Master Thesis
Software Engineering

May 2012

Coordination in Global Software Development - Challenges, associated threats, and mitigating practices

Mod Nath Acharya and Nazam Aslam

School of Computing
Blekinge Institute of Technology
SE – 371 79 Karlskrona
Sweden

This thesis is submitted to the School of Computing at Blekinge Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Software Engineering. The thesis is equivalent to 20 weeks of full time studies.

Contact Information:
Authors:

Mod Nath Acharya
Minervavägen 20, 37141, Karlskrona, Sweden
acharyamod@gmail.com
0046- 765838947

Nazam Aslam
Address: Folkparksvägen 18:03, 37240, Ronneby, Sweden
nazam_aslam@hotmail.com
0046-760565552

University advisor:
Kennet Henningsson
School of Computing, BTH

School of Computing
Blekinge Institute of Technology
SE – 371 79 Karlskrona
Sweden

Internet: www.bth.se/com
Phone: +46 455 38 50 00
Fax: +46 455 38 50 57

Abstract

Context: Global Software Development (GSD) is an emerging trend in today's software world in which teams are geographically dispersed, either in close proximity or globally. GSD provides certain advantages to development companies like low development cost, access to cheap and skilled labour etc. This type of development is noted as a more risky and challenging as compared to projects developed with teams under same roof. Inherently the nature of GSD projects are cooperative in which many software developers work on a common project, share information and coordinate activities. Coordination is a fundamental part of software development.

GSD comprises different types of development systems i.e. insourcing, outsourcing, nearshoring, or farshoring, whatever the types of development systems selected by a company there exist the challenges to coordination. Therefore the knowledge of potential challenges, associated threats to coordination and practices to mitigate them plays a vital role for running a successful global project.

Objective: This study deals with the identification of challenges and threats to coordination in GSD as well as the practices to mitigate them. Furthermore, we will examine that which of them is reported in Systematic literature Review (SLR) is experienced by the practitioners through survey. This will help us to identify the commonalities and gaps between literature and industry.

Methods: In order to answer our research questions and fulfil our aims and objectives, we initially conducted the systematic literature review. For that we analyze the articles published from the year 2001 onward. On the basis of SLR we identified the challenges, associated threats and the mitigation strategies of coordination in GSD. During the SLR we used different authenticated databases like IEEE Xplore, Inspec, Compendex, Springer link, ACM Digital Library, Scopus, Google scholar, Science direct, and Wiley. Moreover, we conducted the survey in order to confirm that the listed challenges, associated threats and the mitigation strategies of coordination in GSD from the SLR are reported by the practitioners or not.

Result: On the basis of SLR of the articles published between the years 2001 to 2011 we have got 6 challenges, 50 associated threats, and 52 related challenges. We established a list and categorize the related threats and practices for each challenge. The result from survey shows that the challenges, associated threats we have listed are also addressed by the practitioner in survey and no more challenges and threats are suggested. But for the practices, the practitioner realized 3 more additional practices.

Conclusion: The result shows that the data collected through SLR is also reported by practitioners during survey. Furthermore, 3 additional practices were identified during survey those are somehow similar with previous practices identified in the literature. But still the absence of additional challenges and threats did not merit a conclusion that all possible challenges associated threats to coordination have been exposed.
Our findings can be used to overcome coordination problems by applying appropriate practices against specific challenge.

Keywords
Global Software Development, Coordination, Collaboration, Systematic Literature Review, Distributed Software Development, Global Software Engineering, Mitigation Strategies, Practices, Empirical study, Offshore, Outsource, Distributed development, Dispersed development.

ACKNOWLEDGEMENT

First of all we would like to thanks our God for giving us the power and competency to complete this research work. Secondly we would like to say thanks to our respected supervisor Mr. Kennet Henningsson for guiding and supporting us for this thesis. Under his good supervision and encouragement we are able to complete our thesis work. We would also like to thank our beloved parents for supporting us both financially and morally. Without their encouragement, prayers and motivations we could not be able to complete this thesis. We would also like to thank all the industrial participants of our survey. Lastly, we would like to say thanks to our friends and colleagues for their support, kindness and motivations during this thesis work.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

GSE	**Global Software Engineering**
GSD	**Global Software Development**
DSD	**Distributed Software Development**
SLR	**Systematic Literature Review**
SR	**Systematic Review**

Chapter 1

1. Introduction

In the early days, the concept of software development in firms was considered as an internal affair. The companies used to have their own development site that developed only the required software for its internal needs. This process is called the "in-house development". But this concept was no longer adopted instead the software companies started to implement the Global Software Development (GSD) where the software development tasks are done on distributed sites. In Software Engineering, GSD is an emerging paradigm which promises many benefits like development cost reduction, proximity to customer, access to large skilled labour pool, improved time to market. However, apart from these advantages there reside different challenges that the GSD needs to overcome in order to exploit these benefits [1] [2] [3] [4]. In GSD, the software project teams are located in different locations that are separated by country or continent boundaries [5]. As the team work from different physical locations, they are separated by the geographical, cultural, political, temporal and organizational boundaries which will impact on the communication, coordination and control of GSD project [2] [6] [7]. This is the reason why it is believed that managing the GSD projects is more complex than most complex-in –house project. Compared to the in-house-project, GSD lacks rich interaction, formal and informal interaction, and common organizational culture which are the key for the coordination yielding the effective control [8].

In GSD, it has been noted that the project works are executed in the dispersed locations by different teams which will have more risks and challenges compared to the project executed under a single roof. Therefore the Distributed Development (DD) requires more settings and arrangements. These settings and arrangements for software development are known as Global Software Engineering (GSE) or Global software development (GSD) or Distributed Software Development (DSD) [9]. Inherently, the GSD projects are cooperative which needs many software developers to work for the common project agreed upon a common definition of what they are building, share information, and coordinating activities in order to make a large and complex software system [10]. Coordination is a fundamental part of software development [11]. In GSD the software developers need to complete their task by exchanging information, seeking the necessary information, or by doing modification in the part of design. Without these types of activities or interaction it seems impossible to complete the work to get the desired result in GSD. Various activities or interactions that performed to assist the project works are called coordination [11].

Coordination in software development means that people working from different locations share information, mesh up their activities to build a common project by agreeing on a common definition of what they are building [3]. According to Erran Carmel, Ritu Agarwal, "*Coordination is the act of integrating each task with each organizational unit, so the unit contributes to the overall objective*"[12].

We have divided this report in 7 main chapters. The first chapter is an introduction to the topic of discussion, background, aims and objectives, research questions, expected outcomes, and the research methodology. Second chapter discuss about Systematic Review Design and Execution. The result of systematic literature review is discussed in the chapter three. Furthermore we present the survey analysis and the result in the fourth chapter. The fifth chapter consists of the conclusion of the thesis. Similarly, chapter six discuss about the validity threats and finally, the seventh chapter consists of the lesson learned from the thesis work.

1.1. Background

In the modern society, IT industry has become an undeniably essential part in the field of knowledge and technology. Every business across the world is integrated with the information and communication technology. Software is one key element in the field of technology, which makes development and the implementation of software more important. Previously, there were in-house development systems of software where a company developed software in its own development site for its internal uses. At the same time some other companies were in opposition of this idea and wanted the other companies to develop them the software [13]. This opposition steps helped in emerging the concept of "go global for software developments". From then, searches began for the lower costs and skilled resources around the globe for software development. Many organizations started outsourcing to experiment the software development facilities that were remotely located [14]. Today, the interest of software industry towards the global software development is increasing rapidly as they experienced growing globalization of business [15]. However, the company should be ready to face different challenges in order to experience the GSD benefits.

Coordination among the team is maintained through the use of information and communication technologies [15]. However, although dispersed teams are coordinated by means of information and communication technologies to achieve the common goal, there exists doubt that there still present some challenges. As recognized by Pär J. Ågerfalk, and Eoin Ó. Conchúir, there is a diverse effect on many levels while working from physical separated location [15]. For example, while dealing with strategic development, there arise the problems in dividing the work between the sites, handling the organizational conflicts [16]. The other is individual issues, such as jobs threaten, loss of control, fear of relocation. These are the problems that the individual experienced while working in distributed environment. Furthermore, some other problems are cultural issues like communication style, sense of time, need of structure and attitude toward hierarchy. These issues may vary according to the physical locations which can create problem of misunderstanding between the people [16]. Physically distributed teams require the rich communications that tie the people in one circle and work for common goal [17]. But unfortunately, because of cultural difference, the communications between the people got worse leading to misalignment and rework. And finally, need to deal with coordination issues. To get the benefits of GSD, an effective-information and knowledge sharing-mechanism is required [15]. Erran Carmel and Ritu Agrawal [12] defined Coordination as "the act of integrating each task with each organizational unit, so the unit contributes to the overall objective". Coordination process helps to glue whole the organization together [18]. According to Mintzberg, there are three main coordination mechanisms [19], Mutual adjustment- achieved by the continuous exchange of information among the participants, Direct supervision- a person takes the responsibility work by giving the instruction and monitoring the activity in project, Standardization- follow certain standard.

In GSD different teams work from different locations so it requires more settings and arrangements than development under a roof. This settings and arrangement for software development is known as Global Software Engineering (GSE) or Global software development (GSD) or Distributed Software Development (DSD) [9]. It provides a framework for the software development from geographical dispersed areas, covering the factors like mitigating risk of offshoring, managing a project across location, communication, coordination, managing people in distributed location, process for global development [20]. In GSD environment, when software companies begin their global collaboration can make a selection to go for either offshore insourcing or outsourcing; nearshoring or farshoring. Offshore insourcing describes the relocation of a work or part of work by an organization from one country to another but within the same organization. While in outsourcing, the work or part of work is transferred to the different organization within the same country. In nearshoring, the task is passed to the same organization within same country. While in farshoring the work or part of work is assigned to different organization located to different country [21]. Whatever the company select (i.e. insouring, outsourcing, nearshoring, or farshoring) while beginning their global collaboration, there exist the challenges to coordination, though they are few or more.

GSD is the concept of 21st century; it requires more research to get in depth knowledge to exploit its benefits. There are different terms defined with the GSD like communication, coordination, and control. These are the challenges of GSD, further depth study and research is required on it. So we planned to study on the coordination related challenges, associated threats and the mitigating practices. We will try to develop a list and categorize the threats and the practices on the basis of the challenges of coordination.

1.1.1. Related Work

Different authors have put forward their views and findings regarding coordination in GSD. We have covered 11 authors' views which are mentioned paragraph wise in the section below. Some of the related works have been taken from our own proposal and few new related works have been added in this section.

Cataldo et al. [22] introduced a technique that helps to have automatically generated archival data to easily compute the coordination requirements and he also describe how to decide that which person has to work with whom to get work done.

Sooraj p and Pratap kj Mohapatra [16] introduced coordination index which encapsulate the difficulties of coordination in GSD projects. Four other indexes- coupling index, need index, effective index and time-zone index were used to formulate coordination index. This coordination index helps to quantify task-level coordination needs in GSD projects.

Mintzberg [19] had done great work to standardize the coordination process. He proposed that we can easily facilitate the coordination process by standardizing the work processes, skills, outputs and also by knowledge. He explained that such activities can enable better management of dependencies across different activities and by allowing different actors in the organizational system to work on collective tasks.

Carmel also agrees with standardization as the suitable coordination approach for GSD. However, the organization policy and standards can create some problem in standardization in case of outsourcing [23].

Kraut and Streeter [24] had found that especially in GSD projects lack of coordination can cause unnecessary delay in software projects. One strong cause often identified in GSD projects because of such delays is "feature churn" [25], here developers spend an amount of time to develop unnecessary components because of lack of coordination those are discarded latterly.

Anita Sarma and André van der Hoek [26] introduced Palantir that build upon the existing system to provide project awareness to the developers work space. Palantir allows developers to have better coordination by providing them graphical display that tells them about the artefacts they are working or modifying. This helps to have better coordination between distributed team members.

Barstow [27] has explained that software engineer spend his more time to exchange information than any other activities. Lack of coordination leads to delay in software development, which results in increase in the overall cost of the GSD project. In GSD projects informal and ad-hoc interactions play an important role in facilitating effective coordination [28]. Coordination is a key and very important for organizations working in GSD projects especially to work on common goals at geographically distributed locations.

Jimenez et al [29] illustrated the threats and some solutions in GSD through SLR. Their study showed that coordination is one of the major problems along with communication in GSD projects that should be discussed and resolved to have better results from distributed development.

Alejandro et al [30] mentioned some of the risks and their mitigation strategies through SLR for requirement engineering process in the GSD. According to the findings and discussions of Smite et al [31], many studies in GSD reported challenges but there are few studies that provide recommendations or mitigation strategies to reduce these challenges faced by teams working in GSD environment.

Sabherwal has categorized the coordination mechanism after studying coordination in outsourced software development. He categorized the coordination mechanism as formal mutual adjustment, informal mutual adjustment, plans and standards [32].

1.2. Aims and Objectives

The aim of this study is to identify the challenges of the coordination and associated threats, and their mitigation strategies from literature and industrial point of view. Initially SLR is conducted to identify the challenges, associated threats and the mitigation practices in coordination then after a survey is conducted to check if the identified challenges, associated threats and the practices of coordination exist in industry . Finally we will give a result on the basis of analysis of the gaps and commonalities between survey results and the results from SLR.

In the below section we have mentioned the objectives of our study:

- Identification of coordination related challenges and associated threats in GSD from literature.
- Identification of the practices to mitigate the challenges and associated threats related to coordination from literature.
- Identification of coordination related challenges and associated threats faced in industry.
- Identification of the practices to mitigate the challenges and associated threats related to coordination in GSD from industry.
- Results and Analysis of the gaps and commonalities between the literature results and the results from industry.

1.3. Research Questions

RQ1: What are the coordination related challenges, associated threats and practices reported in the literature?

RQ2: What are the coordination related challenges, associated threats faced in the industry?

RQ3: What are the practices used in the industry to mitigate the coordination challenges, and associated threats in GSD?

RQ4: What are the gaps and commonalities between literature results and the results from industry?

1.4. Expected Outcome

- The possible list of challenges and associated threats of coordination in GSD through SLR and survey.
- The practices to mitigate the challenges and associated threats of coordination in GSD through SLR and survey.
- Results and Analysis of the gaps and commonalities between survey results and the results from SLR.

1.5. Structure of thesis

The structure of thesis has been categorized into 3 main classes as shown below:

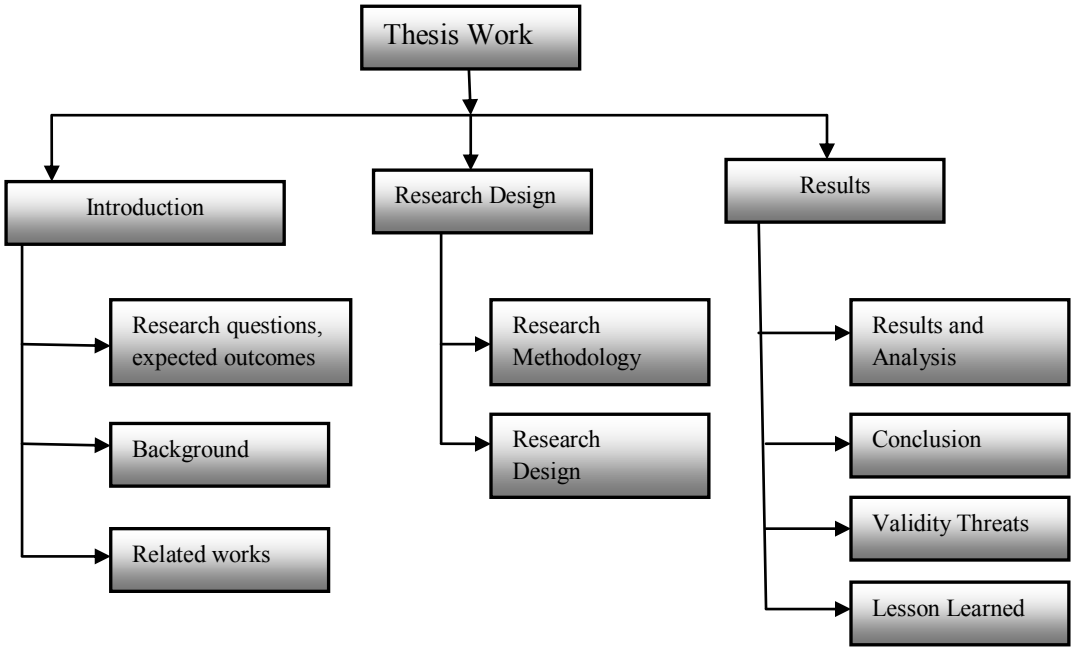

Figure 1: Thesis structure

1.6. Research Methodology

In this paper, we have used both methodology i.e. the SLR and the Survey. Initially SLR will be performed in order to find coordination challenges, associated threats, and the practices to mitigate them in GSD. Later these literature findings will be compared with the survey findings to answer research questions. The following sections cover detail explanation of two research approaches.

1.6.1. Systematic Literature Review

Systematic literature review is " *a means of identifying, evaluating and understanding all the available research relevant to a particular topic area or research question, or phenomenon of interest*" [33]. SLR is a scientific approach to identify, evaluate and to interpret the available research related to some specific research questions [33].

SLR is a prerequisite of meta-analysis and meta-synthesis review techniques [33]. Meta- analysis is a type of SLR that uses statistical technique to obtain quantitative synthesis [33]. Meanwhile, meta-synthesis is a non-statistical SLR technique that involves synthesizing and analyzing the key points in each article [34] [35]. The steps in meta-synthesis are almost same as SLR i.e. search for articles, exclusion and inclusion criteria, appraise studies, analyze the studies and then synthesize the findings [36].

For this work, we agreed to follow the SLR instructions suggested by Kitchenham [33]. Mainly there are three steps to perform SLR i.e. planning the review, conducting the review, and reporting the review [33].

During planning the review, it is needed to conduct and develop review protocol. Conducting the review protocol includes the process of searching the primary studies to answer specific research questions. Lastly, in reporting the review the results extracted from primary studies are documented.

For this study we used SLR to search, collect, and give a summary of empirical evidences available regarding coordination challenges, associated threats and practices to mitigate them in GSD projects. For this there is a need of well-defined methodology that makes it less probable that study results are unfair [33]. A well-defined methodology also helps in providing background knowledge to properly position new research activities [33]. Study [9] had done a systematic literature review in selected subject area for published literature between 2000 and 2009. In this research work primary studies are included that published from 2001 onwards. The published papers prior to 2001 were not included in this thesis work as GSD is a more prevalent trend in 21st century due to globalization [9]. In this work, the centre of interest is coordination challenges, associated threats and practices to overcome these challenges.

The outcome of SLR is a collection of challenges, associated threats, and practices to overcome these challenges in GSD projects..

1.6.2. Empirical Research

There are different methods to conduct empirical research like- case study, survey and experiment [37]. The purpose of the case studies is to inspect how and why things happen. The case studies are conducted to investigate the contextual realities and examine the difference between the results from literature review and what is actually happening in software industry [38]. Experiment is a type of control study that is used to control over the situation and manipulate behaviours directly, systematically and with precision [37]. Both of them, experiments and case studies are not suitable for our work. We decided to use industrial surveys as they will help to explore to the extent to which the industrial practitioners are realizing coordination challenges, associated threats and practices in comparison with what literature stated [37]. Surveys have ability to provide more number of variables to evaluate findings [37]. The authors will thoroughly review the literature to design survey questionnaire.. The survey questionnaire will be designed on the basis of the SLR and sent to the practitioners of the company to see if they have experienced them or not.

