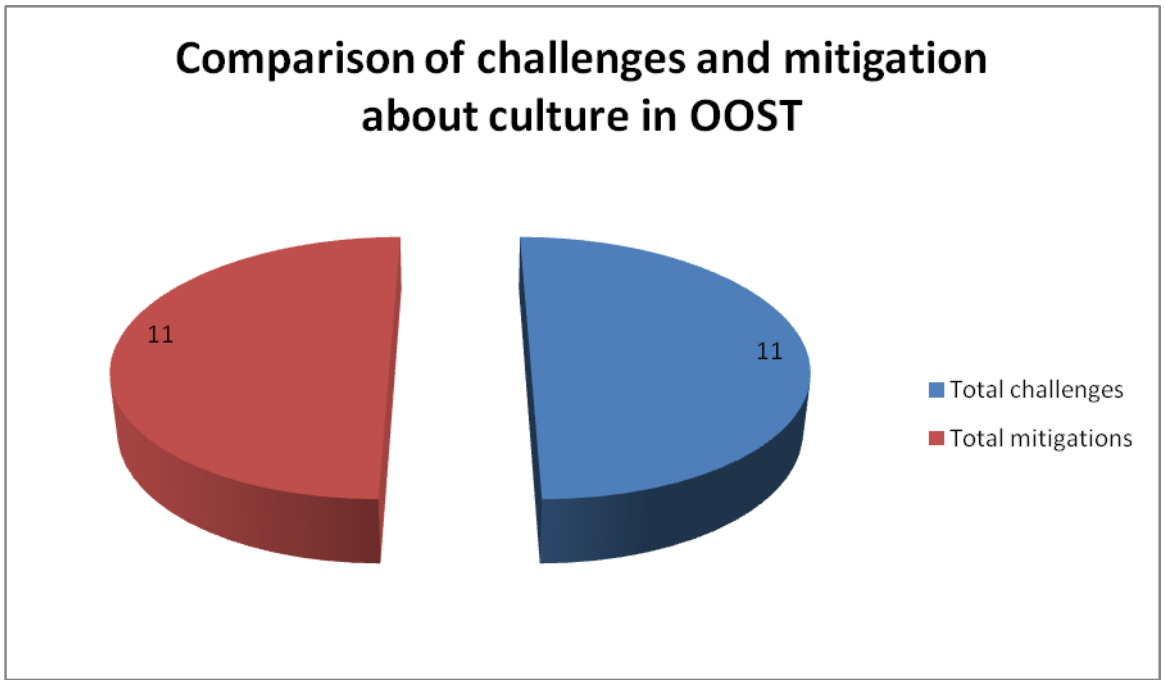

Figure 7-4: Population of cultural challenges in SLR

When we created surveys, participants expressed that they have found some cultural similarities between their vendor and client organizations; they are like same language, organizational style, Hierarchies in roles, Team structure, decision making, working style and approach to solution. From figure 7-4 we got seven mitigation strategies to overcome the challenge of Culture. But, it wasn't sufficient to bridge the gap in this area of research. Culture is deeply rooted in individuals and their everyday practice s because culture molds the way people thinks Comparing all the study pertaining to culture, 69% of all outsourcing projects fail due to the cultural incompatibilities [S12], [40], [S9], [S25], [S8], [S12].

7.6.2 How much is the role of Communication in OOST?

It is well known that in global software engineering, communication challenges occur prominently, considering OOST set up during the test execution phase long and rigid communication channels posed significant challenges. Almost in all scenarios both onshore and offshore share different time zones, offshore vendor employees who are in India and China have relied on asynchronous communication, in some scenarios they have to wait until the concerned employee from onshore comes and take up the duty. Information sharing and seeking are part of communication activities, finding proper information from right person and exchanging accurate information is also highly challenge. Language problems also identified in this category, onshore employees found very few employees who can speak English fluently, cultural also affected the way of communication, Indian employee's refuses to admit their mistakes, and it had created huge delay in problem escalation and status reporting. In both literature and surveys we found appropriate mitigating strategies cope up with these challenges for the smooth flow of testing activities in both offshore and onshore, communication is the only way to coordinate every activity pertaining to software

development and its activities, it forms trust, team adherence, great coordination of work, building good relationships which may lead to extending contracts and opportunity for strategic collaboration of work and smooth flow of testing activities. Some offshore employees have very good communication activities and they have built very good relation with onshore employees from the high level staff to junior test engineers, onshore employees also showed interest in contacting those employees who always turn up and communicate well in problem escalation and status reporting. Offshore employees employed some patterns and communication channels to exchange information for conducting testing activities. In OOST, both onshore and offshore employees relying on sending daily status reports, conducting weekly phone calls and discussions, installing good communication tactics in employees, using good groupware and communication tools, interaction with offshore employees by voice and video chats. In common to all practices both onshore and offshore employees used instant messaging to get fast responses. In some critical issues, offshore vendor organizations sent their employees to onshore to coordinate the work, due to some visa extension problems offshore teams followed the strategy of shadow practice. In surveys also practitioners have expressed that they have followed the shadow practice, which means that offshore team had sent shadow employee to continue the further support for onshore team when previously sent offshore employee's visa expired. In some other scenarios Tech leads filled the information gaps.