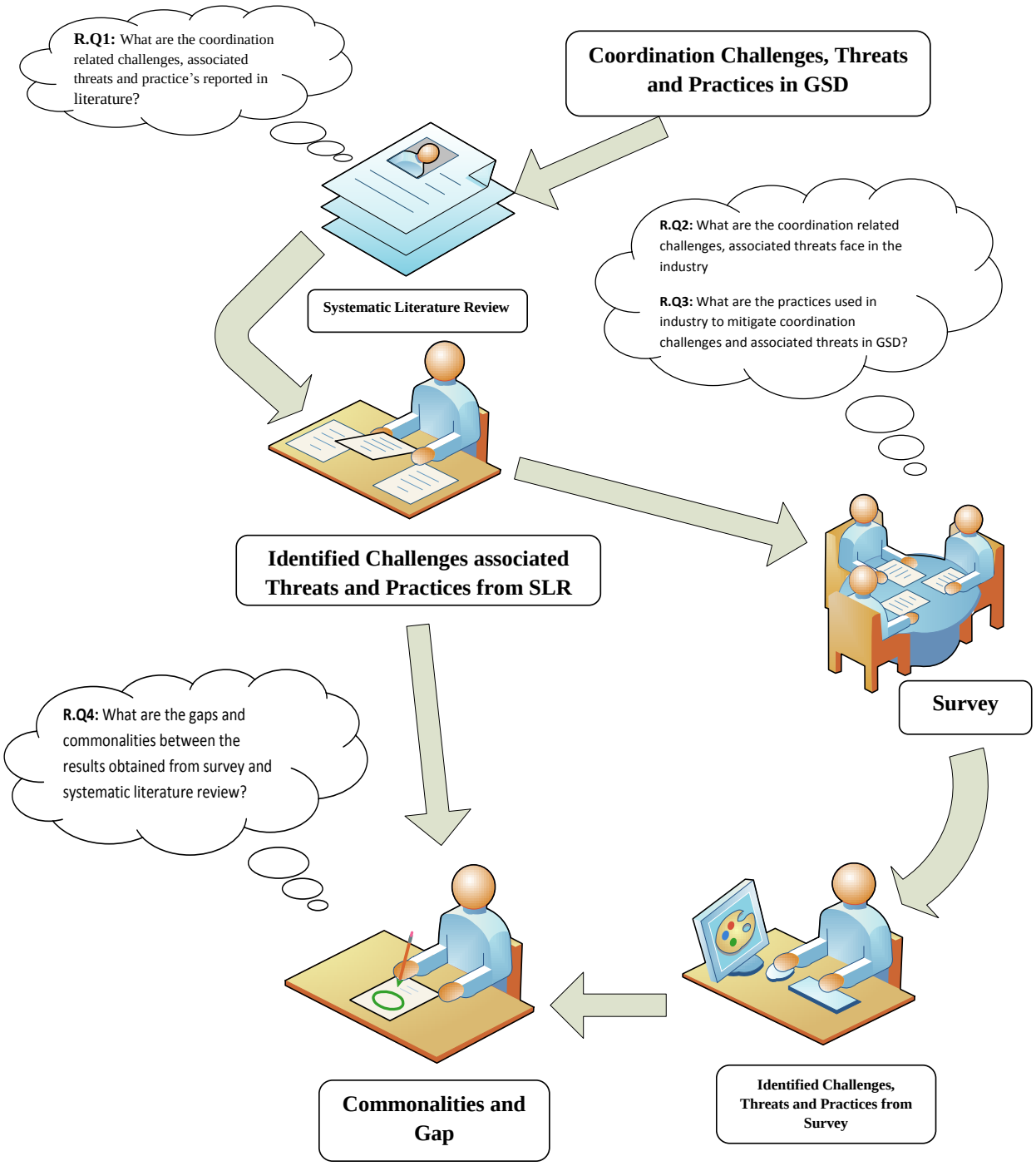

Figure 2: Research Design

Chapter 2

2. Systematic Review

A systematic review is used to identify, evaluate and interpret current researches that are related to specific research questions [33]. This approach uses more rigorous and well-defined method to review the research articles [34]. According to Kitchenham [33], systematic review is a well defined methodology that makes it less probable that the literature results are unfair. That means SLR is a repeatable and structured process which helps in minimizing the researchers biases. Moreover, SLR is a systematic literature review also provides background knowledge so that it gives proper position to new research findings.

Systematic review has three main phases i.e. planning the review, conducting the review and reporting the review. First phase, planning the review describes the steps to perform literature review in a systematic way and development of the review protocol. A review protocol describes the aim and process of the systematic review [39]. There is a need to have a well designed review protocol while doing systematic review which aids to avoid researcher bias in performing the review [33] [39]. The second phase started by conducting systematic review which consists of primary study, a check list for quality assessment, data extraction and synthesis. At third and last phase, results collected from systematic review are reported and distributed among the interested participants [33].

In systematic review following steps are followed [33] [34]:

- First of all a review protocol is described that can help to identify the research questions to be addressed and the approach used to conduct the review study.
- This study has the procedure for inclusion and exclusion of the data in order to access the related articles.
- It uses a well defined search string in order to recognize most relevant and significant literature as much as possible.
- In systematic review, there is also a criterion to evaluate the quality of selected articles.
- At the end, it includes a well defined criterion to analyze, synthesize and disseminate the findings from the study.

2.1. Systematic Review Design and Execution

A systematic review, design and execution consist of following three phases:

- Planning the review
- Conducting the review
- Reporting the review

2.1.1. Planning the Review

The main purpose of this phase is the development of review protocol and to define the steps to conduct the literature review in a systematic way [33].

2.1.1.1. Purpose of Systematic Review

The purpose of systematic review is twofold. First is to search and collect information about the challenges, associated threats and the best practices of coordination in GSD to mitigate them. Secondly, to perform meta-synthesis for analyzing the research studies. Systematic literature review is performed to summarize the empirical evidences regarding the challenges, associated threats of coordination in GSD and the best practices to mitigate them which will be confirmed by the practitioners from survey.

2.1.1.2. Defining Research Questions

The following research questions will provide a guideline to understand the challenges, associated threats of coordination and the practices used to mitigate them in global software development. It will be answered by systematic literature review.

RQ1. What are the coordination related challenges associated threats and practice reported in the literature?

This question will help us to find the data from previous published literature. All the possible challenges and associated threats faced by team members during coordination of GSD projects and the practices used to mitigate them will be identified and noted.

R.Q2 and R.Q3 will be answered based on survey results whereas RQ4 will be answered on the basis of R.Q1 and R.Q2, RQ3. by comparing them with each other to find the similarities and difference between RQ1 and RQ2 with RQ3 to answer RQ4.

2.1.1.3. Review Protocol Development

A review protocol helps to define a procedure to perform a specific systematic review [33]. It also helps to minimize the researcher bias [33]. A review protocol has the phases like search strategy, criteria for study selection and quality assessment, data extraction form, and synthesis strategy.

2.1.1.3.1. Search Strategy

Search string aids the researcher to answer the research questions effectively. In the below section we have defined and discussed the steps involved in making search string.

a. Key Words

First, the key words are defined which will help us to find out related research articles regarding challenges associated threats to coordination in GSD and the best practices to mitigate them. To cover large number of articles we will revise the key words to choose synonyms and alternative words. At next step we will use Boolean operators such as 'OR' and 'AND' to identify the related study areas. Lastly, we will refine the research with respect to specific field in software engineering.

Following table 1 is the list of identified key words to conduct systematic literature review.

Table 1: Key words

A	B	C	D	E	F
A1=Coordination	B1= Global software development	C1= Software engineering	D1= Empirical	E1= Challenge	F1= Distributed processing
A2=Collaboration	B2= GSD	C2= Software engineering project	D2=Experiment	E2= Risk	F2= Construction industry
	B3= GSE	C3= Software project	D3= Interview	E3= Hurdle	F3= Grid computing
	B4= Offshore		D4= Survey	E4= Problem	F4= Computer aided software engineering
	B5= Outsource		D5= Case Study	E5= Threat	F5= Software engineering
	B6= Near			E6=	F6= Virtual

	shore			Solution	enterprises
	B7= Distributed			E7= Practice	F7= Distributed programming
				E8= Mitigation	F8= Computer networks
					F9= Software architecture
					F10= Business data processing
					F11= Software tools
					F12= Supply chain management
					F13= Telecommunication
					F14= Computing
					F15= Information management
					F16= Technology transfer
					F17= Web services
					F18= Interactive systems
					F19= Distributed databases
					F20= Medical information systems
					F21= knowledge management

b. Search String

The selection of articles is based on search string. The following search string is defined with the help of key words defined in table 1

(A1 OR A2) AND (B1 OR B2 OR B3 OR B4 OR B5 OR B6 OR B7) AND (C1 OR C2 OR C3) AND (D1 OR D2 OR D3 OR D4 OR D5) AND (E1 OR E2 OR E3 OR E4 OR E5 OR E6 OR E7 OR E8) AND (F1 OR F2 OR F3 OR F4 OR F5 OR F6 OR F7 OR F8 OR F9 OR F10 OR F11 OR F12 OR F13 OR F14 OR F15 OR F16 OR F17 OR F18 OR F19 OR F20 OR F21)

c. Resources

The articles, workshops, conference papers and journals, will be identified from most authenticate databases. These databases are:

- IEEE Explorer
- ACM Digital Library
- Inspec
- Compendex
- Google Scholar
- Science Direct

- Wiley Inter Science Journal Finder
- Springer Links

The above mentioned databases are well know and authenticated. The rationale behind the use of Inspec and Compendex databases is that both are wide rang and have huge number of publications specially related to software engineering. IEEE Explorer, ACM Digital Library, Google Scholar, Science Direct, Wiley Inter Science Journal Finder is used so that we cannot miss any important publication for systematic literature review. All are well known, fully organized, widely used, reliable, and up-to-date and have relevant data about software engineering field.

2.1.1.3.2. Study Selection Criteria

Appropriate research articles for this study are selected on the basis of study selection criteria. The articles selection process is based on title, abstract, introduction and conclusions that give us relevant data to answer our research questions. Data inclusion is done with the help of Tollgate method [40], this method helped us to select the articles by using key words, synonyms, revised key words and alternative key words mentioned above. Tollgate method helps us to design a gate as per our requirements so to get the results. Different gates can be defined to refine the result. Four different stages of this method are defined in the table below.

a. Inclusion Criteria

The articles those full fill the criteria in the following table are included for research. The full criteria with the help of Tollgate method [40] is defined in the table 2

Table 2: Data Inclusion Criteria

Sr. No	Stage	Criteria
1	Overall Selection	-Language = English -Full Text -Date of publication -Non-Duplicate -Published papers in conference/journal/ and workshop proceedings -Others?
2	Title and Abstract level	-Must have empirical background -Contains search words -Must focuses on coordination challenges and their mitigation strategies along with the associated threats faced during coordination in GSD projects.
3	Introduction and conclusion level	-Empirical background -Focuses on coordination challenges and their mitigation strategies along with the associated threats faced during coordination in GSD projects.
4	Full Text level	-Papers must contain the empirical research work -Mainly focus on the Challenges and associated threats of coordination and the practices to mitigate them faced by GSD teams.

b. Exclusion Criteria

All the articles those do not fulfill the criteria defined in the above table 2 are excluded from the study.

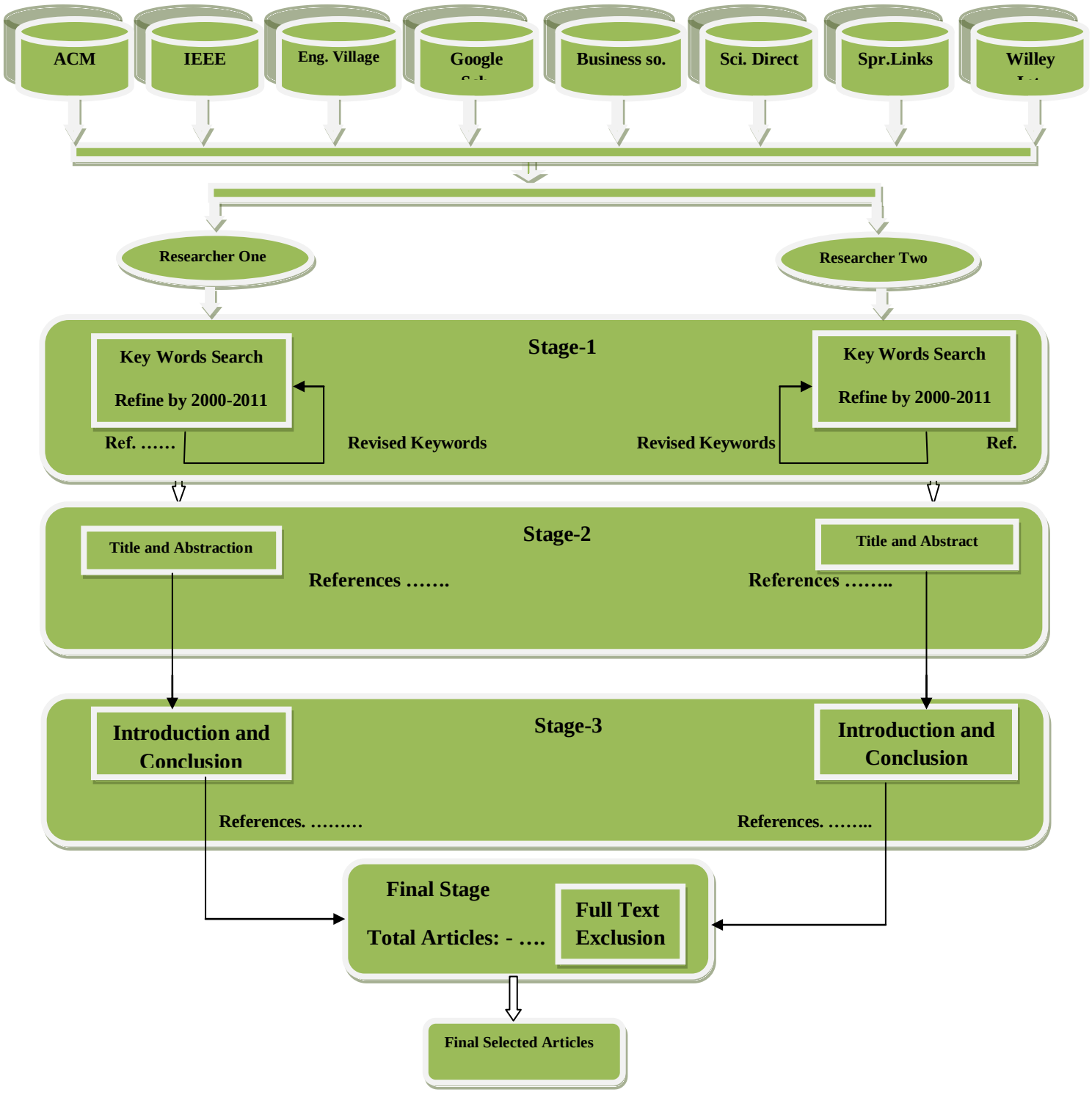

Figure 3: Steps in Tollgate Method to select literature

2.1.1.3.3. Data Extraction Strategy

The purpose of data extraction strategy is two folded, first to collect enough relevant information to address our research questions and secondly data synthesis. Data extraction form is used to ease the process of synthesis from collected data [31] [40]. This form is defined below in table 3.

Table 3: Date Extraction Form

Basic information about the research work/Articles	
Title of Article	
Author Name	
Publication Date	
Source	
Search Query	
Journal / Conference Proceedings / Conference	
Empirical Background	
Study Method	-Interviews -Surveys -Case study -Experiments -Others
Research Background	-Industrial work -Academia -Laboratory
Investigation	-Industry -Students
Empirical Focus	-Empirical Evaluated -Empirical Based
Background (GSD)	
Mode of Collaboration	-Inter-Organizational -Intra-Organizational -Unclear
Head office location	- ------- - Irrelevant - Unclear
Site Location	- ------- - Irrelevant - Unclear
Number of Site's	- ------- - Irrelevant - Unclear
Team Size	- ------- - Unclear
Application Domain	- ------- - Unclear
Project Size	- Small (4-6 months) - Medium(1-2Years) - Large(More than 2 years)
Project Type	- Industrial - Non-Industrial
Organizational Size	- Small - Medium - Large
Data Analysis	Are the Challenges to coordination in -Yes

	GSD are discussed?	-No		
	Are the Threats to coordination in GSD are discussed?	-Yes -No		
	Are the best practices to mitigate the challenges and threats to coordination are discussed?	-Yes -No		
Sr. #	**Quality Assessment Checklist**	**Answers**		
		Yes	**No**	**Partial**
01	Do the research papers clearly explain the research methodology?			
02	Do the research methodology was appropriate to answer the problems?			
03	Are the results in the study clearly mentioned and explained?			

2.1.1.3.4. Quality Assessment Criteria

Empirical evidences are qualified on the basis of criteria defined by Kitchenham [33]. These are defined in above table 3

2.1.1.3.5. Data synthesis Strategy

We collect and summarize the results of primary research that is relevant to our research questions to synthesize data. A brief summary of the selected research articles with respect to primary area of study is described in table 4.

Table 4: Summary of final selected research articles

Key Area	Authors	Year	References
Challenges to Coordination in GSD project	Author 1……. Author 2……. Author 3……. Author 4……. . . . Author N……	2001-2011	Reference 1…….. Reference 2…….. Reference 3…….. Reference 4…….. . . . Reference N…….
Threats to coordination in GSD projects	Author 1……. Author 2……. Author 3……. Author 4……. . . . Author N……	2001-2011	Reference 1…….. Reference 2…….. Reference 3…….. Reference 4…….. . . . Reference N…….
Practices to mitigate the Challenges and Threats to Coordination in GSD projects	Author 1……. Author 2……. Author 3……. Author 4……. . . .	2001-2011	Reference 1…….. Reference 2…….. Reference 3…….. Reference 4…….. . . .

2.1.2. Conducting the Review

2.1.2.1. Identification of Research

Systematic literature review is used to determine, evaluate and interpret the research articles specific to research questions. To identify the related research articles and to answer our research questions we used search strategy. All the steps of search strategy are discussed above in 2.1.1.3.1. Key words are identified to find the articles related to our topic "Challenges and associated threats to coordination in GSD and practices". These key words are further revised to cover all the important and relevant data from published literature. Identification of research is purified by using Boolean operators like "AND" and "OR" and with a detail discussion with librarian and experts.

While conducting literature review publication bias is a big issue. According to the description of Kitchenham [33], "Publication bias refers to the problem that positive results are more likely to be published than negative results". To overcome publication bias we use steps from Kitchenham [33] those are discussed below.

- Scanned conference proceedings
- Scanned grey literature (i.e. technical reports, work in progress)
- Approach professionals to validate published literature's results
- Perform manual search

We use Zetero software to manage large number of references those we collected while doing systematic literature review.

2.1.2.2. Selection of Primary Studies

To select the relevant research articles we use Tollgate [40] approach. This approach consists of four phases those are discussed in details in table 2. Same search string is used for all the selected databases depending upon their specific format. Below table 5 is used to address search string along with number of articles extracted from each database.

Table 5: Research papers from different databases

Sr.#	Data Base	Search String	Articles Found
1	**Engineering Village**	(((Coordination or collaboration) and (Global software development or GSD or GSE or Offshore or Outsource or near shore or Distributed or Dispersed or Multi-site or Virtual team or onshore) and (Software engineering or project) and (Empirical or experiment or interview or survey or case study) and (Challenge or risk or hurdle or problem or threat or Solution or practice or mitigation or strategy or success story	753

		or safe guard)))	
2	**IEEE**	(((Coordination or collaboration) and (Global software development or GSD or GSE or Offshore or Outsource or nearshore or Distributed or Dispersed or Multi-site or Virtual team or onshore) and (Software engineering or project) and (Empirical or experiment or interview or survey or case study) and (Challenge or risk or hurdle or problem or threat or Solution or practice or mitigation or strategy or success story or safe guard)))	345
3	**ACM**	(((Coordination or collaboration) and (Global software development or GSD or GSE or Offshore or Outsource or near shore or Distributed or Dispersed or Multi-site or Virtual team or onshore) and (Software engineering or project) and (Empirical or experiment or interview or survey or case study) and (Challenge or risk or hurdle or problem or threat or Solution or practice or mitigation or strategy or success story or safe guard)))	210
4	**Springer links**	(((Coordination or collaboration) and (Global software development or GSD or GSE or Offshore or Outsource or near shore or Distributed or Dispersed or Multi-site or Virtual team or onshore) and (Software engineering or project) and (Empirical or experiment or interview or survey or case study) and (Challenge or risk or hurdle or problem or threat or Solution or practice or mitigation or strategy or success story or safe guard)))	489
5	**Business Source Primer**	(((Coordination or collaboration) and (Global software development or GSD or GSE or Offshore or Outsource or near shore or Distributed or Dispersed or Multi-site or Virtual team or onshore) and (Software engineering or project) and (Empirical or experiment or interview or survey or case study) and (Challenge or risk or hurdle or problem or threat or Solution or practice or mitigation or strategy or success story or safe guard)))	341

6	**Wiley inter science**	(((Coordination or collaboration) and (Global software development or GSD or GSE or Offshore or Outsource or near shore or Distributed or Dispersed or Multi-site or Virtual team or onshore) and (Software engineering or project) and (Empirical or experiment or interview or survey or case study) and (Challenge or risk or hurdle or problem or threat or Solution or practice or mitigation or strategy or success story or safe guard)))	446
7	**Science Direct**	(((Coordination or collaboration) and (Global software development or GSD or GSE or Offshore or Outsource or near shore or Distributed or Dispersed or Multi-site or Virtual team or onshore) and (Software engineering or project) and (Empirical or experiment or interview or survey or case study) and (Challenge or risk or hurdle or problem or threat or Solution or practice or mitigation or strategy or success story or safe guard)))	371
8	**Google Scholar**	(((Coordination or collaboration) and (Global software development or GSD or GSE or Offshore or Outsource or near shore or Distributed or Dispersed or Multi-site or Virtual team or onshore) and (Software engineering or project) and (Empirical or experiment or interview or survey or case study) and (Challenge or risk or hurdle or problem or threat or Solution or practice or mitigation or strategy or success story or safe guard)))	314
	Total		**3289**

2.1.2.2.1. Papers Selected from Primary Studies

The process of final papers selection in based on Tollgate [40] approach. All the process and phases of this method are defined below.