Language is the way by which people communicates, in the corporate world it is bare minimum thing that people must speak fluent English. As we have discussed above people in offshore cannot speak English fluently. They must be trained well to improve their communication skills, specifically they must learn and understand accent and tone differences to communicate in a better way to deal U.S clients. Communication is very essential, in a country like India, they are not trained and they are unable to understand U.S accents. Though offshore team understand and interprets the language there are numerous situations miscommunication happened several times.

Knowledge Transfer and training of employees got a huge share which builds strong process of performing software testing activities. In some countries there are high staff turnover rates, employees will not continue to work in companies for long time or until their project completes in which they are working on. In this instance offshore team has to hire new employees who are unaware of domain knowledge and may lack good testing activities, to cope up with this challenge proper flow of knowledge transfer reinforces and steers up the testing activities. In some scenarios total software testing activities are deteriorated due to the lack of good knowledge transfer. Onshore employees are also reluctant to share their knowledge due to lack of trust and considering onshore employees career growth. Lack of training and good experience in testing highly affected the quality of software testing. When we conducted the surveys for experts one of them said that they are following good knowledge transfer methods and their knowledge transfer will be done online. Survey practitioners have also uncovered some of the approaches they have used to fill the working locations with knowledge, they are like exchanging emails, live meetings, video conferences, skype meetings, instant messaging, frequent visit to onshore and sending their company consultants to onshore. By this we have acknowledged that some organizations have very good knowledge transfer ways, but still in literature dearth to conduct literature is prevailing. Wasif et al..Conducted some research in knowledge Transfer challenges in GSE [46] Language barriers, Trust, Personal attributes hampers the flow of knowledge transfer in GSE. Both onshore and offshore employees must work together to solve the problems in knowledge transfer among the working locations. After conducting this much research, we

also realized that Training is not only confined to knowledge transfer but also essential to strengthen some areas in OOST like building cultural differences, building team cohesiveness and implanting personality development skills of employees.

7.6.3 How can we overcome the delay caused by Geopolitical issues?

This challenge was spotted mainly in India, unstable condition of politics in vendor countries hampered the testing activities up to a large extent. It is also created huge delays in shipments, onshore team employees, worked for long hours to reach the deadlines, even in surveys one of the practitioner claimed that their organization has opened new locations as geopolitical issues posed challenges and created huge delays in results. Some of the coping up strategies that were implemented by survey practitioners include extension of their testing signoff which means that they have to work for few more hours to complete the pending activities, starting service at multiple locations also one of the best strategy adapted by the survey practitioners, Business continuity plans, deploying associates at offshore vendor organization based on criticality and having daily meetings are some the coping up strategies that were being implemented by the industrial experts who participated in our surveys.

7.6.4 Work Delays caused by personnel and project factors

When we are conducting literature review, we found that there are some delays in deploying code by the developers; testing team has to wait until they get code to test. Testing team unable to meet deadlines imposed by the onshore team particularly when there are releases in software versions. In recent days software development has shifted from waterfall model to Agile to reach the market needs, in Agile software development is iterative, in each iterations developers have to write a codes of line in a motive of increasing functionality with new features in a software. If developers unable to deliver the code, it impacted the schedule of testers testing activities. When we asked for experts opinion about this work delays, they have added some other challenges which created work delays, they include complex topics, requirements freeze delay, unavailability of business analyst, lack of availability of environmental support build teams, frequent change in requirements, geographical issues, lack of process understanding, lack of expertise to conduct testing and Agile methods created great work delays.

We have also asked experts for the mitigations to overcome this challenges, they suggested to follow test driven development which associates with the start of software testing from requirements gathering phase, even the same response was acknowledged from the other expert that, he also suggested to start testing activity from User Acceptance Test phase so that testing activities will go simultaneously which doesn't create any delays in testing activities. Proper scheduling of project and consulting the design team to solving out delays also was recommended by one of the survey participant.

7.6.5 How to gain Process Transparency?

In most of the OOST scenario, onshore employees feel that there is some loss of control and vendor employees always work inside their offshore facility. Onshore employees unable to view what exactly going on at the offshore, some of the Client organization managers also wonder how to cut some work out to send it offshore, when everything onshore employees perform has been done onshore. In client organizations managers must take some responsibilities, they have to visit offshore offices to get a clear view and build trust about the testing activities and process at offshore. Relying on regular follow up on offshore employees, receiving daily status report about the testing activities implemented, issues

resolved will further reinforce in process of receiving great transparency at offshore. There are also some other coping strategies covered during surveys they also includes common tools for both onshore and offshore employees to record test results, sticking to Microsoft project plans, having a shared drive for audit to view by all members, maintaining issue log and discussion upon the issue raised by daily basis, shared testing tools and defect tracking tools, video conferences and proper documentation maximizes the process transparency.