At stage one the articles are selected on the basis of criteria defined in table 6.

Table 6: Stage-1(papers selected from primary studies)

1	**Overall Selection**	**-Language = English** **-Full Text** **-Date of publication** **-Non-Duplicate** **-Published papers in conference/journal/ and workshop proceedings** **-Others?**

At stage-1 we identified the articles on the basis of above defined criteria. By applying above criteria we identified 3289 articles from 8 different databases. Then the articles are equally distributed between the researchers to identify and replace duplication. To remove duplication, make references and categorize the articles we used reference management software Zetro.

This data is passed out to stage-2 for further filtration. At stage-2 we identified the articles on the basis of criteria defined in table 7.

Table 7: Stage-2(papers selected from primary studies)

2	**Title and Abstract level**	**-Must have empirical background** **- no- duplicate** **-Contains search words** **-Must focuses on coordination challenges and their mitigation strategies along with the associated threats faced during coordination in GSD projects.**

By applying above specified criteria we identified 283 articles out of 3289. The articles we identified on the basis of title and abstract are further managed by removing the duplicate articles. We identified 144 articles out of 283 after removing duplicate articles.

These, 144 articles are then passed to stage-3 for further process. The criterion for stage-3 is defined in table 8 below.

Table 8: Stage-3(papers selected from primary studies)

3	**Introduction and conclusion level**	**-Empirical background** **-Focuses on coordination challenges and their mitigation strategies along with the associated threats faced during coordination in GSD projects.**

After applying above criteria we identified 89 articles out of 144 articles. These articles are then further processed at stage-4.

Criterion for stage-4 is defined in table 9 below.

Table 9: Stage-4(papers selected from primary studies)

4	**Full Text level**	**-Papers must contain the empirical data** **-Mainly focus on the Challenges and associated threats of coordination and the best practices to mitigate them faced by GSD teams.**

After having full text study, applying above criteria we identified 47 articles out of 89 articles. The list of finally selected articles is summarized in Appendix A. The agreement level between the authors is checked using the Kappa coefficient method.

A detailed description of this process is given in table 10. The whole process is also defined with the help of diagram. In figure 3 we explained all the stages of Tollgate [40] method.

Table 10: Selection of Research Studies

Sr.#	Name of database's	Stage-1 Total number of articles found	Stage-2		Stage-3 Introduction and Conclusions	Stage-4 Full Text
			Title & Abstract	Duplication		
001	Engineering Village	753	127			
002	ACM	210	31			
003	IEEE	345	56			
004	Willey Inter Science	446	25			
005	Business Source Primer	341	15	144 →	89 →	47
006	Google Scholar	314	22			
007	Springer link	489	15			
008	Science Direct	371	08			

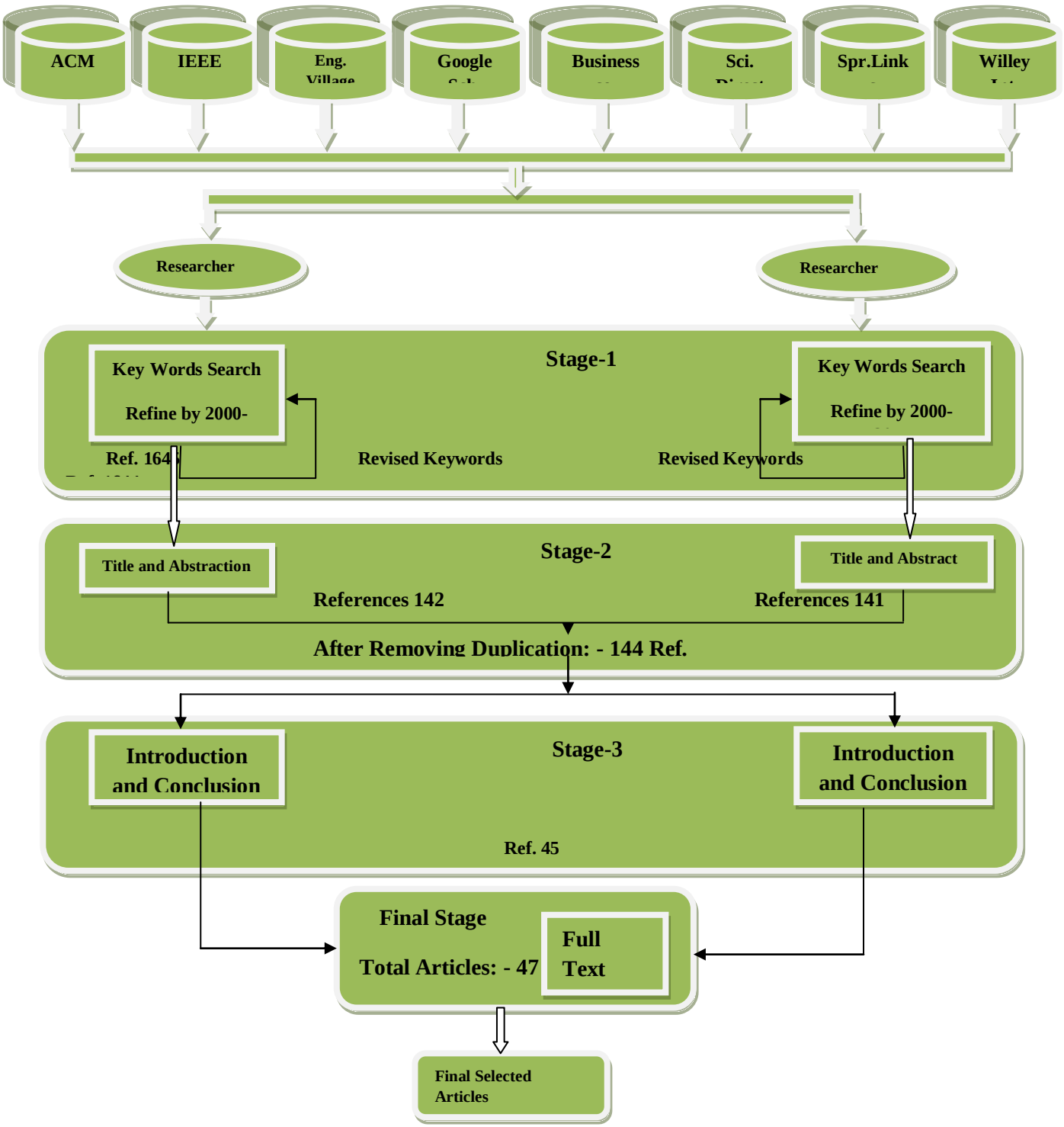

Figure 4: Tollgate Approach to select literature

2.1.2.3. Study Quality Assessment

Study quality assessment is very important to assess the quality of primary study [33]. Significance of individual study is analyzed through this assessment and along with synthesizing the results of individual study this is also used to make recommendations for further research [33]. In table 11 we used a quality assessment criterion and by using this criterion we analyzed the results of the study. We use three values Partial, Yes and No criteria to explain each article selected for final review.

Table 11: Quality Assessment Criteria

Sr. #	Quality Assessment Checklist	Answers		
		Yes	No	Partial
01	Do the research papers clearly explain the research methodology?	11	11	25
02	Do the research methodology was appropriate to answer the problems?	14	10	23
03	Are the results in the study clearly mentioned and explained?	13	13	21

2.1.2.4. Data Extraction

Data extraction form helps the researchers to record the information acquired from primary study and it also help to condense the chances of bias [33]. To ensure that both the authors have a common interpretation of data and form to be extracted, both the authors performed the pilot extraction before going to start actual data extraction. We selected 8 research papers for piloting and each author read these papers thoroughly. In order to check the level of agreement we used the kappa coefficient method. It is a statistical method used to check the consistency of agreement among the authors. Data extraction is done individually by both authors according to their understanding using the data extraction form.

Extracted data were evaluated with the help of kappa method to check if both the authors have common understanding or not. For some confusion the thorough discussion helps in identifying the required data and make clear about the confusion. After this the collected articles were divided among the authors for data extraction. For data extraction we used MS Excel sheet that was lately used for data synthesis phase.

The details of kappa coefficient method are given in the *Appendix D.*

2.1.2.5. Data Synthesis

Selected research papers were studied and data was extracted and documented in MS Excel sheet. Than after we need to collect and give a summary of our findings. Data synthesis is very important phase in systematic literature review that involves collection of data and gives summary of results of the selected study [33]. To answer our research questions we categorize and analyze our findings related to challenges, threats and practices to coordination in GSD. Tabular format is used to present our findings. Frequencies are used to give the number of times each of them related to our research questions determined in different papers.

2.1.3. Reporting the Review

Reporting the systematic review results is the final stage in systematic literature review. At this stage, result of systematic review which is presented in the section 3.2 are reported and then distributed among participants

Chapter 3

3. Systematic Literature Review Results

In this chapter, we discuss the findings that were gathered from 47 selected articles. The findings of the articles are the coordination related challenges, associated threats, and the mitigating practices in GSD. Along with this information we describe the characteristics of studied literature which are discussed on the section 3.1. Furthermore, they are separated in different categories i.e. Select primary research studies, Research method used, and context and publication year. In the second part of this chapter we discuss the identified challenges, associated threats and practices to mitigate them. Finally, we present a detailed discussion and conclusions about our findings during literature review.

3.1. Characteristics of primary study

3.1.1. Selected Primary Research Studies

In this section we present the information about the selected studies. Each research paper has described with the information like, author's name, publication year, publication name, and application domain and study type and finally we present this information in a tabular form that is attached in appendix A.

3.1.2. Research Method

On the basis of our research, we concluded that most of the studies are exploratory in nature, collected research data is mainly focusing on empirical evidences regarding the challenges, associated threats to coordination and mitigation practices in GSD. Research methods like- case study, surveys, interviews, experiments and industrial reports are used to give empirical evidences [37] which are discussed below:

- **Case Study**
  This is a type of study where projects, activities or assignments are monitored. During these activities data are collected throughout the process for some specific purposes. Then some statistical analyses are performed. This is an observational type of study having less control as compared to experiments.
- **Surveys**
  This is a retrospect type of investigation in which primary means of gathering data are interviews or questioners. A sample of population is collected that represent the whole population and then results are analyzed to give descriptive and explanatory explanations.
- **Experiments**
  Experiments are formal, controlled and rigorous type of investigation. Experiments are done in laboratory environment having high level of control. Different treatments are assigned to the objects. The values of these variables are observed and then statistical analyses are performed to provide conclusions of the study.

❖ Industrial Experience reports

These reports are mostly depends upon industrial or regional experiences. We do not have any clear method used in such experience reports.

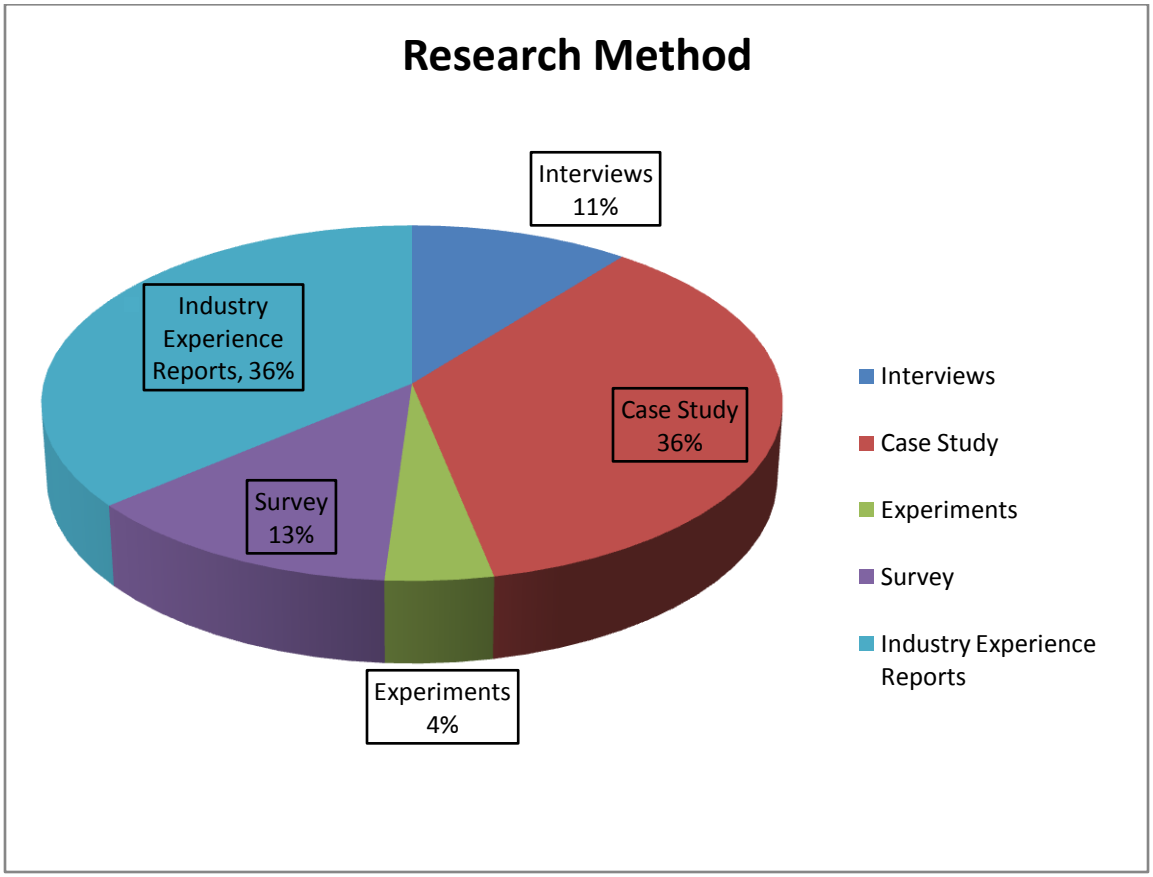

Figure 5: Research Method

In table 12 and figure 5 we have categorized the research papers according to the research method used in these studies. Our findings show that the collected studies are based on the research methods like, Case study, Interviews, Surveys, Experiments and Industry experience reports. Our findings show that 36 % of the total articles are based on case studies. In these studies interviews and grounded theory are used as sub-methods to collect and verify the data. Such types of studies are useful to transfer the knowledge from academia to industry. Figure 5 show that 13 % of the articles used surveys as base research methods to collect and verify their findings. In these surveys, researchers used questioners to elicit the data from participants then this data is verified and reported. We found same number of papers in which interviews are used to collect and verify the data. According to the figure 5, we have 4% research papers in which experiments are conducted to collect and verify the data. Most of these experiments are conducted with university students. Figure 5 and table 12 shows that most of the research papers are based on industry experience reports. We have 36 % research papers in which industry experience reports are discussed. In these reports researchers does not use any particular research method but their own past experience. Such types of studies are useful to transfer the knowledge from industry to academia.

3.1.3. Publication Year

For our research we selected the papers from 2001-2011. The main reason behind it is that global software development is the concept of 21st century so going behind is useless. GSD is a more prevalent trend in 21st century due to globalization [57]. Below figure 6 shows the number of selected studies published on specific year.

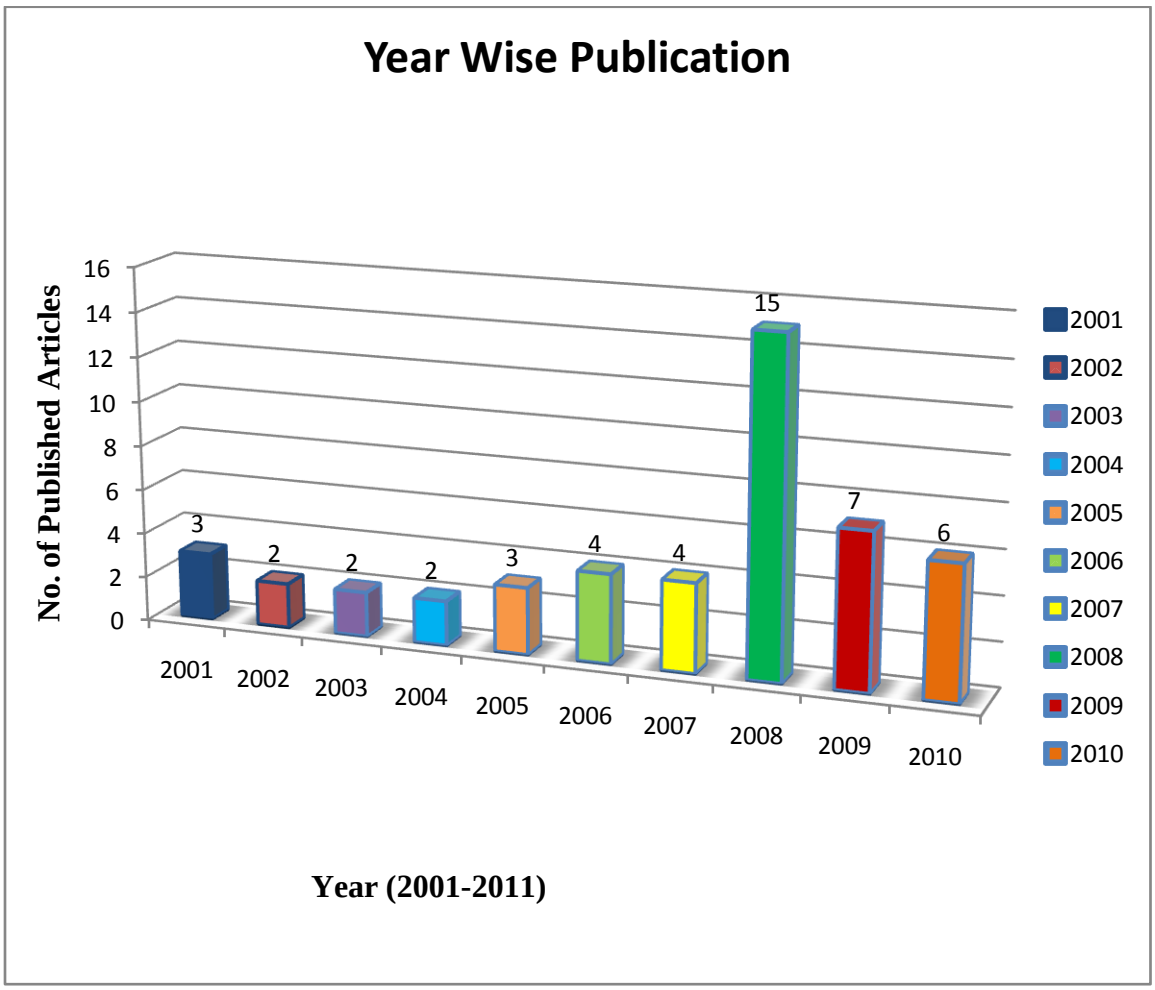

Figure 6: Year wise Published Articles

At the first stage we have collected 3289 articles from year 2001-2011. After passing different stages of data exclusion we have selected 47 articles out of 3289 studies those are suitable for our research work. Above diagram shows that numbers of published articles are almost same during the start of 21st century. Might be the reason behind that is global software development is the phenomenon of 21st century but with the passage of time this field become more popular. Above figure shows that during 2007 till now the numbers of published papers are increasing day by day. In 2008 we have high number of 14 research articles. This shows that during this period of time most of research started working on this field.

3.1.4. Context

In this paragraph we discuss the context of the each studied articles. Here we categorize it in, empirical and GSD background. Empirical background contains the information like, research method used in the study and subject of investigation. In GSD background it contains the information like, project background, GSD team architecture, team size and application domain. We use table 12 to discuss empirical and GSD background information.

Table 12: Context of the selected study articles

Research Work category		No. of publications
Research Methodology	Interviews	5
	Case Study	17
	Experiment	2
	Surveys	6
	Industrial Experience Report	17
Investigation Subject	Students	5
	Practitioners	42
Background	Industry	42
	Academia	5
Team Structure (GSD)	Team located on the same site	7
	Team members located different site	17
	Unclear	23
Team Size	Up to 20	12
	More then 20	7
	Unclear	28
Application Domain	Computer based software's	4
	Information system development	3
	Airline solutions	1
	Research corporate	1
	Software management	7
	Telecommunication	4
	Tools and processes for GSD	1
	Software Development projects	6
	Simulating GSD Scenarios	1
	Service Computing	1
	Emergency Management	1
	Business process off-shoring	1
	Unclear	16

Table 12 and figure 6 shows that there is more empirical studies as compared to industry experience reports. From the literature review the total findings is 47 articles out of which 17 are industries experience reports and the rest 30 are empirical studies.

Above table 12 also shows other related properties of the research studies like, the subject of investigation in these studies, background, team structure, team size and application domain in which these researches are conducted. Mostly the findings of investigation are industry practitioners as we have 42 studies on practitioners and 5 on students. This shows that most of the literature has industrial validation.

Results show that 12 studies had mentioned that the numbers of employees involved in the project are less than 20. Out of 42 selected research papers we have 7 studies those have more than 20 employees involved in the project and 28 studies do not give any information about the number of employees involved in the project.

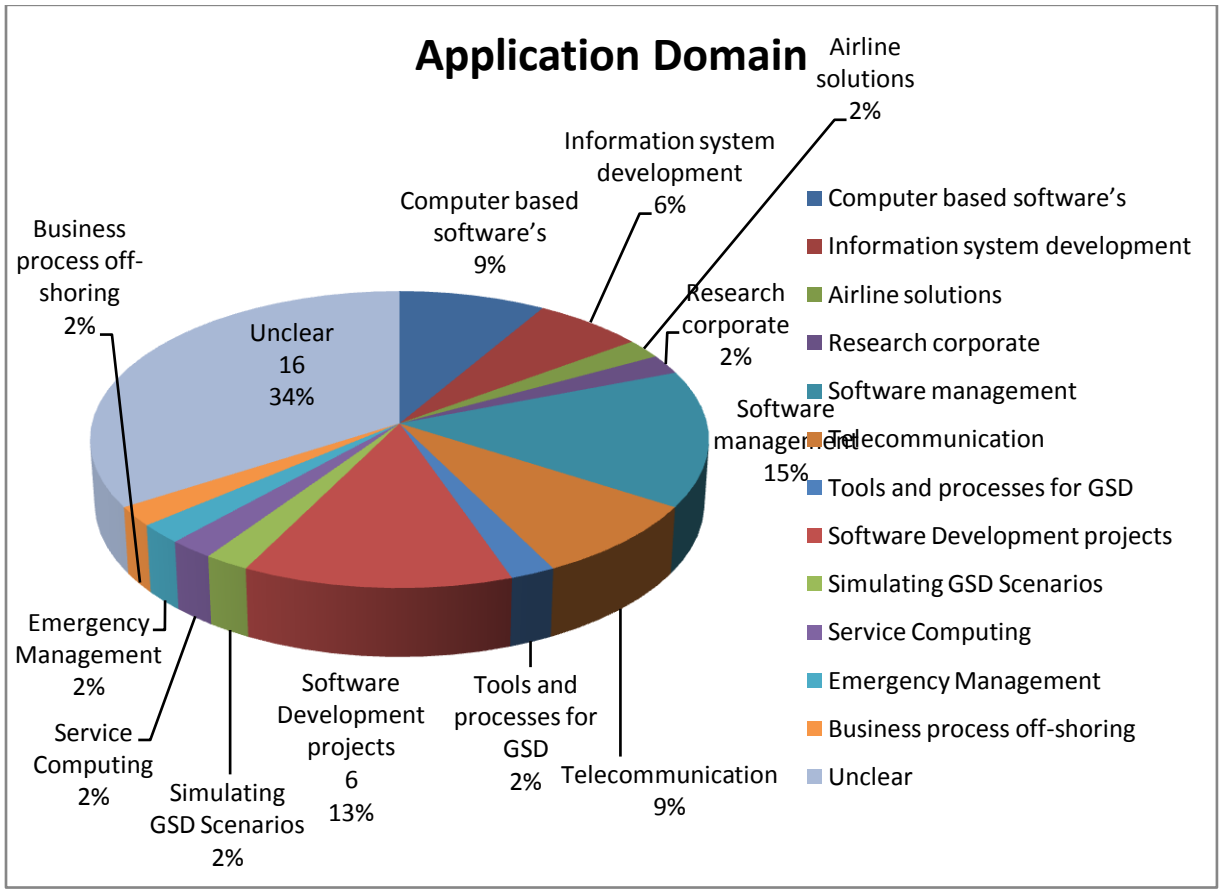

Figure 7: Application Domain

Figure 7 gives the information about the domain of the selected studies. In this study we have identified 12 domains in 47 selected articles. Most of the data is related to software or software management. We have identified them in percentage where 15 % studies are related to software management, 13 % software development project and 9 % computer based software's. Furthermore, it shows that 34 % of the studies do not mention any domain.

3.2. Reported Challenges and Associated Threats

We selected 47 papers as a primary studies. On the basis of these papers we identified 6 challenges of coordination. These challenges are Geographical distance, Culture and language, temporal distance, Communication, Trust, Software architerature. The challenges identified from the SLR are tabulated in

table 13 along with the article reference numbers. Figure 8 gives information about the challenges and the count of articles numbers that discuss the challenges.

Table 13: Identified Challenges

Sr. No	Challenges	Reference's
01	Geographical Distance	[p1] [p3] [p9] [p10] [p14] [p15] [P16] [P18] [P22] [p23] [p26] [p27] [p28] [p29] [p30] [p31] [p32] [p34] [p35] [p38] [p39] [p40] [p41] [p42] [p43] [p46] [p47]
02	Cultural and Language	[p1] [p3] [p4] [p9] [P13] [p15] [p26] [p30] [p33] [p35] [p36] [p39] [p40] [p42] [p43] [p46] [p47]
03	Temporal Distance	[p3] [p8] [p9] [p14] [p15] [P17] [P18] [p22] [p23] [p25] [p30] [p32] [p33] [p35] [P36] [p39] [p40] [p43] [P44] [p47]
04	Communication	[p1] [p3] [p4] [p9] [p10] [p1] [p20] [P22] [p23] [p27] [p28] [p30] [p33] [p35] [p40] [p42]
05	Trust	[p4] [p23] [p36] [p39]
06	Software Architecture	[P3] [p19] [p35] [p42]

Table 13 shows the list of challenges identified in 47 selected studies. Here the identifier "P" is used to denote the references of primary papers which will later used in the reference section. Authors have identified 6 key challenges- Communication, Trust, Software Architecture, Geographical Distance, Culture and Language and Temporal Distance faced by organizations to coordinate GSD projects. These challenges are discussed in detail in section 3.4.1.

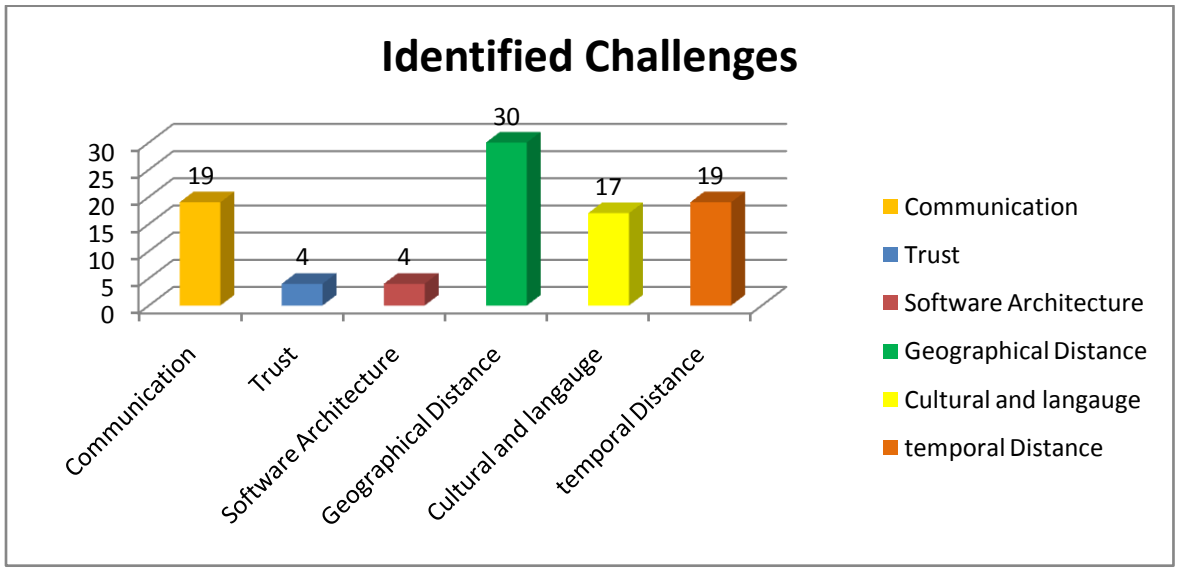

Figure 8: Number of studies discussed each Challenge

Figure 8 shows the challenges and the numbers of articles that discussed them. Communication is an important factor in GSD projects. Lack of communication or loss of communication richness can result in poor communication among the parties which can lead to difficulty in collaborating work [P35, P42]. According to figure number 8 there are 19 studies out of 47 those discussed that communication is challenging in GSD projects.

Similarly, Trust is another factor when we discuss coordination in GSD. Trust can positively or negatively affect coordination among global teams [46]. Trust is undermined by fear, when an organization introduces remote development on the part of the "home" team members. The home team members can feel that their jobs are threatened when work is transferred to lower cost countries [47]. In the above figure, there are 4 studies those discuss that trust is a challenging task in GSD projects.

Software architecture does not only influence software quality attributes but also important to coordinate software projects in GSD context. In this study, there are 4 out of 47 studies those highlighted that software architecture is a challenge in GSD projects.

Geographical distance is another very challenging factor in GSD projects. It impedes the awareness of remote teams participating on a global project [48]. Geographical distance introduces many hurdles to coordinate work like- lack of informal encounters that provide the opportunity to exchange the implicit knowledge and also develop personal relationships [46] [48] [49] [12] [50] [51]. Geographical distance also increases organizational working complexities [43] [51]. Coordination activities seem difficult in GSD because of negative impact of geographical distance among team members [P1]. In this research work there are 29 studies out of 47 those discussed that geographical distance has negative effect to coordinate GSD projects.

Now a day's English is the Lingua franca of global software development [52]. This effect the quality of communication and choice of communication media used to communicate with other team members. Different cultures have different language and when two parties having different languages communicate with each other there is always a chance to misunderstand the message. Culture heavily effects the coordination in GSD projects. Different cultures have different approaches to solve or deal with a matter and when people work with conflicting cultures they feel problems [53]. In this research work Authors identified 17 studies in which culture is discussed as a challenging factor in GSD projects.

Another challenge to coordination in GSD projects is time zone difference. In this work we have identified 17 studies those discuss that time zone difference causes problems to coordinate work in GSD. When team members have different time zones there are few working hours for synchronous meetings [4]. This can causes delays in decisions. The other problem is delay in response to asynchronous communication [4]. Temporal distance causes less or no overlapping hours which will cause delay in getting replies meaning that the replies cannot come until next morning.

3.2.1. Reported Challenges

In table 13 and figure 7, we have mentioned identified challenges to coordination in GSD projects from 47 selected studies. In this section Authors discussed them in detail with reference to the literature. :In this study the challenges of coordination means the factor that hampers or make problems in coordination of GSD projects.

3.2.1.1. Communication

There are number of studies [p1] [p3] [p4] [p9] [p10] [p13] [P22] [p23] [p27] [p28] [p30] [p33] [p35] [p40] [p42] which discuss that communication is very challenging when team members try to coordinate with each other in GSD projects. According to [P23] [P30] [P33] [P35] [P40], in GSD projects the team members are geographically distributed they have different culture so lack of common language causes problem to communicate. When the team members are geographically distributed and have no common language for communication, they hesitate to interact with each other [P23] [P27] which results to the inadequate informal communication [P27] [P28] [P35] [P42]. Temporal distance and geographical separation among the development sites make it difficult to have effective communication and coordination [P35]. Here it can be seen that different challenges are inter related to each other to make themselves as challenges of coordination in GSD. Here it can be seen that the communication is a challenge to the coordination because it is the problem arises because of geographical distance, temporal distance and cultural distance. Similar relation can be seen in other challenges as well.

Temporal and geographical distance reduces communication frequency that leads to difficulty in coordinative work [P35] which might delay in software development. The tasks like software development need more communication to maintain coordination between team members. A richer communication media can provide a better communication between teams [P13, P35]. However geographical and temporal distance prohibits the use of rich media (e.g. face-to-face communication and video conferencing, etc.) due to cost, quality and implementation issues [P35]. In GSD context the communication among development teams is more complex [P13]. In GSD context temporal distance causes problems to coordinate work among parties. Lean communication media and reduced opportunities for spontaneous interaction decreases frequency of communication [P20]. Distance among the parties intensifies the coordination and control problems directly. Distance among parties increases negative impact on communication which indirectly affects the effectiveness of the coordination process [P46].

3.2.1.2. Trust

In this study we have identified 4 studies [p4] [p23] [p36] [p39] that discuss trust as a challenging task in GSD which plays a vital role in coordination. In GSD, trust can effect positively or negatively among development teams [46]. When GSD teams are geographically and temporally different then there is less chance for team members to interact with each other, low frequency of synchronous communication causes lack of trust [P36]. When team members have no trust on each other they lose confidence this results low productivity [P39]. Plans are defined in GSD those greatly impacted by Distance, Culture, Time and Team member Trust [P39]. According to [P39], trust exists between the team members when one team member assumes that other team members will not lie, do not withhold information that needs to be frequently delivered, do their work with best of them and will complete their work even if they are physically not present. When any one of these missed they lose confidence on each other [P39].

3.2.1.3. Software Architecture

According to [P3] [p19] [p35] [p42], designing software architecture which fulfill all requirements of teams is a challenging task. Almost 30 years ago, in the study [54] realize the relationship between software architecture and coordination. The "*Software architecture mirrors the structure of the organization that designed the architecture*" [54]. When software architectural components are dependent to each other then geographical dispersed teams cannot easily develop the software [55]. Such type of architecture requires good coordination between the teams or members for successful complication of components. We can say architecture is a type of coordination mechanism [P42]. When software architectural components share common functionality they affect each other [P42]. System is composed of functional components, results of one component are used by other components and especially it is very challenging to integrate all of these components into working system [P42]. Software architecture is not only an important means of coordination, but it also influences quality attributes of software [P3]. Adopting software architecture guides developers to take compatible decisions in the presence of effective communication and coordination [P3].

Software architecture is very challenging in GSD context because it has major role in designing and structuring the software, but it also "*shapes the tasks dependencies among the teams designing and building the system*" [P3]. Architecture determines whether global teams can work harmoniously and simultaneously [P35]; this also effects the selection of software development strategy.

3.2.1.4. Geographical Distance

The articles [p1] [p3] [p9] [p10] [p14] [p15] [P16] [P18] [P22] [p23] [p26] [p27] [p28] [p29] [p30] [p31] [p32] [p34] [p35] [p38] [p39] [p40] [p41] [p42] [p43] [p46] [p47] discuss that geographical distance among teams is very challenging to coordinate work. When team members have geographical distance then it is very challenging to develop a sense of "Teamness" within groups [P46]. Geographical distance among development teams creates communication and coordination problems in GSD [P10, P35]. When

team members are not at the same location there is less chance that they can meet face-to-face. When team members have less chance for asynchronous communication the level of trust affects, this can challenge the coordination among team members. Geographical distance can also decrease productivity and quality of software [P35]. When teams are separated by distance it is hard to coordinate them. More often we cannot visit their offices to solve the matter and it also decrease the level of control on team members this results low productivity and also software quality [P35.]. When a development team is geographical distributed among many sites it takes much longer development time as compared to collocated team [P31]. Geographical distance effects duration if more than one sites are working on same component their work is dependent on each other delay at one site can delay the working of other site. A small confusion or a little misunderstanding might take longer time to overcome. This can cause a lengthy development process which causes delay in software development. If team member are located at the same site then this problem can be minimized easily. When teams are geographically dispersed then distribution and synchronization of work is very difficult [P23]. Temporal, socio-cultural and geographical distance causes less communication this effects coordination [P3]. When teams are geographically dispersed they share little context, they have relatively little knowledge about the working of other team members. Lack of contextual information causes problems to initiate contract, and leads to misunderstandings [P3]. When developers are located at different locations they feel the difficulty to interact and coordinate their work this decreases their productivity and software quality [P10]. When teams are geographically dispersed sometimes there is a need to travel and communicate with them but it's costly in GSD. Geographical dispersion causes some serious problems like communication, travelling and attitude towards rural area companies [P11]. Geographical distance makes teambuilding and establishing trust more difficult and may induce cultural and language barriers that can hamper effective communication and coordination among team members [P14]. Globally distributed teams face extraordinary communication and coordination challenges due to cultural, temporal and geographical separations among members [P15]

3.2.1.5. Culture and Language

In this study [p1] [p3] [p4] [p9] [P13] [p15] [p26] [p30] [p33] [p35] [p36] [p39] [p40] [p42] [p43] [p46] [p47], we have reported that culture and language differences creates many problems to coordinate the work in GSD. Barriers like language difference and miscommunication create problems such as ambiguity in requirements and misunderstanding of design intent, this cause lot of rework [P33]. Study [P33] shows many collaboration challenges including cultural barriers, time zone distance, miscommunication due to difference in language and mismatched skills. David and Setamanit [P35] discuss that no doubt programming languages transcend national boundaries but developers still need to communicate with each other to settle matters, lack of common language causes problems, they cannot communicate as effectively as using their own language. Non-native English personals always prefer to have asynchronous communication but unfortunately it causes serious delays in development and resulted in longer development time [P5, P35]. According to the study [P35], national cultural difference among the team members is one of the most challenging factors in GSD projects. Due to cultural separation, spatial and temporal differences GSD team members face coordination challenges during work activities [P36]. The "*Spatial, temporal, and cultural separations as well as many product, personnel, project, and site related factors are known to affect inter-site coordination in GSD*" [P36]. According to David and Setamanit [P35] cultural and language differences among teams make it harder and difficult to manage and coordinate collaborative project work. They explained that when a work is distributed among teams and more than one distributed member are working on such components they take longer development time as compared to co-located teams. Because distributed teams have no common language to communicate and their culture is also different, these hinder the work and take longer development time as compared to co-located teams. Another study [P35] discusses that cultural difference among parties might affect GSD in many ways, including coordination effectiveness, communication richness, group decision making and overall team performance. According to [P3] cultural mismatch can pose serious challenges for achieving a shared understanding of the software requirements among team members.

According to M. j. Monasor, A. vizcino and M. Piattini [P4] when cultural and language difference appears among team members as in case of GSD, communication and coordination with distant members is very hard and sometimes creates lot of confusions.

3.2.1.6. Temporal Distance

Numerous studies [p3] [p8] [p9] [p14] [p15] [P17] [P18] [p22] [p23] [p25] [p30] [p32] [p33] [p35] [p36] [p39] [p40] [p43] [P44] [p47], discuss that temporal distance among developing sites imposes serious challenges to coordinate work. According to study [P39] when team members are at temporal distance they cannot work full day together. They argue that when team members are at different time zones lack of overlapping hours causes irregular hours to facilitate team members and increase development time [P8]. Less overlapping hours means fewer hours to coordinate with the distributd team members. Coordination among the team depends on the asynchronous communication. Temporal distance also imposes a serious problem during analysis and project management phase that all team members cannot attend jointly one project meeting [P39]. Time zone and geographical location have important role in shaping how product development teams have to shape their work [P15]. This is a strategic issue when teams are at different time zones then such teams need time adjustment to effectively communicate and coordinate with each other. Time zone difference effects overlapping hours. If time zone difference is high there are few overlapping hours [P15], it means replies for queries will not come until the next day [P3]. So software development teams have to wait their work until the replies come from other side. Further [P15] mentioned that when teams are at different time zones there is a strong sense that such teams are remote in all sense of word. Communication overhead of non compatible time zone teams is double as compared to compatible time zone teams [P15]. According to [P8] temporal distance among different development sites causes problems to manage the software development and resources. Temporal distance among developing teams causes communication lag in response time. According to [P27], "*I received e-mails this morning from a conversation that kicked off after I left yesterday. Sometime conversation jumps ahead, and you fall a bit behind. Often, I turn it on (Internet connection) and review emails at night for half an hour*".

Lagging in the response time make it feel of "missing out" and "being behind", in long run this cause burnout of people or make them frustrated [P27]. The critical issue when teams are at temporal, geographical and cultural distance effective communication among members is hard, this causes serious problems like irregular information flow, lack of shared understanding and finally weak coordination [P9]. Time separation decreases the volume and communication richness especially ad-hoc and informal communication among teams, which is very important for effective coordination [P14].

3.2.2. Reported Threats

Threat is one that is regarded as a possible danger or an indication of impending danger or harm. The challenges discussed in table 13 and figure 7 causes serious threats to coordination in GSD projects. In this paragraph the Authors discuss these challenges identified from the literature.