7.6.6 How Geographical distances can affect OOST?

Geographical distances also hampered the software testing activities, there is no shared time window hence employees have relied on asynchronous communication. Geographical distances created an effect on information gathering and **communication** issues. Employees unable to coordinate the work, employees at offshore have to have to wait for long hours for proper information from the right person. Adapting to round the clock and follow the sun approach resolved issues to a maximum extent.

7.6.7 *Testing Specific challenges*

What is the Significance of Technological and Infrastructural issues in OOST?

In this thesis we have observed significance to conduct research on Technological and Infrastructural issues. In every primary study, we identified challenges and mitigations about personnel and project categories on a good note. But most of the primary studies doesn't have adequate amount of importance on technological and infrastructural issues. We have tried to explore much in surveys, interestingly we obtained some good information to discuss. They are presented in the following sections.

In offshore location setting up environment for testing is a critical issue; client team must have to help offshore team to iron out these issues. Sometimes in these situations onshore unable to send offshore to help offshore team, to overcome this client depended mostly on exchanging emails, exchanging trouble tickets and phone calls, due to some miscommunication process became slow.

There are also plethora of variables which caused infrastructure to malfunction, including software which are installed by vendor side or the number of hot patches on their operating system. We have also observed that in SLR information security also seemed very challenging and also access to the remote test environment also created issues, in this scenario people opted to extend their support for 24X7. Firewall and permission rules also inhibit the ability to setup connectivity between vendor and client.

These are the challenges that were obtained during the Systematic Literature Review, but all the above highlighted issues are found at offshore. Firewall and permission issues, infrastructure mall function, access to remote infrastructure at onshore, dearth in sophisticated working technology, networking issues and differences in infrastructures are major challenges at offshore. Some offshore firms unable to afford testing tools which are of high cost, they have replaced with low cost tools to cut down the expenses. Client team should always come up support and uplift the vendor organizations to overcome the challenges by investing in vendor capabilities. Our survey results are in contrast to SLR results, maximum survey practitioners satisfied with the testing environment and tools used for testing. It appear that even vendor teams investing and paying much attention to come up with better technology and infrastructure for the strategic alliances in offshore testing.

7.6.7.1 Manual testing or automate testing? Which is having highest precedence according to industrial experts?

Depending upon the system phase, software testing can be done either by manually or automatically [47]. Very few research articles were written about what and how the testing activities are executed in offshore. In this thesis out of 27 primary studies we have got only five research articles conducted about Software test automation and its importance in offshore vendor organizations. Depending upon the challenges and content in those primary studies we have formulated few survey questions in order to incorporate more data about software test automation and its practices. Those surveys questions are given below. In this thesis reliability on tools and technology's, infrastructural, lack of knowledge on automated tools by offshore testers, lack of reliability for onshore personnel to invest in automated tools and personal factors of testers in offshore are the major challenges found from both SLR and Surveys. We didn't get enough challenges in SLR but from surveys we have extracted good number of challenges.

Q21. Do you feel automated testing has precedence over manual testing? If so please give two to three points to strengthen your choice?

Q23. Do you have automated testing scripts and defect tracking tools to test scenarios and record the bugs and defects?

Q18. How reliable you are on the tools that are being used in offshore for test automation? IS that test environment sophisticated and efficient? If so what are the problems you have faced in getting the work done? What are the consequences you have faced due to the poor testing environment at offshore?

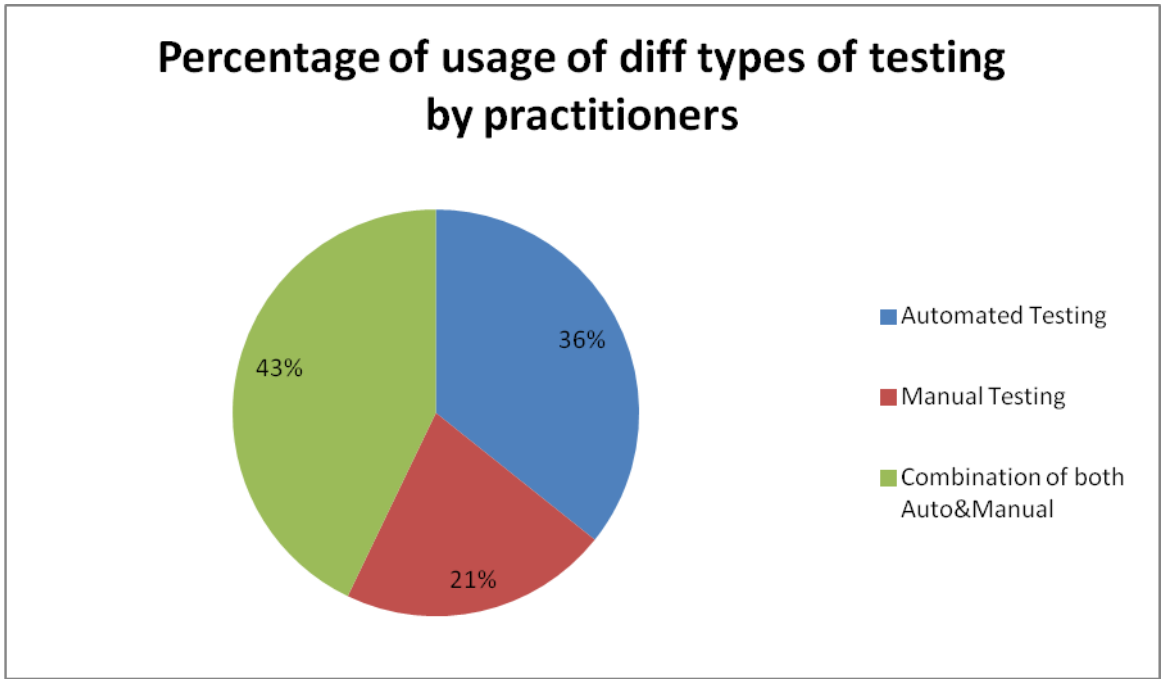

Figure 7-5: Implementation of different approach of testing in real time scenario

For Q21 based on the responses from industrial practitioners we have drawn above pie chart to reveal the opinion of industrial experts. 36% of total industrial experts say that they implement Automated Testing, 21% of people say that they feel good to implement manual testing and 43% of people say that besides doing manual testing it is better to implement testing in certain critical tasks. Compared to the Manual testing automated testing is implemented much in recent days. In some projects testers executing their testing activities manually for some modules of software and they performing automated testing for some software modules which are to be tested by the automated tools. According to Dustin et al

[47]Software Test Automation means to automate software testing activities including development and execution of test scripts, verification of testing requirements and the use of automated testing tools. One of the main reasons for using automated testing is that manual testing is time consuming and that testing automation increases efficiency when regression testing is conducted to software which was underwent some changes in software code [S10] [48].
If we analyze the answers given by practitioners in surveys, *"Not really in all scenario .In case of complex scenarios manual testing will be better than automated.1.Complex scenarios were too many interfaces.2.Different sets of test data."* Practitioners feel that not really the automated testing is implemented in all scenarios but when there are some Complex scenarios to test which contains too many interfaces it they best way is to test it manually.

If we consider others practitioners opinion" *This differs from business to business. In case of automated scenarios large implementations Automation is a better solution and for small project the manual testing.1. Automated scenarios gives quick and accurate result.2.Result will be consistent."* From these lines, leaving no doubt implementation of particular approach of software testing differs from one project to another. For large implementation it is better to implement automated testing and for small projects manual testing is the best. Automated testing will produce quick, accurate and consistent results compared to the manual testing.

Another practitioner said that" *Yes and No - certain parts need manual testing as well. Bulk of the product needs to be automatically tested."* It is clear that bulk of the software needs to be tested automatically.

Throwing light on another practitioner, "*With Automation Testing, We can deliver Error Free Code to Production. Reduce".* even this practitioner said automated testing is widely implemented for delivering error free code to production.

Drawing overall conclusion from the above comments and pie chart, automated testing is implemented for bulk of the product to deliver error free code to production. Automated testing is having some advantages like it produce quick and accurate results within less time with better consistency. Manual testing is implemented for projects which are small in size and to perform unit testing. As per our inferences either Manual or Automated testing is implemented depending upon the criticality and importance.

7.6.7.2 Affect of Process Models (Agile) on Automated Testing
Test Automation is considered an essential activity for agile methodologies being the key to speed up the Quality assurance process. The agile software process model accommodates changes in new requirements rapidly. Agile process is iterative in nature so that test activities must align to change of requirements with a great swift. Whenever new iteration turns up test activities need to be executed fast and efficiently leading to the use of automated testing [49] tools. There are some issues which will influence the success of software test automation. Programmers are not likely to test the code much, since they think there is QA team which will look after those kinds of issues [50]. It is hard to implement automated regression test suite instead of old way of doing manual regression test [50]. Sense of fear for both Testers and Programmers, testers don't have knowledge of programming and programmers don't have knowledge in testing [50]. Thus it is challenging for the testers to work in Agile

development who have been working in traditional waterfall model. They have to work with the development team right from the first phase to reach the deadline for every iteration and also they must have good team cohesiveness, experience and training to get the success in these challenges [50]. In agile model the delay of code by developers also hampers the testing process. During surveys one of the participant said that*" Yes..sometimes..Particularly if an Agile methodology is being used."* It means that there is a delay in code by developers which makes testers to wait until they receive the code from developers.