3.2.2.1. Communication

Table 14 shows communication threats to coordination in GSD. In the following paragraphs authors discuss each threat according to the studies selected for this research.

Table 14: Communication Threats

Sr. No	Challenges	Associated Threats	References
01	**Communication**	No common language for communication	[P23][P33][P30][P40][P35]
		No readiness for communication	[P23][P27]

		Inadequate informal communication	[P11] [P12][P27] [P42]
		Loss of communication richness	[P1] [P3] [P35]
		Lean communication media	[P20]
		Reduce opportunities for spontaneous interaction	[P20]

"No readiness for communication"

Studies [P23] [P27], discuss that lack of common language among members stop them to communicate with each other, especially when team members are geographically distributed. So the possible threat for communication is No readiness for communication because of language variations. According to [P23], when there is "no readiness for communication existed between different representatives" it's hard to collaborate in GSD projects.

Furthermore, [P27] explains that "*The drastically attenuated communication across sites makes it difficult to manage dependencies among developers working on the same modules*".

"Loss of communication richness"

In GSD projects, much less and less effective communication happens due to geographical distance. People hesitate to communicate with the people with whom they have not seen and talked before. They even hesitate to ask their minor problems that they faced during their work. This causes the less frequency of communication between the distributed members. According to [P4], Loss of communication richness in distributed projects has" *many effects, including a lack of information about who is expert in what, and who is responsible for what*".

"Lean communication media"

Different locations have their own settings for communication. It might be possible that the offshore site could have lean communication media which could hamper the communication and coordination between the distributed teams. The communication media could be the type of internet they use, type of instruments they need for communication etc. In study [P20], lean communication media (videoconference, voice conference and electronic mail) make it difficult and some time very challenging to effectively coordinate work in GSD context. When team members have language and cultural difference it's more difficult for them to communicate clearly. According to [P20], a geographically distributed team that "communicates via inexpensive voice conference, then the lean communication media will make it more difficult to convey ideas clearly" this causes serious delays and increase response time.

"Reduce opportunities for spontaneous interaction"

Spontaneous interaction among team members is very important to build up trust by having informal meeting, communication. When teams have problem in communication media or languages problem the possible threat might be the less spontaneous interaction. Any problem in communication makes hard to have spontaneous interaction which effects coordination in GSD. As [P20], discusses that due to reduce opportunities for spontaneous interaction among team members coordination is difficult and can increase cost.

"Inadequate informal communication"

In studies [P11] [P12] [P27] [P42] discuss that the informal communication plays very important role in coordination especially when projects are uncertain. Since the different sites have their own ways and hardware of communication, so it might be possible that this infrastructure of communication can make problem in informal communication between the distributed team members. Therefore enough attention should be given to ensure that the members can have adequate informal communication among the

members. According to [P42], "*The lack of informal communication channels can lead to problems in software development, which increases the development time*".

"No common language for communication"

The possible threats for the communication could be no common language for communication; it is because if they selected sites that have expert but their speaking is not clear in this case their language and prefer their own language to communicate then it can create a problem. According to the studies [P23] [P33] [P30] [P40] [P35], in GSD projects when teams are geographically and culturally distributed then lack of common language among team members causes problems for effective coordination.
According to [P23], "*Collaboration did not function at all in the project, because there was no common language for communication*".

3.2.2.2. Trust

Table 15 shows possible threats caused by trust in GSD. In the following paragraphs authors discuss each threat according to the studies selected for this research.

Table 15: Trust Related Threats

Sr. No	Challenge	Associated Threats	References
02	**Trust**	Uncommitted and avoids responsibilities	[P23]
		Reduce trust	[P15] [P46]
		Doubtful about others capability	[P15]

"Uncommitted and avoids responsibilities"

The possible threat for the trust could be the "Uncommitted and avoids responsibilities". In GSD projects when team members are distributed among many site's having different skills and level of expertise [P23]. In this situation sometimes people do not trust on others abilities so they uncommitted and try to avoid responsibilities.
In the study [P23], one of the representative uncommitted and avoids responsibilities. He did not ready to assign agreement because he "*did not believe in the skills of his subordinate, a young girl named Ellie. He thus felt Ellie would not be able to do the work given to her well enough that he would dare to put his name on the agreement*". From management point of view avoiding responsibilities and shifting work to others is a serious problem in GSD projects.

"Reduce trust"

In GSD as the time passes, some people start losing trust on others if they would not get what they expected from them. Same in the study [P23], with the passage of time management start losing trust on one of employee because she did not deliver according to her expertise. As "*these are such serious matters that they should be unerring, so if I think of her role, of which we spoke earlier, that what exactly is her expertise…" It was felt that the effort she put in the project was minimal*" [P23]. According to [P46], lack of informal communication and increase in response time from remote partners causes reduction in trust as time passes. This affects overall productivity of the software development team.

"Doubtful about others capability"

In global software development where team members are at different geographical locations they have fewer chances for face-to-face interaction. Lack of face-to-face meetings reduces trust among team members that is very important to coordinate work. As in study [P15], when teams are at geographically distant locations they not trust and doubtful of the knowledge, their capabilities and skills.

3.2.2.3. Software Architecture

In table 16 authors have listed out the possible threats caused by software architecture during coordination in GSD projects. In the paragraphs below these are discussed according to the literature findings.

Table 16: Software Architecture Threats

Sr. No	Challenge	Associated Threats	References
03	**Software Architecture**	Development site infrastructure	[P35]
		Product architecture	[P35][P46]
		Development strategy	[P35]
		Process interdependency	[P3] [P19]

"Development site infrastructure"

In GSD projects while distributing the work the main thing that needs to be taken into consideration is the development site infrastructure of the sites. If the work load does not match with the site infrastructure then the project will fail. It means that the difference in development site is a main threat so software architecture design should be good and fit enough to other sites infrastructure. For example geographically distributed have different technological and communication infrastructures. So while designing the software architecture the attention must be given according to the site infrastructure [P35].

"Development strategy"

Development strategy or task allocation strategy is a mechanism which guides how to allocate tasks or components among development sites [P35]. According to D. Raffo and S. Setamanit [P35], development or tasks allocation strategy will have a "*direct impact on software development operations since it impacts working hours per day, distribution overhead, and distribution effort loss*."

"Process interdependency"

According to [P19], "*We find that interdependence between offshored and onshore processes can lower offshored process performance, and investing in coordination mechanisms can ameliorate the performance impact of interdependence*".

In another study [P3], interdependencies among processes / tasks are more difficult and challenging if the interfaces are unstable or if there are presence of important semantic dependencies among process/ tasks.

"Product architecture"

In study [P46], the systems are composed of components and the allocation of these components among teams affects the productivity of distributed development.

Further, study [P46] explains that "*Product structure can also introduce subtle obstacles among collaborating teams: when a component contains high-visibility functionality, cooperation may be replaced by competition among teams to claim ownership of the component*". In another study [P35], the author's explain that product architecture helps to decides whether distributed teams can work harmoniously and simultaneously or not. Product architecture has direct affect on the selection of product development strategy

3.2.2.4. Geographical Distance

Table 17: Geographical Distance Threats

Sr. No	Challenge	Associated Threats	References
04	**Geographical Distance**	Frequent Re-planning required	[P27]
		Interdependence of tasks	[P37][P38] [P41] [P42]
		Much longer development time	[P31][P37] [P38]
		Integration of work	[P32] [P42]
		Distribution of work	[P23]
		Unclear role to team members	[P23]
		Infrastructure management	[P27]
		To manage software quality	[P33][P39]
		Hard to conduct efficient and effective meetings	[P24]
		Lack of "Teamness"	[P1][P15]
		Lack of shared understanding	[P9]
		Lack of Trust on other team member	[P39][P46]
		Reduces communication frequency and richness	[P14][P45]
		Lack of task awareness	[P3][P15][P37][P43]
		Less opportunity to form personal relations	[P46]
		Reliance on documentation as a coordination mechanism	[P28]

"*Frequent Re-planning required*"

When teams are distributed among several geographically distributed locations there is a need to re-plan the things. According to [P27], in GSD there is more often re-planning required to provide additional information to team members like, "*beginning of the first iteration unanticipated issues began to surface. Teams frequently required additional information related to a task that hadn't been completed yet*". Study [P27], further elaborate it in a way that when there is a dependency among system components sometimes additional information required to complete. When such interdependencies occur among components and no additional information is provided to teams then they might not move forward. So there is always a need of re-planning required in GSD projects.

"*Interdependence of tasks*"

In distributed software development the components of a system are distributed among teams those have dependencies among them. According to [P41], "*One of the dominant characteristics of contemporary software development is the global distribution of tasks, of developers, of information and of technologies. Undoubtedly, such distribution engenders new coordination challenges in the form of distance-related interdependencies*". When tasks are globally distributed among persons then managing interdependencies and related uncertainties is most crucial organizational challenge of GSD [P41]. When multiple components share some common resources and functionality there is need to manage these interdependencies because functionality of one component can affect the functionality of other component [P42]. In another study [38], the researchers compare the data collected from same-site and cross-site development projects and concluded that the development time of cross-site projects is 2.5

times as compared to same-site projects, the reason is interdependencies among tasks those need rich communication that is very difficult in GSD.

"Much longer development time"

Study [P31] results show that multisite development tasks take much longer development time as compared to co-located tasks. As in multisite development system components are distributed among geographically distributed team members, sometimes these components have interdependencies which effect the development time. Another study [P38], discusses that when tasks are distributed among geographically distributed this always take longer time to complete as compared to co-located teams.

"Software Integration"

In distributed software environment system components are assigned to different teams to enjoy the benefits of GSD environment. This is also challenging as [P32], working with large number of independent software development teams causes some problems. As "*it increased the amount of effort required to integrate the parts*" [P32], developed by different geographically distributed teams. System integration phase is the process through which system was composed from its components and this is time consuming in GSD [P42]. Integration of system in GSD causes lot of problems and need "*many changes to the interfaces and components had to be made before the integration of the components into a working system*" [P42]. These problems can affect testing phase "*in which the integration problems made it impossible to run the tests*" [P42]. Problems in components integration and failure in testing phase can cause delays in finalization of the project.

"Distribution of work"

In distributed software development when the team members are at different locations its hard and challenging to distributed work among them as it affect integration and synchronization of components. According to [P23], distribution of work is problematic in collaborative work this had the effect of hindering integration of components. There is a need to carefully distribute the work among the development sites so that there is no duplication or extra work done. As "*These suppliers are rascals enough to gladly do and produce more than was ordered if we're not careful"* [P23].

"Unclear roles to team members"

Unclear roles to team members can have an effect on relationship management process. According to [P23], collaboration among team members in GSD is very problematic when team members have unclear roles and responsibilities. According to words of [P23], "*Sometimes it comes to my mind that I don't know if these people had a mandate to speak, that what role they have there, like the representatives of the educational administration. So certain people say they can't say anything, they can't decide anything. On the other hand, did they see this as such a project … did they just consider this as some kind of group work where we meet every now and then and discuss about*".

"Infrastructure management"

When teams are working in GSD context, geographical distance among them imposes infrastructure management issues. As in [P27], several issues are attached with infrastructure management when teams are at geographical distance. According to them some teams use their own local repositories that mirrored the central one and some use central version control system as working repository.

"To manage software quality"

According to [P39], geographical distance among team members imposes some negative impacts on overall quality of software. Negative impact is observed in the instance of project sites using different development process and methodologies. When developing teams are "*in different geographic regions you may have different kinds of standards and therefore some non-uniformity in terms of the quality*" [P39]. In another study [P33], researchers explained that geographical distance along with temporal and cultural separation cause negative effect in term of software quality.

"Hard to conduct efficient and effective meetings"

In GSD, team members are at geographical and temporal distance in this case there are few overlapping hours which make it hard to conduct meetings with offsite team members. According to [P24], "*Another issue that comes up is how do you have an effective and efficient meeting when the team is in different locations?*" This question is very challenging to answer in GSD even there are many asynchronous methods to overcome this problem but still geographical distance is a problem to conduct fruitful meetings with subordinates.

"Lack of "Teamness"

In GSD context, where team members have few chances for face-to-face contacts and they also at cultural and temporal distance, there is a need to create a feeling of "teamness" among team members. According to [P15], the feeling of "teamness" among team members can be strongly affected because of geographical distance among participants and lack of informal contacts. Presumably, "*distance affects the stages by which individuals become coherent groups or teams*" [P15]. In another study [P1], distance among team members affects negatively on team building activities. The researchers in this study explain, the effect of geographical distribution of team members among different sites causes lack of coordination, communication breakdown, loss of "teamness" and cultural differences.

"Lack of shared understanding"

Geographical distance among developing teams causes some critical issues like inability to communicate effectively. According to [P9], inefficient communications across distances give rise to other problems like lack of shared understanding among persons. Geographical separation is one of the stumbling block to have informal communication that is very important to establish trust among persons, also effective to develop a common understand among sites.

"Lack of Trust on other team member"

It is very hard to build trust among team members when they are at different geographical and temporal distances. According to [P39], it takes much longer time to establish trust among GSD team members as compared to co-located team members. Study further elaborate that once trust was established among team members, however, "*it could be eroded or lost when colleagues at other sites did not respond to emails, instant messages or phone calls in a timely fashion*" [P39]. In the absence of face-to-face meetings it is more difficult to establish trust among geographically distributed teams.

Lack of trust and poor communication among distributed teams are the main problems to coordinate work in GSD teams [P46]. Further, in study [P46], delays, lack of shared understanding and lack of trust among team members can affect the working of GSD team to perform activities like, "*enthusiastically strive toward the agreed goals, develop the agreed products owned, faithfully carry out the established processes, and perform the tasks specified in agreed work plans*" [P46]. When team members have weaker personal relationship they have low level of trust among them.

"Reduces communication frequency and richness"

One of the central problems of distributed software development is generated by the fact that distance reduces communication frequency and richness [P45]. In addition to reducing communication frequency and richness, distance among teams also increases the cost of communication [P45]. The study [P45], further explain that informal communication among geographically distributed sites is much frequent as compared to same-site interactions. In another study [P14], the researchers explain that geographical and temporal distance among team members make teambuilding very difficult and can induce language and cultural problems those can hamper effective communication. Time and geographical distance among teams can reduce communication frequency and richness [P14].

"Lack of task awareness"

Lack of tasks awareness is a problem caused by geographical distance among team members. According to [P3], when team members are at geographical distant locations they share relatively less contextual information, they have little knowledge of what team members at other location are doing. In another study [P15,P43], when team members are distributed among geographically distant locations they have

less face-to-face contact, team members may not be aware of other team members work activities. This situation can lead to misunderstandings and lack of trust among team members.

"Less opportunity for form personal relationships"

Geographical distance among GSD teams creates numerous challenges to coordination. According to [P46], when team members are at geographically distant they have fewer chances to have face-to-face meetings this affects informal communication, lack of informal communication means team members have less opportunity to form personal relationships that improve trust.

3.2.2.5. Language and culture

Table 18: Culture and Language Threats

Sr. No	Challenge	Associated Threats	References
06	**Culture and language**	Limited feedback from the remote locations	[P39][P47]
		Negative impact on the effectiveness of plans	[P39]
		Reduce mutual understanding	[P1]
		Problem in communication	[P4] [P13]
		Lack of shared understanding	[P9]
		Mismatch skills	[P30][P33][P36]
		Lack of team spirit	[P15]
		Inconsistency in work practices	[P43]
		Ambiguity in requirements	[P33]
		Human relations knots affecting	[P23]
		Lack of proficiency in language	[P46]

"Limited feedback from the remote locations"

According to [P39], communication and cultures problems arose among team members because of different geographical locations. If the project working language is not native or first language then the team members feel difficulties with language. In this case most of persons like to have emails then participating in conference calls as they feel comfortable in writing then speaking. Language difficulties cause limited feedback from remote locations. Study [P39] stated that "*other sites reported that team members at his site don't say anything just listen and do not provide any active feedback!*". In another study [P47], coordination also not works well when there is geographical distance among team members because of limited feedback from remote locations.

"Negative impact on the effectiveness of plans"

According to [P39], coordination plans are any documentation that can be used to direct and coordinate team members (schedules, project plans etc.). Plans are basically projected related so formulated and communicated before the commencement of project with virtual teams. The researchers further explain that cultural distance among team members has highly negative impact on the effectiveness of coordination plans, "*some team members observing that those with different cultural backgrounds in other sites tended to avoid saying 'no' to work requests. This behavior had serious ramifications for the project schedule and completion, due to inadvertent over commitment through an inability to say 'no'*" [P39].

"Reduce mutual understanding"

Mutual understand with direct supervision is very important to reduce coordination challenges in GSD [P1]. Study argues that use of mutual understanding along with "standardization" as primary coordination mechanism is very important in GSD. When team members belong to different cultures it reduces mutual

understanding as study [P1] discusses that socio-cultural distance among GSD team members can reduce mutual understand which can effect coordination.

"Problem in communication"

Cultural and language difference effects communication among GSD team members. According to [P4], coordination among distant team members is not an easy task there are always some serious issues must be confronted mainly related with the communication with distant members, when language and cultural differences appear. In another study [P13], communication is related to cultural and temporal distance problem. In this study the researchers discuss that coordination and communication among GSD teams is more complex then co-located teams because of cultural and temporal distance.

"Lack of shared understanding"

In distributed software development developing common understanding among team members is very important. Lack for shared understanding among team members caused problems to coordinate work effectively. As in study [P9], GSD team members are unable to communicate effectively across geographical and cultural distances. This in turn causes lack of shared understanding among teams.

"Inconsistency in work practices"

In distributed software development team members belong to different cultures. Different cultures have different work practices. According to [P43] "*Inconsistency in work practices can impinge on effective coordination, as can reduce cooperation through misunderstandings*"

"Reliance on documentation as a coordination mechanism"

According to [P28], in GSD projects software documentation plays an important role, actually it is used as a coordination mechanism. Furthermore it explains that as documentation plays an important role then there is a need to sure that there is minimum divergence between source code and software documentation. Main challenge is "*devising mechanisms that could ensure that the gap between the contents of the documentation and the actual source code implementation is closed*" [P28].

"Mismatch skills"

When people are from different cultures and geographical locations especially in the case of GSD, they have different skills. According to [P33], mismatch skills is one of the main problem in GSD. Researchers share their study [P33] experience that "*one offshore resource had excellent CAD skills, but did not have the programming experience required to solve problems with security and recursive model composition. Our onshore resources had these programming skills, but did not know the CAD programming interface. The root cause was an offshore hiring decision based on a telephone interview and a limited pool of qualified candidates. Instead of anticipated cost savings, we had unanticipated expenses and a minor change in product direction*". In a study [P36], authors discuss that along with communication skills in GSD there is a need to have multicultural, time management and leadership skills to effectively manage and coordinate projects. Multidimensional skills are a key to success to coordinate GSD projects [P36].

"Ambiguity in requirements"

Ambiguity in requirements is a cultural barrier as [P33] explained; it is a cultural barrier to coordination because "*ambiguity makes collaboration on distributed teams difficult*". Further the researchers explained that cultural distance caused some serious language problems in requirements documentation, some time it's hard to understand such ambiguous documents by others.

"Human relations knots affecting"

According to [P23], inappropriate language during the course of action can harm human relations and affect the working of GSD. The researchers in this study share their experience, in an important meeting one of the user representative of one organization was absent "*the reason was one person's (Matthew, project management) participation in several previous projects and possible knots in human relations*" [P23]. Project management concluded that the language used by users was inappropriate.

"Lack of proficiency in language"

When team members belong to different cultures and languages sometimes it affects on collaboration mechanism. In study [P46], the researchers explain that lack of proficiency in working language effects communication that ultimately creates problems in coordination. Furthermore, "*lack of proficiency in the chosen language can lead to a preference for asynchronous communication*" [P46], this can be more serious problem if teleconference and video conference are important communication media. So for that if team has a mixture of cultures there is a need that all participants must have proficiency in working language.

3.2.2.6. Temporal Distance

Table 19: Temporal Distance Threats

Sr. No	Challenge	Associated Threats	References
07	**Temporal Distance**	Problems in the attainment of common understanding among team members	[P4]
		Difficulties in resolving unclear messages	[P20]
		Reduced opportunity for spontaneous interaction	[P20]
		Irregular information flow	[P9]
		Rely on asynchronous communication	[P3] [P15] [P46]
		Challenge everyday communication	[P8]
		Reduce collaboration hours	[P15] [P43]
		Reduces communication frequency and richness	[P14],[P45]
		Delay in response	[P37][P43]
		Synchronization of work	[P31]
		Mutual misunderstanding within and among teams	[P43]

"Problems in the attainment of common understanding among team members"

Common understanding among the team members working in GSD context is very important to have better results from distributed environment. According to study [P4], temporal and cultural distance among GSD team members causes serious problems in the attainment of common understanding among team members.