7.6.7.3 Reliability on testing tools

In surveys very few participants were feeling bad about usage of tools in offshore.
"Testing tools are reliable but cannot test complex scenarios. The testing environment is quite good. Normally the defect tracking becomes very dif". Some of the testing tools that are implemented are not efficient to track the bugs in the code. If this is a scenario the software fails at User Acceptance Testing (UAT). It will create great problems for onshore employees; it will degrade the reliability of client employees. But rest of the practitioners expressed great confidence on testing tools that were used at offshore. Offshore organizations must invest on good defect tracking tools to increase the quality and productivity of offshore testing. Results of the survey also say that 90% of offshore employees are implementing good defect tracking tools to test the code.

7.7 Effectiveness in OOST

Besides collecting challenges and mitigations in OOST, we also tried to add some knowledge about some attributes which belongs to OOST. We have asked survey practitioners about the effectiveness of OOST in both onshore and offshore perspective. We have taken cost effectiveness, Quality standards, productivity and turnaround time as a factor which influence the effectiveness of OOST. Quality standards and productivity are very high according to both onshore and offshore employees.

We asked survey practitioners about what are the attributes that they will look when they are selecting a service provider for testing. Highest percentages of survey practitioners revealed that less development costs and Innovation and shared best practices are highly motivating factors when they are selecting offshore vendors. Some other factors that were also obtained during surveys are access to large skilled labor pool, improved resource allocation, leveraging time zone differences and strategic contractual relationship.

7.8 Future work

It was identified that population of research articles was more in recent years; even we have conducted this complete research with 28 papers. It signifies that this research has taken the pace in recent years. So future work in this research area is comprehensive. During this research conducted we have found the challenges, mitigations that exist at both offshore vendor side and onsite client side. We also integrated the results that obtained from the survey results to further investigate whether there are any similarities or differences in practices by practitioners. After performing our systematic literature review we planned to design a framework which guides the practitioners to opt for a kind of challenges, threats and best practices of Outsourced Offshore software testing. Hence it made the researchers of this thesis to design a frame work as a future work. In this framework each and every challenges along its mitigation and related practices were wrapped and kept in one section. Researcher of this thesis too fascinated about the concept of test automation in outsourced offshore

software testing. There is a dearth in the area of how the test engineers handling the pressure situations when they are supposed to automate the test case with rigid deadlines. So we speculate organizational team structures highly influences the pressure for offshore team employees. Further investigations that are likely to be conducted are

(1) Whether importance are given to team-structure configurations before setting up outsourced offshore software test teams.

(2) Whether having vendor organizations that work closely with client hinders the quality of testing activities

(3) What type of team structure would be ideal for reducing pressure and therefore facilitating a practice that affords higher quality work and product.

7.9 Contribution to research

Using research methodologies like systematic literature review and Surveys we examined how the challenges and their mitigations constitute a process of Outsourced offshore software testing. We have examined how the challenges hamper the working activities of software testing outsourced to offshore vendors. Through the analysis of various software testing activities, we identified not only the challenges that exist in product, process and personnel categories but also some coping strategies they used to overcome the challenges in both offshore and onshore environment. In doing so, we also integrated insights from organizational communications, client and vendor relations, client manager's roles, management issues and offshore outsourcing literature to theoretically ground these strategies. We have performed the systematic literature review in quest of challenges and their appropriate coping strategies that are being followed in practice to overcome them. We have organized all the identified challenges into three categories by using grounded theory. Some of the types of challenges that were identified like knowledge transfer, infrastructural, tools and technologies, information gaps, extra costs, domain knowledge and requirement specification. When we further went deep into our study, our research got the blend of some aspects like highly management and technical too. So it motivated us to answer the research question for knowing the process effectiveness my collectively producing the results that were answered by the practitioners to all challenges that were found which had a touch off all aspects as it was specified above. Thus our study draws attention to not only for specific agenda, we as a researchers for this thesis tried to figure out the challenges and in depth study both management ,technical stuff and by inspecting the challenges to its deeper level to know how effective is this process of outsourced offshore software testing.

7.10 Contribution to practice

From both offshore and onshore we identified several areas which had covered both management aspects like decision making of client managers, extra costs, and when coming to the technical aspects like automated testing, tools and testing environment, productive of the test engineers etc. We have extracted the data from the practitioners in the form of questionnaire sent to them. We have determined that client personnel require greater levels of transparency in the work and they need to adapt the various coping strategies identified here to meet their off shoring needs. Throwing light into the other side of the process offshore team employees must be provided with sufficient training, tools and testing environment. There are some situations where offshore employees faced challenges during the stay at offshore because of legal sanctions imposed on them. Flow of knowledge transfer must be efficient enough to fulfill the tasks given to offshore. During the test automation it is very essential to provide the enough test cases and test case selection. There shouldn't be any

conflicts in the nature of perception about productivity of offshore employees in client side. Client employees make sure that they have to provide a pressure less environment to the offshore employees by providing enough resources and training and proper extension of deadlines.