"Difficulties in resolving unclear messages"

According to [P20], "A message can be unclear with some probability". Further, study elaborate that unclear message might lead to rework resulting in additional developing cost or delay in development and/or a request for clarification, resulting in additional coordination costs. Probability of unclear messages is affected by communication media and amount of work-time overlap [P20]. Coordination in different-time context (different holidays, overlapping) is very difficult because of lean communication and difficulty in resolving unclear messages [P20].

"Reduced opportunity for spontaneous interaction"

Alberto and E. Carmel [P20], presented a theory in which they explained that time separation among teams is asymmetric, which can affect the planning of team interactions. They further say that cost of rework and resolving misunderstanding increases with time separation among sites. In different-time contexts (holiday and time zone differences) coordination is very difficult because of reduced opportunities for spontaneous interaction among members and lack of contextual reference [P20].

"Irregular information flow"

Providing useful information at regular intervals is very important to successfully coordinate GSD projects. According to [P9], the most critical issue to GSD is inability to communicate effectively across different time-zones. This gives rise to other problems like irregular information flows and ultimately weak coordination [P9].

"Rely on asynchronous communication"

When there is a temporal distance among development teams, a remotely located team member might not available when needed [P15]. Further in this study [P46], time zone difference and reliance on asynchronous communication can delay results. This situation increases response time that will ultimately increase development time and cost [P46]. In the situation when team members are at temporal distance asynchronous communication technologies (e-mail and fax) are used that can increase response time [P15].

"Challenge everyday communication"

Temporal distance causes problems in everyday communication within and between teams in GSD [P8]. Particularly high response time is problematic and frustrating for persons working in different projects. Study [P8], describes it as "*If you're trying to progress something very quickly, there can be an issue with the time zones…If there's any need for me to ask something or find an update, I can't really get hold of him [American college] until 3pm my time – maybe two o'clock at the earliest*"

"Reduce collaboration hours"

Temporal distance among development site's decreases overlapping hours. According to [P1, P43], the big disadvantage of temporal distance among distributed team members is that the number of overlapping hours during a work day is reduced. Even a slight time distance can reduce much overlapping hours among development sites during a workday [P15]. Further, in study [P43] the researchers explain "*the lag in response time brings with it a feeling of "being behind" and "missing out," which makes people frustrated*". Few overlapping hours and delay in responses make people frustrated and they lose tract of the work process [P43]

"Delay in response"

Communication and coordination are challenged by temporal distance [P43]. Temporal distance among development sites reduces overlapping hours this results in delay in responses from developers [P43].

"Synchronization of work"

Synchronization requires some commonly defined milestones and clearly discussed entry and exit criteria [P31]. Lack of synchronization can be more critical in GSD projects because of unstable specifications, lack of informal communication, volatile requirements and unavailability of good tools that support coordination across geographical and temporal distances [P31].

"Mutual misunderstanding within and among teams"

Socio-cultural distance is a complex and multidimensional term involving language, politics, individual motivations and work ethics, national and organizational culture [P43]. According to study [P43] findings, misunderstandings and confusions among team members are resulted because of language and interpretation problems. Confusions and misunderstandings among teams "*have implications for communication, coordination, and control and make it a real challenge to create mutual understanding within and between teams*" [P43].

3.2.3. Reported Practices

3.2.3.1. Communication

Table 20: Practices to mitigate communication Challenges & Threats

Sr. No	Challenges	Practices to mitigate them	References
01	Communication	Foreign Language courses	[P34]
		Work packages	[P27]
		Bulletin Boards and E-mail Lists	[P40]
		Problem E-mailbox	[P40]
		Weekly Meeting	[P27] [P39] [P40]
		Documents to show how to use documents (For Non- Native Language Persons)	[P39]
		Progress Reports	[P40]
		Intranet connectivity	[P32]

"Foreign Language courses"

The executive level personals hesitate to collaborate with the nation where the English command is week. The success and the failure of the offshore IT work is also determined by the language so the preference is given to those countries which has strong English language capabilities like Singapore and Philippine. To improve the professional communication and making English fluent, companies from US invest in English as a foreign Language courses [p34].

"Work packages"

In distributed system, the remote teams get a set of artefacts (called a work package) from the central team which contains all the artefacts that are essential for the remote team to finish the given task. Work packages helps to minimize the cross team communication. Usually, the work packages contain all the required information about updated architecture, the project plan and the associated requirements. The work packages are distributed along with kick-off teleconference with supplier manager which would be enough for remote team to understand what was expected of them. If no request was found from the site of remote team then they are left alone to finish their task which will minimize the communication overhead [P27].

"Bulletin Boards and E-mail Lists"

Bulletin boards or discussion list is the one of the coordination practices to overcome communication overhead. The main propose of using the bulletin board is to find out the expert from some large projects who can answer the questions asked in the board. For some specific technology topics bulletin boards were proved to be successful in large projects. While project-wide mailing is proved to be useful for the same propose in smaller projects. This technique helps to reduce communication overhead since the most problems are solved through discussion board and emails [P40].

"Problem E-mailbox"

The problem E-mail box is used in the beginning of the project. On the pool of unknown persons, this helps in finding the correct person to ask the questions. The email address is considered as the problem box through which the questions are forwarded to the person he/she believed to have the answer. This approach helps to control the communication in the initial stage [P40].

"Weekly meeting"

This practice helps in monitoring and informing the project works. The subcontractors are always hoping for the feedback whether the project does something right or wrong, which is a motivating factor for them. The information about the current state of the project work are rarely available to the subcontractor

sometimes even they didn't get any feedback. Many studies in the project show that the communication required for this purpose was worthless. On the other hand the information about the project progress is required to all the team members either they are from the customer or the subcontractor to determine what task need to be performed next and on changes. Furthermore, the feedback to the subcontractors is more essential. So to overcome this challenge and minimize the more and one to one communication weekly meeting is essential. For large project, a meeting can be conducted in a every site and later on the project managers can have teleconference or videoconference [P40].

"Documents to show how to use document (For Non-Native Language Persons)"

While writing the project documentation like bug report and template, the language will play a vital role. So to write a document the test team leader will develop a set of documents which are useful in writing an email, asking questions etc. this document will provide the details for asking question, writing email etc. this document is called the documents to show how to use document [P39].

"Progress reports"

This practice helps for monitoring and informing the project works. The subcontractors are always hoping for the feedback whether the project does something right or wrong, which is a motivating factor for them. The information about the current state of the project work are rarely available to the subcontractor sometimes even they didn't get any feedback. Many studies in the project show that the communication required for this purpose was worthless. Instead the progress reports helps subcontractor to get feedback of every issues. In the form of report, the customer gives the information on the every issue as a feedback. The customer could acknowledge the current state of the project and could report them if the project is going on the right track or not which would be worthy enough to handle and resolve the problematic situation [P40].

"Intranet connectivity"

In study [P32] intranet connectivity is used among team members to communicate in non-real-time for sharing documents. This is a less expensive and more productive way of communication among the members.

3.2.3.2. Trust

Table 21: Practices to mitigate Trust Challenges & Threats

Sr. No	Challenges	Practices to mitigate them	References
02	**Trust**	Face- to- face Meetings	[P22] [P38] [P40]
		Hold frequent, regularly scheduled status meetings	[P22]
		Co-located analysis phase	[P21]
		Give Faces	[P40]
		Organizational Chart	[P40]
		Frequent Deliveries	[P40]

"Face-to-face Meetings"

It is hard and causes anxiety to wait the dependent team for the information about the status of task. Furthermore, the contractor also does very little communication with the requester of the task. In this case it is hard to keep track of the things that are asked to develop. The expected factors like service, speed, and reliability of the task are often not communicated which can lead to conflict and misunderstanding and finally loose the trust among them. So to handle this type of conflicts the solution proposed is to hold frequent, regular scheduled status meeting with the dependent team. Face to face meeting will be the best possible solution in this scenario [P22].

"Hold frequent, regularly scheduled status meetings"

It is hard and causes anxiety to wait the dependent team for the information about the status of task. Furthermore, the contractor also does very little communication with the requester of the task. In this case it is hard to keep track of the things that are asked to develop. The expected factors like service, speed, and reliability of the task are often not communicated which can lead to conflict and misunderstanding and finally loose the trust among them. So to handle this type of conflicts the solution proposed is to hold frequent, regular scheduled status meeting with the dependent team. Posting the status updates online could help everyone to handle the progress [p22].

"Co-located analysis phase"

The functional specifications are developed jointly during the analysis phase by the two leading team from the remote and central site. This practice create an environment to work together for the team that has not worked together before which helps in developing the working relationship, insight to the system need to be developed. In this practice teams come closer and work together which helps in building a common understanding, personal relationship, and high level of acceptance since they work it together which helps in maintaining trust among the team [p21].

"Give faces"

If everyone from the one site gets chances to meet at least someone in the other site will aid collaboration. This practice helps to arrange this type of meetings to which can give a "face" to the distant sites and companies which helps them to make improve relationship and they will be no longer unknown. "Giving face" is one of the forms of face-to face arrangements which seem more beneficial in building good relationship and trust between the distant sites [P40].

"Organizational chart"

Organization chart is one of the practices for building trust and a good relation between the distant sites. This chart helps whenever it is necessary to select the correct person to answer the questions. One of the benefits it has is that it provides full information about the project personals, including other information like photos, role, name, contact information etc which are proven to be very useful in developing the trust [P40].

"Frequent deliveries"

In the distributed system the use of frequent deliveries between the subcontractor and distributed sites seems beneficial. In the initial phases the subcontractor keeps on delivering the draft version document and later on the coding and testing which helps distributed site to give feedback on them. These frequent deliveries helps the subcontractor to deliver or update the project work to the customer as the result the customer's started to trust the subcontractor [p40].

3.2.3.3. Software Architecture

Table 22: Practices to mitigate Software Architecture Challenges & Threats

Sr. No	Challenges	Practices to mitigate them	References
03	**Software Architecture**	Measuring architectural/organizational fit	[P3]
		Improve Architecture Understanding	[P42]
		Tactics for improving architecture/organization fit	[P3]

"Measuring architectural/organizational fit"

Software architecture imposes some interdependencies among system components [P3]. An organization must be well equipped so that it can carry out the design and implementation of a system with a particular architecture [P3]. Therefore, an early and proactive architecture and organizational fit is especially important in the project, so appropriate and timely adjustments can be made [P3]

"Improve Architecture Understanding"

In distributed software development, software architecture is a type of coordination mechanism. A better understanding of software architecture among distributed team members is important for effective work [P42].

"Tactics for improving architecture/organization fit"

As in study [P42] software architecture is a type of coordination mechanism so there is a need of architecture and organization fit [P3]. In order to act effectively there must be organizational and architecture fit. Tactics should be used to better adjust the architecture to the organization, or organization to the architecture [P3]. Organizational tactics are measures like use of additional communication technology, reassigning work to co-located team members and technical *"tactics favor solutions that sacrifice cost or quality attribute in order to reduce the need to coordinate*" [P3].

3.2.3.4. Geographical Distance

Table 23: Practices to mitigate Geographical Distance Challenges & Threats

Sr. No	Challenges	Practices to mitigate them	References
04	**Geographical Distance**	Unfiltered Communication	[P21]
		Video Conferences	[P24] [P34] [P36] [P42]
		Conference Calls	[P24] [P32] [P34] [P39] [P41]
		Scrum of Scrums	[P24]
		Use of Instant Messenger	[P25] [P40] [P42]
		Phone Based Meetings	[P28] [P40]
		Email interactions	[P28] [P34] [P39] [P41] [P42]
		Early Identification of Dependencies and their management	[P27] [P29] [P41]
		Daily Builds	[P27] [P28]
		Periodic Meetings	[P27] [P39]
		Use of E-Mail Aliases and Shared calendars	[P39] [P42]
		Ad-hoc phone calls between team members	[P39]
		Let the sites operate independently working	[P31]
		Incremental integration plan	[P32]
		Synchronization of main milestones	[P40]
		Traveling Steering Group	[P40]
		Shared Practice's	[P26]
		Central version control system	[P27]
		Documentation	[P27] [P28] [P42]
		Urgent Request	[P21]
		Distributed pair programming	[P21]
		Onsite Management Visits	[P21] [P26]
		Cross Site Delegation	[P21]
		Send Status updates Electronically	[P22]
		Weekly Meeting	[P40]
		Establishment of peer-to-peer links	[P40]

"Unfiltered communication"

Geographically dispersed teams are bounded by the some sort of relationship, this establishment of relationships helps to maintain good coordination in team. There are several approaches that help in maintaining the relationship between team. Among those practices or approaches unfiltered communication is one, which is similar to onsite management visit. The line managers visit to the remote sites developers to aware and help them with the problems they are experiencing. The developer in the remote sites set the agenda and discusses the issues that could hamper their work. The line manger takes 1 to 4 persons with him. During the visit the line manager can get the overall project visibility. This visit is useful in indentifying and making connection across different sites which can finally helps in creating the sense of team [P21].

"Video Conferences"

This practice is useful to overcome the issue caused by the distance. It helps for the efficient and effective meeting when the teams are geographically distributed. This approach is considered as a great idea since we can read the body language and hear the sound of other team in other site which helps them to be familiar with each other. This helps to discuss the problem, assign the role to the person, and also the frequent communication helps them to know each other which will build a trust between the team [P24].

"Conference calls"

This is also the practice similar to video conference that helps in overcoming the geographical distance. But this practice lacks the video as in video conferencing. But it helps in making the meeting more efficient that is help on daily or weekly basis. For this a separate room called conference room with phone are made available for conference call. This also helps team to discuss various matters and resolve them [P24].

"Scrum of Scrums"

The idea behind the Scrum of Scrums is to bring the Sub-Teams as a single Working Team. This practice helps to scale the team and create a small group of 6-10 people or large 8-12 people. Among these people one is selected to lead a scrum team in each site and they conduct a scrum meeting every morning. This is an iterative process so it keeps on going which helps to resolve everyday problem occurred in the sites [P24].

"Use of instant messenger"

Informal communication and discussion among the team members is as important as formal communication. In everyday project life the instant messenger helps for the informal communication among the team members. Though the teams are separated by the physical distance, the use of instant messenger helps informal communication as well as tracking the progress of the project work [P25] [P40] [P42].

"Phone based meetings"

The central team conducts the phone based meetings with the remote team on almost weekly basis. The main purpose of this meeting is to obtain the work progress of remote team and to plan the action items for the coming week. This helps to keep track of work in the remote sites. This practice helps the central team and remote team to build trust as they remain in touch on weekly basis and get the information about the task progress [P28].

"Email interactions"

The email in the distributed development plays vital roles. It is used for the various proposes like informing the status of the task in progress, problem solving techniques, to request team to perform specific task (i.e. work on defect number 34) etc. For any information the team are heavily dependent on email. To maintain the communication between inter remote team the central team launched a mailing system [P28] [P34] [P39] [P41] [P42].

"Early Identification of Dependencies and their management"

Interdependencies among distributed tasks need more coordination and communication to complete them [P28]. If these interdependencies among tasks are identified and managed early in the planning phase then it is easy to distribute independent tasks among teams [P28, P29]. According to [P28], use architectural documentation to identify and represent dependencies, identify the set of tasks to be assigned to each geographical distant team.

According to [P41] "One *of the things I tried to do in terms of task interdependencies as Technical Lead is to minimize those interdependencies especially between Killarney and Bloomington and Watertown. I tried to design the tasks so that they are completely independent between the regions. I would not necessarily actually do those if it's between two engineers on the same site."*

"Daily builds"

Daily builds is one of the mechanism of coordination. Daily builds system is designed to check whether the code is compiled successfully or not and if the passed the unit test or not. If the system found some problems in code it will send an email to the team that made last submission and the central team. The team that made a last submission is responsible for the changes since it is established for the version control. If this problem could not be resolved the central team will ask to revert the changes made and back to the same state it was before [P28].

"Use of mail aliases and shared calendars"

There are some processes or practices that are used in the coordination between the different sites. The use of shared calendar and electronic mail, video conferencing, Internet Relay Chat (IRC) helps in the informal communication between the sites [P39] [P42].

"Ad-hoc phone calls between team members"

Ad-hoc communication is used for interacting between the team members in informal manners. Ad-hoc phone calls are making and receive between the team members which help in building the coordination between the team members by informal mutual adjustment (IMA) [P39].

"Let the sites operate independently working"

When team members are distributed among geographical distance then work distribution according to their level of expertise, resources available at site and infrastructure is very challenging and difficult [P31]. One of the solutions used in study [P31] is let the sites operate as independently as possible while providing them easy, flexible, and effective communication.

"Incremental integration plan"

In geographical distance software development integration of system components at different level is a challenging task [P32]. The use of incremental integration plan bases on clusters and shared milestones is very helpful to integrate the software at different levels and to build trust and confidence among team members [P32].

"Synchronization of main milestones"

Closely collaborating companies may not always necessarily use the same software development process. It might be possible that the companies can use their own process for software development in this scenario to coordinate among their task we use synchronization of main mile stone practice. Although the two different companies uses two different processes this practice helps keep on synchronizing the main process milestone [P40].

"Traveling Steering Group"

Feedbacks are the key for the subcontractors and are always hoping to get it even though they are doing well. Especially the feedback related to the quality of task is more expected from the subcontractor which is a motivating factor. Travelling steering is a group which is formed by including the members from all the sites and partners. This group arrange meeting in all the sites which will be more positive in giving

faces to all sites. This practice helps in informing the task status and progress; and monitoring the team. [P40]

"Shared Practices"

To achieve the high degree of collaboration, shared practices has to be established between the participants. This practice helps people in different sites to know each other more with their shared practices. Furthermore this helps to know the difference in competencies between the participant and the need that needs to establish some shared practices [P26].

"Central version control system"

During the iteration the central version control is used as the working repository by some team. The design artifacts, code, test cases and other related documents are transferred to the central version control system by the remote team. Finally the central team will gather all and conduct system tests. If some issues are uncovered that central team will reassign the responsibility [P27].

"Documentation"

Basically the central level focuses the use of documentation in the architectural and design level. The component dependencies of the development process are identified earlier by the central team by using the architectural documentation and finally these dependencies are used in developing the design structure matrix (DSM) which can be finally used to assign the tasks to the remote team [P28] [P27].

"Urgent request"

There are several issues that makes problem in global software development. The possible issue could be like selecting the right person for the questions, to know the task status, who is responsible for doing what etc makes more difficult across the sites. To overcome these sorts of problems urgent requests are made between the sites. Urgent request is the mechanism to broadcast the messages as an unplanned communication from a member of project to get the urgent information regarding the technology, tools, advice or product [P21].

"Distributed pair programming"

If the code component having dependencies at is notified in one site than the developer at that site asks the other developer in the other site for instant review. They both try to fix the problem and make some changes on it to make the code error free. This is made possible by the use of this practice. Distributed pair programming are used to eliminate the potential conflicts quickly.

"Onsite management visits"

Project manager visit the remote site to address the budget issues, planning the next release, risk management etc in every 6-8 weeks. Likewise the line managers also visit the remote site twice a year. This frequency of the remote site visits increases with the work progress. This visit helps in increasing the relation between the team in different sites. This relation among the teams that are geographically distributed aids in coordination.

"Cross-site delegation"

Basically, individuals are delegated from the central site to the remote site and vice versa which aids in establishing the communication between the teams. This process helps the project if the cross site information is needed at any moment. Furthermore this approach helps to build the relationship between the members and also to get better integration of many distributed teams. Good relation among the geographically distributed teams aid a lot in coordination [P21].

"Send status updates electronically"

In GSD, location creates problems for meeting therefore many informal meetings are conducted in hallway and made decisions which later are electronically send to the other members about the status, decision of the meeting. Team members they are not in the same building cannot join in the hallway meeting, which will be the disadvantage for them [P22].

"Weekly Meetings"

This practice helps for monitoring and informing the project works. The subcontractors are always hoping for the feedback whether the project does something right or wrong, which is a motivating factor for them. The information about the current state of the project work are rarely available to the subcontractor sometimes even they didn't get any feedback. Many studies in the project show that the communication required for this purpose was worthless. On the other hand the information about the project progress is required to all the team members either they are from the customer or the subcontractor to determine what task need to be performed next and on changes. Furthermore, the feedback to the subcontractors is more essential. So to overcome this challenge and minimize the more and one to one communication weekly meeting is essential. For large project, a meeting can be conducted in a every site and later on the project managers can have teleconference or videoconference [P40].

"Establishment of peer-to-peer links"

Different roles are created and assigned to different team members in distributed environment and specify which roles are responsible to communicate with which team members in the company. This practice promotes the communication between the team members in companies which helps in solving problem, building the relationship, and informing and monitoring [P40].

3.2.3.5. Cultural and Language

Table 24: Practices to mitigate Cultural & Language Challenges & Threats

Sr. No	Challenges	Practices to mitigate them	References
06	**Culture and Language**	Eliminate Ambiguity	[P33]
		Foreign Language courses	[P34]
		Cultural liaison	[P32] [P34]
		Cultural awareness	[P46]

"Eliminate Ambiguity"

Ambiguity is a cultural hurdle to coordination because it makes coordination on GSD teams difficult [P33]. In study [P33], Elimination of Ambiguity is used as first strategy to overcome cultural hurdle to coordinate GSD projects. The researchers used unambiguous artifacts like decision tables and code-generated documents to build common understanding.

"Foreign Language courses"

According to [P34], spoken language is an important part of the national cultural distance. Decision makers at executive levels sometimes hesitate for international alliances and show serious reservations about coordination with the nations have weak proficiency in English [P34]. One of the approaches used in [P34] to overcome coordination problems is use of Foreign Language courses for employees to increase their professional communication skills.

"Cultural liaison"

In study [P32, P34], cultural liaisons are used to overcome cultural problems. Liaisons might be engineers, project managers or key executives and their main responsibility is to help developers, meet peoples, learn the system, help to complete system level requirements and specifications, and communicate this information back to head office [P32]. Cultural liaison's role is to facilitate linguistic, cultural and organizational flow of communication and to bridge cultures, overcome conflicts and try to resolve miscommunications [P34].

"Cultural awareness"

Cultural difference among development teams can be reduced by developing understanding of different cultures through interaction with team members, via face-to-face meetings using video conferencing technology or on site management visits [P46]. Cultural awareness among on-site teams can be introduced by including a member from each remote team's culture, to serve as "cultural ambassadors" [P46].

3.2.3.6. Temporal Distance

Table 25: Practices to mitigate Temporal Distance Challenges & Threats

Sr. No	Challenges	Practices to mitigate them	References
07	Temporal Distance	Presentation of Agile customer	[P24]
		Presentation of Feature owner	[P24]
		Email interactions	[P28] [P34]

"Presentation of Agile customer"

The basic principle behind the use of Agile is to satisfy customer by delivering valuable software [P24]. There was a need to have a customer representative who works well across time zones and geographical distance. In study [P24], a highly experienced and more close to selling and marketing department parson was chosen as agile customer. Agile customer needs to communicate with temporal distant team and to start planning by creating stories, acceptance criteria, validating testing and answer questions from customers [P24]. During planning phase the presentation or agile customer who was involved and available to the developers, testers and have better business understanding can overcome temporal distance problems [P24].

"Presentation of Feature owner"

The presentation of Feature owner is like an extension to agile customer [P24]. Feature owner assist agile customer in creating stories and acceptance criteria, this is a type of proxy to agile customer [P24].

"Email interactions"

When there is temporal distance among development teams then it is hard to have effective communication. Email was the recommended means of communication among geographical and temporal distance team members [P28]. Researchers in study [P28] found 5486 emails that corresponded to 2443 interaction threads across temporal distance team members. Asynchronous technologies are most often used for communication among distributed team members to overcome temporal distance among them [P34]. Researchers in [P34] further motivate the use of email and fax (asynchronous) as these have communication history that can be used to overcome many communication misunderstanding that is hard in asynchronous communication.

3.3. Discussion

Our analysis of systematic literature review revealed that there are some challenges as mentioned in section 3.2.1 which exist in global software development. These observed challenges are obstacle in coordination of task, team, and organization. Moreover, some threats are identified by SLR on the basis of the coordination challenges which are reported in section 3.2.2. Furthermore, several practices are identified from SLR in section 3.2.3 that is helpful in minimizing or eliminating the challenges to coordination in GSD. Moreover we have noticed that different challenges are interrelated to each other to make themselves a challenge of coordination. For example the communication is a challenge to coordination because it is the problem arises because of geographical distance, temporal distance, and cultural and language distance. Similar relation can be seen in other challenges as well. We have discussed each and every challenge, associated threats and related practices of coordination individually in the above sections, but here we will have brief discussion on each challenge taking its threats along with the practices.

Communication plays a great role in both formal and informal meetings. The geographically separated teams are connected to each other by means of communication. It is a means for sharing the views, solving problems by asking questions to the distributed teams, organizing meetings, reporting task status,

informing task progress etc. Furthermore, it helps the team feels together although teams are separated physically and unknown to each other which will directly helps in building the relationship, trust among the team members. The good relationship and trust among the distributed team aids coordination. It has proven to be more beneficial for the geographically distributed teams to maintain coordination, but still communication is a challenge to coordination. Geographical distances, temporal distance, cultural distance are the main influencing factor for the communication. According to [P34], distance has positive impact with the communication and negative impact with coordination. This means as the communication distance, temporal distance, and cultural distances increases the problem of communication also increase yielding the decrease in coordination. These factors are responsible in introducing several threats of communication to coordination in GSD. Several findings are also there to reduce this challenge and to aid coordination.

Trust is a key of success in GSD. Maintaining a trust among distributed teams is a difficult task. There are several factors that make the trust as a challenge. Geographical distance, temporal distance, communication, and cultural distance are the major factors that challenge the trust in between the distributed teams. Geographical distance has direct impact on trust as people are separated by physical distance they are unknown to each other and even more they don't have idea about the nature of other people. As a human nature, people cannot trust anyone without seeing, dealing or communicating him/her. This happens here and they lose trust among each other. As mentioned before, the trust building factor is a communication between the team members. If the company from different locations has less or no overlapping hours they almost miss the chances of synchronous communication. Synchronous communication aids more in coordination. Similarly culture will also have some impact on trust. Several threats for trust has been identified which can endanger the GSD task if some mitigating strategies or practices are not implemented. Furthermore, some practices are also identified with the help of literature review which helps to minimize or remove the challenge.

Geographical distance create problem in communication as well as coordination. When teams are geographically distributed in different zone, they cannot meet each other which can cause the lack of "teamness". Physically dispersed team lacks the face-to-face meeting which is helpful in building trust among the team. This means that the physical distance influence the trust directly. Some other impacts of geographical distance are the uncommitted and avoidance of responsibility which means not trusting the ability of team member separated geographically. Temporal distance is also impacted by the geographical distance. The temporal distance also increases with the increase in physical distance. This issue impacts the synchronous communication which will be later described in temporal section. Some of the article focuses on the productivity and the quality of software indicating that they are also influenced by the geographical distance. The great distance between the teams will create problem for the frequent visit though it is necessary. Furthermore, the dependencies among the task also create problem and finally the integration of the finished task is also a bug problem caused by distance. Different practices have been identified to overcome the geographical distance challenge. Some focus on making effective communication while others are helpful in building "teamness" and trust.

Temporal distance is the overlapping hours between the distant organizations which challenges the coordination between team. When the team members are at different temporal distance it becomes impossible to work together which means the overlapping hours between them will be decreased which makes them to rely on asynchronous communication for communication. As the team rely on

asynchronous communication it is possible that one team get delay response from the other team. Temporal distance decreases the frequency of communication richness which and make team rely on asynchronous communication which will create problem in resolving unclear message. Temporal distance has some more issues like Problems in the attainment of common understanding among team members, Mutual misunderstanding within and among teams etc. these issues are the key to hamper the coordination in the distributed environment. Several practices have been identifies which can mitigate these issues and aids in coordination.

Culture and Language is the consequence of the geographical distance. Culture and language skills are likely to vary as the physical distance increases. With the increase in culture there will be language problem, as different cultures have different way and technique of speaking. People from different cultural background have different skills i.e. mismatch skills. Language also becomes the barrier as different cultures have different language, this lacking of common language hinder the communication. Teams cannot communicate as fluent as their native language as they belong to different culture. Language can create the problems like ambiguity in requirements; problem in communication etc. cultural mismatch can pose serious challenges for achieving a shared understanding of the software requirements among team members. To overcome the cultural and language challenge, several practices have been identified. Training language is one of the practices to solve the language problem; similarly training to cultural awareness is other approach to know the other culture.

Software architecture has direct relation with the coordination. The architecture will define the need of coordination and communication in the distributed environment. If software architecture components having less dependency are distributed among the sites than the communication and coordination require will be less. The components having dependency should be distributed in near shore so that the synchronous communication and regular site visit can solve the dependency issues. While distributing the task to remote sites the software architecture components should not be fully or partially dependent for the well execution of task. Some other threats are also identified like development site infrastructure, development strategy. All these are defined in the section 3.5. Finally we have found some practices used to mitigate this problem. The section 3.3.3 discuss about the identified practices.

3.4. Conclusions

´We conducted systematic literature review in order to find possible challenges, associated threats, and the practices to mitigate the challenges of coordination in GSD from academic point of view. We collected the articles from 2001 to 2011, as the main concept of GSD was introduced from the beginning of 21st century and the articles after 2001 seems more useful and beneficial than the previous ones for our use. Most of the articles identified are industrial report and case study and the rest are interview, surveys and experiment related studies. The challenges associated threats to coordination are described in section 3.2. All the selected studies discussed that to coordination work in GSD is challenging.

Finally, authors identified 6 challenges out of them 3 are the main challenges and remaining 3 are sub challenges. Here main and sub challenges are categorized on the basis of numbers of articles discuss about it in SLR.

We use SLR to identify the practices to mitigate the challenges to coordination in GSD. We found different practices for different challenges which are listed in the section 3.3. Each identified practice is useful in mitigating the challenges of coordination.

During SLR we identified 6 challenges, 50 threats associated and 52 practices to mitigate or overcome these challenges.

Chapter 4

4. Survey

The rationale for conducting survey is to investigate industry experiences and practices in relation to coordination challenges, associated threats and practices in GSD. To conduct this type of research, survey is the best option as compared to other methods, like experiments and case studies. Case studies are used to inspect why and how things happened. Case studies are best to explore contextual realities and to observe the difference in literature and what is happening in industry [38]. Similarly, experiment is a controlled study in which a situation is controlled and behavior is manipulated directly, systematically and precisely [37]. Therefore experiment and case study are not appropriate methods for this study. In our work we need to gain knowledge from various industries. Survey has the ability to present huge number of variables for evolution [37]. Survey is helpful in collecting the data from different part of globe as it is not influenced by temporal distance and geographical distance. It is a feasible method to conduct as concerned to the time and budget. To conduct survey the questionnaire was designed on the basis of data identified from SLR.

Later, the questionnaire are distributed by different means which helped us to identify similarities and differences between literature and current industrial experience in relation to challenges, associated threats to coordination and practices to mitigate them in GSD. The survey aids in answering the research question R.Q2 and R.Q3.

The following sections 4.1 and 4.2 provide the information regarding questionnaire design and questionnaire distribution.

4.1. Questionnaire Design

We thoroughly reviewed the literature to design the survey questionnaire. The questionnaire is set in a way to capture as much information as possible from industry practitioners. The form of data collection used in this study is self-administrated and internet based survey, (Kwik Surverys, http://www.kwiksurveys.com/). This type of survey is best when the participants are located at different locations as the case in GSD. Therefore, it is easy to send the survey link to the participants at different locations to get their responses. This is also cost effective and convenient in logistics (means of distribution). Kwik is free of cost for students and also provide reasonable data analysis features.

The questions for this survey are divided into two categories.

- The demographic information
- Open ended questions

4.1.1. The Demographic Information

Demographic information aids authors to get the view point from a particular perspective.The following information is asked from respondents of this survey

- Brief description of the project they are currently involved in.
- Their roles and responsibilities in current and past distributed software development projects.
- Working experience in distributed software development settings

Furthermore, the main purpose of this section is to obtain a brief insight on the participant's background, experience and type of project they are working or worked in DSD setting.

4.1.2. Survey Questions

This section is divided into two sections. The first section deals with the coordination challenges and associated threats where as the second section is about the practices used to overcome these challenges and threats asked in GSD.

The purpose of this section is to capture the information in order to see whether the challenges associated threats and practices reported in the literature can be confirmed from the industry. Furthermore, it will also help the authors to identify similarities and differences between industry practitioners experience and empirical based research papers.
The detailed information regarding these two sections (survey questionnaires) is show in Appendix C.

4.2. Questionnaire Distribution

Initially we prepared a list of organizations that are working in distributed software development. Then they were contacted to participate in survey. As soon as we get their acceptance we gave them an electronic link for the survey. Participants were requested to completely fill the survey questionnaire. Furthermore, they were also requested to distribute the survey to the other participant who is working in global software development. The selected participants were project managers, system analysts, developers and testers who are presently working or had worked in GSD context.

The rationale behind the selection of these respondents was the fact that they are mostly involved in distributed software development.

4.3. Survey Piloting

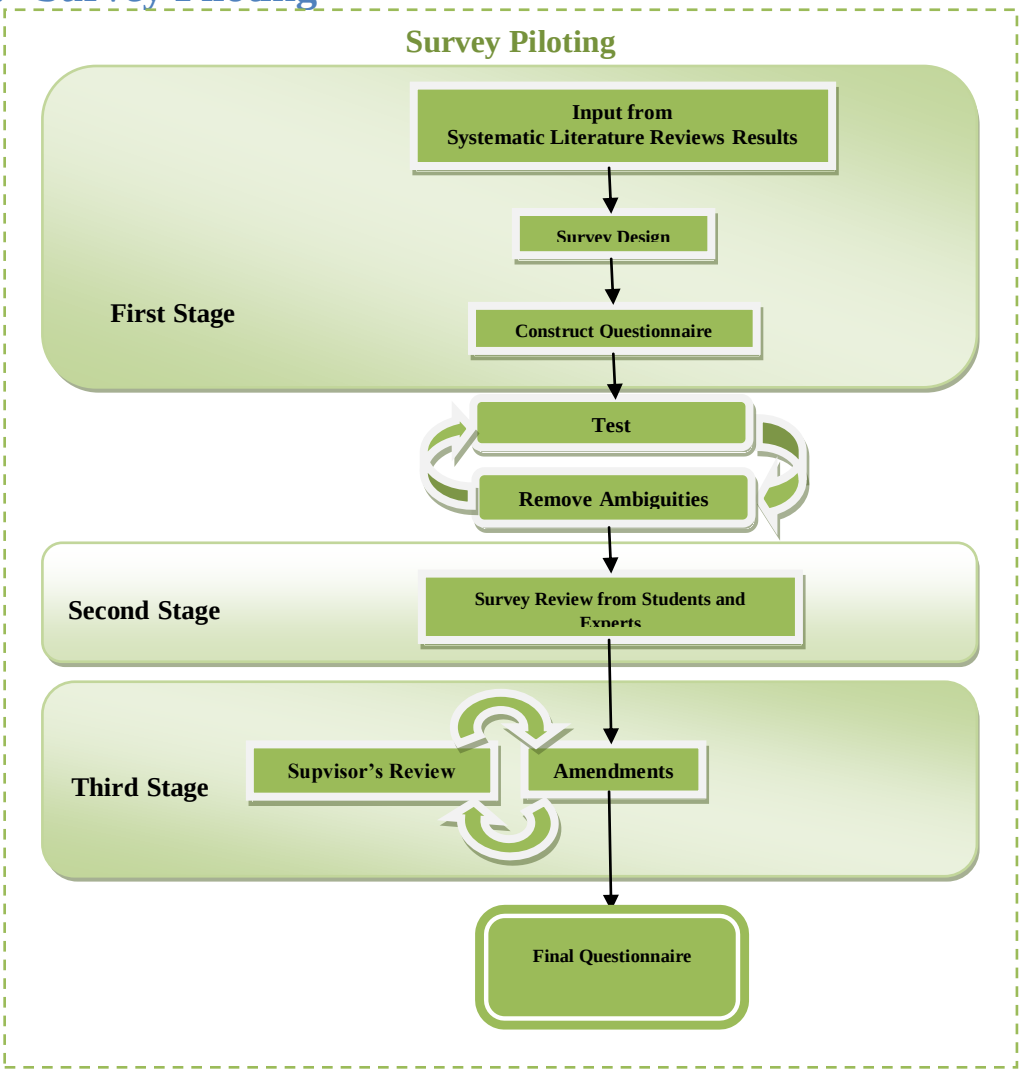

Figure 9: Survey Piloting

Stage 1

At stage one, we have captured initial data from the systematic literature review as input to formulate and design survey questionnaires. Authors design and test every question carefully to remove ambiguities. Unambiguous questionnaires facilitate the respondents to easily understand them. At this stage authors also finalized the format and layout of questionnaires.

Stage 2

At this stage we have approached some students that took Global Software Engineering course and also have some knowledge and experience in distributed software development. The initial survey questionnaires are given to students and requested them to fill and give us their feedback. On the basis of their feedback authors removed some ambiguities in the questionnaires and tried to make it easy and clear for participants.

After that the questionnaires was send to an expert for her feedback that was very productive. Initially, authors asked more details from respondents regarding their personal information like first and last name, e-mail address and company. According to her such type of information is perceived to be too confidential to be revealed in survey. She also mentioned that because of contractual agreement some employees are stopped to disclose company related information in that case there is a chance to lose some potential respondents. With fear of losing some potential respondents the authors decided not to ask the following information through survey:

- Name of Respondents
- E-mail Id's
- Company Name

No personal information was asked from respondents so that they can feel comfort to answer the questionnaires.

Stage 3

Finally, after making some modifications in survey questionnaires authors send it to their supervisor to verify and give more suggestions. We made some more changes in the structure of survey questionnaires and then resend it to supervisor for final approval. After getting approval from supervisor the final survey questionnaires selected for distribution.

4.4. Survey Results and Analysis

4.4.1. Results and Analysis of Number of Respondents and Their Companies

We tried our best to receive as much results as possible, but unfortunately only 26 total responses were received from different software organizations. Authors removed partially filled responses from the survey questionnaire and considered those responses which fulfill the demands of this research work. After eliminating partially filled responses only 17 were selected for this work.

The information about the participant organizations is summarized in table 26.

Table 26: Organization Type and Number of Respondents

Sr. No	Company Name	Organization Type	Head Office Location	Distributed Offices	Number of Respondents
1	A	Information and	New-	USA, UL	Project Manager = 1

		communication technology	Zeeland		Software Developer = 1
2	B	Software product development	Australia	USA	Software Developer = 1 Software Tester = 1
3	C	Software subcontracting & I.T	Sweden	Romania, China, India	Software Developer = 2
4	D	Telecommunication	Sweden	Romania, Poland	Project Manager = 1 Software Developer = 1
5	E	Web development	Pakistan	U.K	Business process analyst = 1 Consultant = 1
6	F	Software development and consulting	USA	Europe, India	Project Manager = 1 Business process analyst = 1
7	G	Software Automation	Germany	Canada, Finland, Norway	Software Developer = 2
8	H	Software product development	Sweden	China, Japan, USA	Process Engineer = 1
9	I	Telecommunication	Canada	India	Business process analyst = 1 Consultant = 1

Table 26 shows that the participant organizations belong to different geographical locations, some of them are from Asia, Europe and others from Australia and U.S.A.

The role and responsibilities of the participants in GSD projects are also varies like project manager, software developer, analyst, process engineer and consultant. This can help the authors to view the results from different prospective.

In table 27 roles and responsibilities assigned to respondents in geographically distributed projects and frequency of responses to each is listed.

Table 27: Roles of Respondents

Sr. No	Roles of Respondents	Number of Respondents
1	**Business process analyst**	**3**
2	**Software Developer**	**7**
3	**Consultant**	**2**
4	**Process Engineer**	**1**
5	**Project Manager**	**3**
6	**Software Tester**	**1**
Total		**17**

Table 28: Working Experience of Respondents

Sr. No	Years of Experience	Number of Respondents
1	Less than 3	10
2	3-5	6
3	More then 5	1

It is also observed that the experience of respondents in distributed projects also varies. There are 9 respondents with less than 3 years of experience, 6 of them have experience ranging from 3 to 5 and only one respondent have more than 5 years of experience in GSD. Such information is mentioned in table 28.

4.4.2. Analysis of survey

Finally we got 25 survey results. The survey results that were partially filled were neglected and took the others which are completely filled and useful. There is a field in the survey questionnaires to fill by the respondent if they think that there exist other things that are not mentioned in the survey. From survey, we found that there were three suggestions for the practices which we took as an additional practice and discuss in the section below. The results of survey is then tabulated on the basis of respondents role to see what type of respondent having what roles are participated in the survey. Here we observed that some of the respondent having the same roles experienced same type of challenge, threats in industry. Later a table is drawn on the basis of years of experience of the respondents. On the basis of years of experience we have drawn the table 29. The hits given by the respondent having more experience are placed on the top. From the survey it is observed that the challenges, threats and the practices extracted from the SLR are also experienced by the survey respondent. The procedure we followed is:

1st: Incomplete surveys were discarded

2nd: Categorized the respondents according to their roles and experience

3rd: The survey responses are extracted and tabulated.