7.11 Conclusion

In this thesis authors have gathered, analyzed and discussed challenges and their mitigations of Outsourced Offshored Software Testing. We have conducted Systematic literature reviews and Surveys to collect challenges and mitigations to validate and explore new challenges and mitigations to stretch the area of research in OOST. We have embraced both perspectives of offshore and onshore in this thesis, because in primary studies we have obtained discussing either about onshore issues or offshore issues. Inclusion of both perspectives allowed us find challenges and practices that were being followed at both offshore and onshore. Some of the personnel factors like work delays by developers, Culture, communication between employees, knowledge transfer issues were the mostly captured in both surveys and SLR. Majority of roles that were found in the offshore is Software testers and developers from client. Keeping developers aside, Testers and their attitude plays a vital role in increasing productivity of whole Offshore testing activities. Testers should have good experience in testing; they must attend knowledge transfer sessions in order to bridge the gaps in terms of technology and relations with onshore employees. Communication of should be informative without any misunderstanding as they have a high impact on quality and control. When we have read some primary studies like S6, S8, S14 and S17 which were written on Offshore Test Automation we found some issues like onshore vendors have lack of reliability on Testing tools and productivity of testers. When we included these challenges as a questions in we got survey responses in a positive way like most of the practitioners from onshore are satisfactory about defect tracking tools and environments which are implemented by offshore vendors. It appears that most of the Multi Nation Organizations are investing much for sophistication of tools and technology to raise the quality. Onshore client organizations must also contract to vendors who have good CMM levels; vendors with good CMM levels will always have good software development and testing process. We have staked our effort to encompass the prominence of automated testing in real time scenario. New technologies, products and testing tools have hampered the testing activities for offshoring but we have found that there is a drastic change in reliability aspects, good quality of testing tools and procedures as per the surveys we conducted. Knowledge transfer and training must be needed to overcome these challenges in software test automation.

7.12 Answers to the research questions

1. What are the challenges/ problems encountered in outsourced offshore testing?

We have performed systematic review based on the guidelines proposed by the kitchenham. As a part of data analysis Grounded theory was applied over the extracted literature data to find out challenges and mitigations. After analyzing the data from SLR, challenge and mitigations were found in the context of OOST. These results are presented in their relevant sections.

2. What are the solutions/mitigation strategies for the identified challenges/problems in outsourced offshore testing?

In our surveys we have prepared to types of survey questionnaires which are for Client company employees and another one is for vendor company employees. By doing in this

way, we can cover challenges and their mitigations in both client and vendor side. Total identified Challenges and mitigations were embedded in the survey questionnaire form. Survey questionnaire was sent to the employees who are working in client companies and vendor companies. We have found an extra challenges of and mitigations of .

3. How effective is outsourced offshore software testing based on literature and expert opinion?

As a part of expert opinion we have included some questions other than challenges and mitigations in an objective of taking expert opinion on efficiency of OOST. We started that with asking experts what are the motivating factors that vendors offer to the clients to outsource their projects to offshore. Based on their industrial experience of experts we embedded both views of onshore and offshore and their efficiency terms. Detailed explanation is provided to get in depth idea of what are the factors that affecting the quality of software testing activities that are carried out in OOST.

7.13 Validity Threats

It doesn't matter how well you have performed the research there are still some factors like reliability and accuracy of research results which are to be considered every time. Authors recognized some threats related to systematic literature review and surveys conducted to industrial practitioners; they tried their best to restrict the effect on the research results and reliability. According to Claes wohlin [19] there are four basic types of validity threats internal validity, external validity, construct validity and conclusions validity. These validity threats were explained clearly along with its references.

7.14 Internal Validity

Internal validity related to the design and execution part of the complete research to get refrained from systematic errors [16][18]. Publication Bias refers to the problem that positive results are more likely to be published than negative results [18]. It is very complicated to know which article is to include and exclude as it always tricky to consider which specific article can answer your research question and complete thesis. So we had kept all our study selection criteria under the scrutiny of our professor by sending the systematic literature review protocol. We have also provided the kappa coefficient value which defines the level of agreement by both researchers that are calculated for every database and the articles that we have selected. During the analysis of systematic literature review it is always perplexing to categorize the data into certain data groups like open codes, axial and selective codes. We have made some discussions on this issue with our professor and resolved this after in depth analysis. In this thesis it includes the surveys to industrial experts it targeted both onshore and offshore employees. When we consulted the higher level employees in the multinational companies they refused to reveal to reveal some confidential information hence changes were made according to their comfort levels.

7.15 Construct Validity

The number of respondents in this survey is moderate. It poses a threat for generalizing the study results. By this thesis authors of this thesis are not aimed to make any industrial practice. The main purpose that drives the complete research is to explore and identify challenges and their associated mitigation strategies that are present in both Systematic

Literature Review and surveys. As far as number of articles obtained in Systematic Literature Review, article count was very much less to obtain substantial amount of data. This had become a problem to derive some major solutions for the challenges identified.

7.16 Conclusion Validity

In this thesis we have to cover both onshore and offshore perspective, we tried to reduce maximum number of questions in the online surveys, but along with number of questions increases in the surveys it takes much time for the participant they had show the sign of doubtedness to answer this survey. There are total of 37 participants answered the questions in survey around the world. It is not possible to examine each and every respondent whom we cannot meet physically. Personal biasness of the respondents can also be a threat to our research work.

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APPENDIX A: DETAILS OF SURVEY PRACTITIONERS

S.no	Name	Organization Name	Current Designation	Type or Organization & Work Experience
1	Jacquline K.P	Accenture	Delivery Manager	Service Provider,15years
2	Basava Raju Asu	TCS	Associate IT Consultant	Service Provider,8years
3	Sowmya	ITC Infotech India LTD	Manager	IT services, 6years
4	Venkata Rajesh Pendyala	Accenture	Assistant Project Manager	IT service provider, 7 years
5	Srikanth	NTT DATA Global Services ltd	Assistant Project Manager	Software Application Development and Maintenance, 6years
6	Srinivas Saddi	NTT DATA Global Services ltd	Member Technical	Software Application Development and Maintenance, 5years
7	Shubada	Ceredox Technologies	Associate Director	Outsourcing
8	Krishna Kaki	NTT DATA Global Services ltd	Team Lead	IT service provider, 8years
9	Kishore Chavan	Mahindra Satyam	Test Analyst	IT service provider,4 years
10	Raghavi	Loginsoft	Project Lead	Service Oriented, 5years and 3 months
11	Venkateswara rao Veerapaneni	Satyam Computer Services ltd	Project Lead	IT service provider,7 years
12	Raghu Panchakarla	NTT DATA Global Services ltd	Director	Consulting,16 years
13	Pavan Kumar	Wipro Technologies	Project Manager	IT services, 15years
14	Saraswati Chandrasekhar Kotamraju	Satyam computers services ltd	Associate IT Consultant	Service oriented, 16 years
15	Gouri sankar S	ITC Infotech India LTD	Program Analyst	IT services,6 years
16	-	-	Technical Director	Technology Consulting,18years
17	-	-	System Designer	IT service provider,3 years
18	-	-	Senior Test Engineer	IT service provider,6 years
19	-	-	Senior Software Engineer	IT service provider,4 years
20	-	POLARIS	Associate Consultant	IT service provider,14 years
21	-	-	Senior Software Engineer	Product Based,4 years, 8 months
22	-	-	Software Engineer	Product Based, 2years
23	-	HSBC	Senior Software Engineer	-
24	-	-	Test Lead	IT service provider,4 years
25	-	-	Program Manager	-
26	-	-	Datacenter admin	IT service provider,2

			Level-2	years
27	-	-	Senior Operations Professional	IT service provider
28	-	-	System Engineer	IT service provider,3 years
29	-	-	Associate Manager	IT service provider,2years
30	Radha Krishna Behara	-	ERP Consultant-Global	ERP Software,20years
31	-	IBM	Team Lead	-
32	K.V.R.Murthy	HP	Project Manager	Service Provider, 16 years

APPENDIX B: SELECTED PRIMARY STUDIES

S.no	Article Title	Research Methodology	Year of Publication	Search Venue
S1	Knowledge transfer in global software development: leveraging acceptance test case specifications	Case study	2010	IEEE
S2	Outsourced offshore software testing: vendor side experiences	Interviews	2011	IEEE
S3	Efficient maintenance support in offshore software development: a case study on a global e-commerce project	Case study	2004	Inspec&Compendex
S4	Levaraging global talent for effective test agility	Industrial Experience Report	2012	Inspec&Compendex
S5	Determinants of software quality in offshore development-an empirical study of an Indian vendor	Case study	2011	Science Direct
S6	Test strategies in distributed software development environments	Case study	2012	Science Direct
S7	Exploring defect causes in products developed by virtual teams.	Case study	2004	Science Direct
S8	Off shoring test automation observations and lessons learned	Interviews	2009	ISI WoS
S9	Culture and testing:	Interviews	2013	scopus

	What is the relationship?			
S10	Outsourcing software testing- A case study in Oulu Area	Interviews	2013	Scopus
S11	Information Bridging in a global organization	Interviews	2007	Scopus
S12	Studying the influence of culture on Outsourced offshore software testing	Interviews	2011	ICGSE
S13	Experience with training a remotely located performance test team in quasi-agile global environment	Interviews	2009	ICGSE
S14	Building effective global software test teams through training	Industrial Experience report	2007	ICGSE
S15	Test community of practice in brazil	Surveys	2006	ICGSE
S16	Collaborative international usability testing : moving from document based reporting to information object sharing	Technical report	2006	ICGSE
S17	A test specification method for interoperability tests in offshore scenarios: A case study	Case study	2006	ICGSE
S18	An Empirical investigation of client managers responsibilities in managing outsourced offshore software testing	Case study	2011	IEEE transactions on Engineering management
S19	An empirical approach for the assessment of scheduling risk in a large globally distributed industrial software project.	Interviews	2009	Empirical software engineering
S20	Integrating early VnV support to a GSE tool integration platform	Experiment	2011	ICGSEW
S21	Test Driven global software development	Technical report	2004	IEEE(Snowball Sampling)
S22	Patterns for testing in global software development	Case study	2010	IEEE(Snowball Sampling)
S23	V.Casey. software	Interviews &	2009	IEEE (Snowball

	testing and global industry :Future paradigms. Cambridge scholar paradigms. Cambridge scholars publishing, 2009	Surveys		Sampling)
S24	B. Copstein and F.M. de Oliveira. Management of a Distributed Testing Process using Workflow technologies: A Case Study. In Seventh Workshop on Empirical Studies of Software Maintenance, pages 62–64, 2001	Case study	2001	IEEE
S25	Client communication practices in managing relationships with offshore vendors of software testing services	Case study	2010	IEEE(scanning authors web page)
S26	Global software test automation	Case study	2006	Snowball sampling
S27	Case study: Testing for the utilities sector	Case study	2008	Snowball sampling
S28	Enabling offshore software Testing: A Case study	Case study	2007	Scopus

Appendix C: Survey Questionnaire

Surveys for onshore and offshore employees. This survey questionnaire is used only for our master thesis purpose. We are not intended to extract any confidential information of your organization

For employees working or Worked Offshore-Questionnaire A

The purpose of this page is to gather answers from the employees who are working or worked offshore. Intention of this page is to know how the industry practitioners are handling the challenges during outsourced offshore software testing.

1. Can you specify what is your name and your organization name

Name

Organization name

2. Which type of organization and how long have you been working with the organization?

3. What is your current designation in the organization?

4. Is there any delay by developers (coders) in handing over their code for testing?

5. . What are the problems faced due to legal sanctions imposed on offshore employees during the visit of onsite?

6. How effective is the decision making of client managers in critical situations?

Low	Moderate	Average	Good
○	○	○	○

7. . What are the problems faced due to legal sanctions imposed on offshore employees during the visit of onsite?

8. Is there proper following of shadowing practice to the onsite?

- ☐ Yes
- ☐ No
- ☐ Some times

If you dont have it, what are the other ways that are following in your organization

9. How effectively the knowledge is being transferred to onshore location? Which groupware technologies are employed for the communication?

- ☐ emails
- ☐ live meetings

- [ ] live meetings
- [ ] video conference
- [ ] skype meetings
- [ ] Instant messenger
- [ ] frequent visit to onshore
- [ ] sending employees to onshore

10. What are the cultural similarities between onshore and offsite?

- [ ] Same language
- [ ] Organizational style
- [ ] Hierarchies
- [ ] team structure
- [ ] Decision making
- [ ] Working style
- [ ] Approach to solution

if it is other please specify

11. . Is there proper exchange of information like documents which contains test specification, documents which aids in clear understanding of how to execute the test?

12. How effective is the outsourced offshore software testing ?

Cost effectiveness	
Quality Standards	
Productivity	
Turnaround time	

For employees working or Worked Onshore-Questionnaire B

The purpose of this page is to gather answers from the employees who are working or worked onshore. Intention of this page is to know how the industry practitioners are handling the challenges during outsourced offshore software testing.

13. Can you specify what is your name and your organization name

Name	
Organization name	

14. Which type of organization and how long have you been working with the organization?

15. What is your current designation in the organization?

15. What is your current designation in the organization?

16. What are the attributes that are looked to select a service provider for testing activity?

- [ ] Less development costs
- [ ] Strategic Contractual relation
- [ ] Access to large skilled labor pool
- [ ] Innovation and shared best practices
- [ ] Leveraging time zone effectiveness
- [ ] Improved resource allocation

If it is Others please specify

17. What are the consequences that you have faced due to the delay of work caused by political unrest at offsite? What are the successive measures that you had taken to solve this issue ?

18. How reliable you are on the tools that are being used in the offshore for test automation? Is that testing environment sophisticated and efficient? If so what are the problems you have faced in getting the work done? What are the consequences you have faced due to the poor testing environment at offshore?

19. What are the extra costs that you have paid for offshore? Do they demand an extra cost for the new services rendered and What is the approximate % of savings the company gets from off shoring ?

20. Do you plan knowledge transfer sessions for understanding the business processes and testing tools. If so what would be the % of cost spend on training the offshore team

21. Do you feel automated testing has precedence over manual testing? If so please gives two to three points
to strengthen your choice

22. What are the ways that you have followed to get a transparency in offshore testing activities?

23. . Do you have automated test scripts and defect tracking tools to test scenarios and record the bugs and defects?

24. How effective is the outsourced offshore software testing?

Cost effectiveness	
Quality Standards	
Productivity	
Turn around time	

25. How genuinely offshore team admits their mistakes during problem escalation and daily project status?

- [ ] 0-25%
- [ ] 25%-50%
- [ ] 50%-75%
- [ ] 75%-100%

If it is Others (please specify)

26. For how many times project manager visited the offshore? If so, is that project manager aware of language and culture of offsite?