4th: Most reported and least reported threats are categorized and analyzed.

5th: Additional practices were identified and discussed.

4.4.3. Identified Challenges, Threats and Practices

In this section we discuss coordination challenges, associated threats and practices. Authors identified most reported threats and practices as well as least reported threats and practices by survey respondents. Further investigation was done to see the correlation between most and least reported threats and practices with organizations type. From the analysis of most and least reported threats and practices from survey results, authors tried to find a correlation to respondent's role in the project.

The results of the survey, value of count and the information about participant organizations is available in Appendix B.

In the following table 29, authors listed all identified practice and threats related to a particular challenge to coordination.

Table 29: Identified challenges associated threats and best practice from survey

Associated Threats	Challenge	Best Practices
❖ **Reduce opportunities for spontaneous interaction** ❖ **Inadequate informal communication** ❖ **Loss of communication richness** ❖ **No readiness for communication** ❖ **No common language for communication** ❖ **Lean communication media**	**Communication**	❖ Weekly Meeting ❖ Intranet connectivity ❖ Progress Reports ❖ Documents to show how to use documents (For Non-Native Language Persons) ❖ Work packages ❖ Bulletin Boards and E-mail Lists ❖ Problem E-mailbox ❖ Foreign Language courses
❖ **Doubtful about others capability** ❖ **Uncommitted and avoids responsibilities** ❖ **Reduced Trust**	**Trust**	❖ Face- to- face Meetings ❖ Hold frequent, regularly scheduled status meetings ❖ Give Faces ❖ Frequent Deliveries ❖ Organizational Chart ❖ Co-located analysis phase
❖ **Development strategy** ❖ **Product architecture** ❖ **Development site infrastructure** ❖ **Process interdependency**	**Software Architecture**	❖ Measuring architectural/organizational fit ❖ Tactics for improving architecture/organization fit ❖ Improve Architecture Understanding ❖ Misunderstandings of intent of Requirements

❖ **Less opportunity to form personal relations** ❖ **Reliance on documentation as a coordination mechanism** ❖ **Interdependence of tasks** ❖ **Much longer development time** ❖ **Lack of task awareness** ❖ **Frequent Re-planning required** ❖ **To manage software quality** ❖ **Infrastructure management** ❖ **Lack of "Teamness"** ❖ **Lack of shared understanding** ❖ **Reduces communication frequency and richness** ❖ **Integration of work** ❖ **Distribution of work** ❖ **Hard to conduct efficient and effective meetings** ❖ **Lack of Trust on other team member** ❖ **Unclear role to team members**	**Geographical Distance**	❖ Video Conferences ❖ Conference Calls ❖ Weekly Meeting ❖ Email interactions ❖ Use of Instant Messenger ❖ Phone Based Meetings ❖ Ad-hoc phone calls between team members ❖ Use of E-Mail Aliases and Shared calendars ❖ Scrum of Scrums ❖ Distributed pair programming ❖ Early Identification of Dependencies and their management ❖ Daily Builds ❖ Periodic Meetings ❖ Let the sites operate independently working ❖ Incremental integration plan ❖ Synchronization of main milestones ❖ Shared Practice's ❖ Traveling Steering Group ❖ Urgent Request ❖ Documentation ❖ Central version control system ❖ Onsite Management Visits ❖ Cross Site Delegation ❖ Send Status updates Electronically ❖ Establishment of peer-to-peer links ❖ Unfiltered Communication
❖ **Ambiguity in requirements** ❖ **Human relations knots affecting** ❖ **Lack of proficiency in language** ❖ **Reduce mutual understanding** ❖ **Lack of team spirit** ❖ **Limited feedback from the remote locations** ❖ **Mismatch skills** ❖ **Problem in communication** ❖ **Lack of shared understanding** ❖ **Negative impact on the effectiveness of plans** ❖ **Inconsistency in work practices**	**Culture & Language**	❖ Cultural awareness ❖ Eliminate Ambiguity ❖ Present Cultural liaisons ❖ Mutual Respect for each other ❖ Foreign Language courses

❖ **Difficulties in resolving unclear messages** ❖ **Reduce collaboration hours** ❖ **Delay in response** ❖ **Synchronization of work** ❖ **Irregular information flow** ❖ **Challenge everyday communication** ❖ **Rely on asynchronous communication** ❖ **Mutual misunderstanding within and among teams** ❖ **Problems in the attainment of common understanding among team members** ❖ **Reduced opportunity for spontaneous interaction**	**Temporal Distance**	❖ Email interactions ❖ Presentation of Agile customer ❖ Presentation of Feature owner

From the survey, all threats and practices identified in literature review were confirmed by respondents. All respondents reported that identified threats can effect coordination in GSD projects and practices can be helpful to overcome these challenges and threats. All the terminologies used for the challenges, threats and practices were similar to the literature that we have reviewed in SLR.

Unfortunately, lacks of number of respondents in this survey the authors are not able to claim that these are the only possible threats and that identified practices can overcome or mitigate them.

In table 29 we sorted these threats and practices in a way that most counted threats and practices in each category are at top and least one are at bottom.

Here we can say that against a particular challenge the top most threat and practice is one to whom most of respondents reported and at bottom are least reported by respondents. This is explained in more detail in section 4.4.2.1 and section 4.4.2.2.

4.4.3.1. Results and Analysis of Most Reported Threats and Practices

On the basis of survey results for each challenge the most reported threats and practices are identified. The most reported threats and practices are those which get maximum hits from respondent on the survey. Most reported threats are placed in table 30 and most reported practices in table 31.
Most reported threats as show in table 30 were reported by project managers, system developers, as well as system analyst. Such results show that the most reported threats are faced by different team members regardless of their roles in the project.

Table 30: Most Reported Threats

Communication	Trust	Software Architecture	Geographical Distance	Culture & Language	Temporal Distance
Reduce Opportunities for Spontaneous Interaction	Doubtful about others Capability	Development Strategy	Less opportunity to Form Personal Relations	Ambiguity in Requirements	Difficulties in Resolving Unclear Messages
Loss of Communication Richness	Uncommitted and avoids responsibilities	Development Site Infrastructure	Reliance on Documentation as a	Human Relationships affects	Reduce Collaboration Hours

			Coordination Mechanism		
Inadequate Informal Communication		Product Architecture	Interdependence of Tasks	Lack of Proficiency in Working Language	Delay in Response
			Much longer Development Time	Mutual Understanding	Irregular Information Flow
			Lack of Task Awareness	Lack of Team Spirit	Synchronization of Work

According to survey results communication among GSD members is challenging. Analysis shows that following threats, "*Reduce opportunities for spontaneous interaction", "Loss of communication richness"* and *"Inadequate informal communication*" has high count value. We can say that most of the participants mentioned that these 3 threats are challenging to effectively communicate among GSD team members.

Respondents think that if there is lack of trust among GSD team members they are "*Doubtful about others capability*" and "*Uncommitted and avoids responsibilities*". These two threats have high count value as compared to others.

According to the view point of different participants designing software architecture for GSD is a challenging task. Defining "*Development strategy", "Development site infrastructure*" and "*Product architecture*" are the most valued threats caused by software architecture.

Geographical distance among team members causes some serious problems as the authors identified from literature. According to the survey results most of the participants mentioned that "*Less opportunity to form personal relations"," Reliance on documentation as a coordination mechanism"," Interdependence of tasks"," Much longer development time" and "Lack of task awareness*" are the serious threats to coordination because of geographical distance among team members.

Culture and language imposes some serious hurdles to coordinate GSD projects. Cultural and language difference among team members results in "*Ambiguity in requirements", "Human relationships affects", "Lack of proficiency in language", "Reduce mutual understanding"* and *"Lack of team spirit*".

Survey results show that above mentioned threats has high count value which shows that these are serious issues related to cultural and working language difference among GSD team members.

Time zone difference among GSD teams effects number of overlapping hours. Even one hour difference between two sites reduces number of working hours. According to survey results temporal distance among teams imposes some serious challenges to coordination GSD projects. The following threats, *"Difficulties in resolving unclear messages", "Reduce collaboration hours", "Delay in response", "Irregular information flow"* and *"Synchronization of work*" has high count value that shows these are serious problems caused by temporal distance among GSD teams.

Similarly the most reported threats the most reported practices as shown in table 31 were reported by project managers, system developers, as well as system analyst. Such results show that most reported practices are that followed by different team members regardless of their roles in the project to overcome or mitigate coordination challenges.

Table 31: Most Reported Practice's

Communication	Trust	Software Architecture	Geographical Distance	Culture & Language	Temporal Distance
Weekly Meeting	Hold Frequent Regularly Scheduled Status Meetings	Measuring Architectural/Organizational Fit	Video Conferences	Cultural Awareness	E-mail Interactions
Intranet Connectivity	Give faces	Tactics for Improving Architecture/Organization Fit	Conferences Calls	Mutual Respect for each other	Presentation of Agile Customer
Progress Reports	Frequent Deliveries		Weekly Meeting	Eliminate Ambiguity	
			Email Interactions	Cultural Liaison	

Communication is an important element when team members are working in GSD environment. By analyzing the responses from respondents, authors identified three practices with high count value. These are "Weekly Meeting", "Intranet connectivity" and "Progress Reports". Respondents are agreed that by using these practices we can overcome communication problems in GSD projects. When team members are at different locations then weekly meeting among them is the top most practice identified from the survey responses. According to responses from participants by having intranet connectivity and progress reports we can overcome communication challenges across GSD team members.

It is a challenging task to maintain trust among the team members when they are separated by geographical and temporal distance. Lack of trust among team members causes some problems mentioned in table 4.4. According to the responses from respondents, the practice is to overcome trust related problem is face-to-face meetings. In this work authors have identified 14 respondents recommended this practice to overcome challenges caused by lack of trust. The second most productive practices are, "*Hold frequent regularly scheduled status meetings*", "*Give faces*" and "*Frequent Deliveries*".

Designing a software architecture that fulfills all requirements of GSD team members is a challenging task. According to [P3] there is a link between software architecture and coordination. So there is a need to overcome software architecture problems to coordinate with GSD teams. Survey results show that the best way to tackle this problem is "*Measuring architectural/organizational fit*" and "*Tactics for improving architecture/organization fit*". These two practices have high value of count that shows more number of respondents agree that these can overcome software architecture problems.

Geographical distance among team members causes some critical problems mentioned in table 4.4. To overcome these problems most of the respondents recommend video conferences and conference calls among team members. These can be used as alternative of face-to-face meeting. The other productive practices mentioned by respondents are, "Weekly Meeting", "Email interactions". The use of instant messenger and phone based meetings can also solve many problems caused by geographical distance among parties.

On the basis of responses from survey respondents we can conclude that to overcome culture and language problems in GSD projects, respondents suggested that there is a need for "*Cultural awareness*" among members. This practice can help persons to understand each other culture and norms that can help to establish good relationships among them. If working language among team members is other then

native language they feel problems to interact with each other. This situation can create ambiguity among software development members. Many of respondent recommend to eliminate ambiguity right at time before it make severe. Use of cultural liaison is 3rd most reported practice by practitioners to overcome many cultural and language challenges.
Unfortunately, from survey responses and also literature review we did not find more results for this category. Most of the respondents agree to have E-mail interactions when people working in GSD context. This can overcome many temporal distance problems. Some of respondents also recommend the presentation of agile customer during development especially during analysis and planning phase to mitigate temporal problems.

4.4.3.2. Results and Analysis of Least Reported Threats and Practices

Form the survey the least reported threats and mitigation strategies are identified. The least reported threats and practices are those which get minimum hits from respondent on the survey. The least reported threats are summarized in Table 32 and the least reported mitigation strategies are complied in Table 33.

Table 32: Least Reported Threats

Communication	Trust	Software Architecture	Geographical Distance	Culture & Language	Temporal Distance
No common language for communication	No collaboration despite numerous meetings	Process interdependency	Frequent Re-planning required	Limited feedback from the remote locations	Difficulties in Resolving Unclear Messages
No readiness for communication	Reduce trust		Integration of work	Negative impact on the effectiveness of plans	Reduce Collaboration Hours
Lean communication media			Distribution of work	Mismatch skills	Problems in the attainment of common understanding among team members
			Unclear role	Problem in communication	Schedule problem
			Hard to conduct efficient and effective meetings	Lack of shared understanding	Reduced opportunity for spontaneous interaction
			Time Separation	Inconsistency in work practices	Reduces communication frequency and richness
			Lack of teamness		Rely on asynchronous communication
			Lack of shared		Challenge

			understanding		everyday communication
			Reduces communication frequency and richness		Mutual misunderstanding within and among teams
			Reduced informal contact can lead to lack of task awareness		

The survey result shows that the following are the least hit threats in the communication challenge. *No common language for communication, No readiness for communication, and Lean communication media*.

Trust in GSD is regarded as the key for the success. From the survey result we have got the some trust related threats that are less selected. These threats are "*No collaboration despite numerous meetings", and "Reduce trust"*

Most of the threats of the software architecture are selected and have high count. One of the threats for communication has got less point of selection. *Process interdependency* is the one threat that has got less point in survey from the practitioners.

Though we have identified plenty of threats caused but the challenge geographical distance, only few of them are able to get more hit in the survey. While some of them get lesser hits. Here we have listed the threats that get the less hit in survey- *Use of instant messenger, Scrum of Scrums, Early Identification of Dependencies and their management, Daily builds, Use of mail aliases and shared calendars, Ad-hoc phone calls between team members, Let the sites operate independently working, Incremental integration plan, Synchronization of main milestones, Traveling Steering Group, Offshore–onshore bridgehead, Shared Practice's, Distribute the tasks having less dependency, Renegotiating boundaries and status differences, Central version control system, Documentation, Urgent request, Distributed pair programming, Unfiltered communication, Onsite management visits, Cross-site delegation, Send status updates electronically, and Establishment of peer-to-peer links*

The least reported threats of culture and language are *Limited feedback from the remote locations*, *Negative impact on the effectiveness of plans, Mismatch skills, Problem in communication, Lack of shared understanding, and Inconsistency in work practices.*

Culture and language create lot more problems in the coordination. The threats related with the culture language that are reported more in survey are mentioned in the up section. This section covers all those threats which are less reported in survey. Following are the threats- *Difficulties in Resolving Unclear Messages, Reduce Collaboration Hours, Reduces communication frequency and richness, rely on asynchronous communication, Challenge everyday communication, and Mutual misunderstanding within and among teams*

In survey the respondent like team leader and project manager pointed out the least reported threats. The respondent having these types of roles and responsibilities will have more knowledge or wider overview about the project which helps them to have or develop the knowledge about some issues of project like organizational structure and legal issues. But unfortunately these types of threats which are called least reported threats are not experienced by the tester and developers as they are not engaged in organizational structure tasks or managing joint processes.

Table 33: Least Reported Practices

Communication	Trust	Software Architecture	Geographical Distance	Culture & Language	Temporal Distance
Weekly Meeting	Face- to- face Meetings		Use of instant messenger	Cultural Awareness	Presentation of Feature owner
Documents to show how to use documents	Onsite management visits		Scrum of Scrums	Foreign Language courses	Presentation of Permanent full-time Agile customer
Foreign Language courses	Cross-site delegation		Early Identification of Dependencies and their management	Internalization of Foreign Entity	
Work packages	Co-located analysis phase		Daily builds	Tailored training	
Use of liaisons	Organization chart		Use of mail aliases and shared calendars		
Bulletin Boards and E-mail Lists			Ad-hoc phone calls between team members		
Problem E-mailbox			Let the sites operate independently working		
Solution providers			Incremental integration plan		
			Synchronization of main milestones		
			Traveling Steering Group		
			Offshore–onshore bridgehead		
			Shared Practice's		
			Distribute the tasks having less dependency		
			Renegotiating boundaries and status differences		
			Central version control system		
			Documentation		
			Urgent request		

			Distributed pair programming		
			Unfiltered communication		
			Onsite management visits		
			Cross-site delegation		
			Send status updates electronically		
			Establishment of peer-to-peer links		

Out of 11 practices only 3 were highly reported and rest of them are least reported which are as follows: *Weekly Meeting, Documents to show how to use documents, Foreign Language courses, Work packages, Use of liaisons, Bulletin Boards and E-mail Lists, Problem E-mailbox, and Solution providers.*

For the challenge trust in coordination we have identified 8 practices out of which 5 are least reported practices. *Face- to- face Meetings, Onsite management visits, Cross-site delegation, Co-located analysis phase, and Organization chart* are the least reported practices for trust.

Out of 28 practices 24 practices are least reported. The practices that are least reported are - *Use of instant messenger, Scrum of Scrums, Early Identification of Dependencies and their management, Daily builds, Use of mail aliases and shared calendars, Ad-hoc phone calls between team members, Let the sites operate independently working, Incremental integration plan, Synchronization of main milestones, Traveling Steering Group, Offshore–onshore bridgehead, Shared Practice's, Distribute the tasks having less dependency, Renegotiating boundaries and status differences, Central version control system, Documentation, Urgent request, Distributed pair programming, Unfiltered communication, Onsite management visits, Cross-site delegation, Send status updates electronically, and Establishment of peer-to-peer links.*

The number of least reported and most reported practices for cultural and language threats are equal in number. Both have the 4 practices. The practices are *Cultural Awareness, Foreign Language courses, Internalization of Foreign Entity, and Tailored training*

Presentation of Feature owner and Presentation of Permanent full-time agile customer are the two least reported practices in temporal distance.

The practices reported only few times are listed on least reported practices. The result shows that the respondent for the least reported threats are similar to the least reported practices. In survey the respondent having the roles of team leader and project manager reported the least reported practices. Most of the least reported practices need to accomplish with strategic decision making. The practices like Traveling Steering Group, Onsite Management Visits, Central version control system etc are done with some strategic decision making. Only the respondent having material positions are experienced with these sorts of practices.

4.4.2.3 Results and Analysis of all the Reported challenges, Threats and Practices along with the counts

Table 34: Reported Challenges, Threats and Practices

Counts	Associated Threats	Challenges	Best Practices	Counts
9	❖ Reduce opportunities for spontaneous interaction	Communication	❖ Weekly Meeting	9
7	❖ Inadequate informal communication		❖ Intranet connectivity	6
7	❖ Loss of communication richness		❖ Progress Reports	5
5	❖ No readiness for communication		❖ Documents to show how to use documents	2
3	❖ No common language for communication		❖ Work packages	2
2	❖ Lean communication media		❖ Bulletin Boards and E-mail Lists	2
			❖ Problem E-mailbox	1
			❖ Foreign Language courses	1
12	❖ Doubtful about others capability	Trust	❖ Face- to- face Meetings	14
10	❖ Uncommitted and avoids responsibilities		❖ Hold frequent, regularly scheduled status meetings	7
2	❖ Reduced Trust		❖ Give Faces	7
			❖ Frequent Deliveries	4
			❖ Organizational Chart	3
			❖ Co-located analysis phase	3
9	❖ Development strategy	Software Architecture	❖ Measuring architectural/organizational fit	6
8	❖ Product architecture		❖ Tactics for improving architecture/organization fit	5
6	❖ Development site infrastructure		❖ Improve Architecture Understanding	3
3	❖ Process interdependency		❖ Misunderstandings of intent	2

13	❖ Less opportunity to form personal relations	**Geographical Distance**	❖ Video Conferences	9
6	❖ Reliance on documentation as a coordination mechanism		❖ Conference Calls	8
6	❖ Interdependence of tasks		❖ Weekly Meeting	5
5	❖ Much longer development time		❖ Email interactions	4
5	❖ Lack of task awareness		❖ Use of Instant Messenger	3
2	❖ Frequent Re-planning required		❖ Phone Based Meetings	3
2	❖ To manage software quality		❖ Ad-hoc phone calls between team members	2
2	❖ Infrastructure management		❖ Use of E-Mail Aliases and Shared calendars	2
2	❖ Lack of "Teamness"		❖ Scrum of Scrums	2
2	❖ Lack of shared understanding		❖ Distributed pair programming	2
2	❖ Reduces communication frequency and richness		❖ Early Identification of Dependencies and their management	1
1	❖ Integration of work		❖ Daily Builds	1
1	❖ Distribution of work		❖ Periodic Meetings	1
1	❖ Hard to conduct efficient and effective meetings		❖ Let the sites operate independently working	1
1	❖ Lack of Trust on other team member		❖ Incremental integration plan	1
1	❖ Unclear role to team members		❖ Synchronization of main milestones	1
			❖ Shared Practice's	1
			❖ Traveling Steering Group	1
			❖ Urgent Request	1
			❖ Documentation	1
			❖ Central version control system	1
			❖ Onsite Management Visits	1
			❖ Cross Site Delegation	1
			❖ Send Status updates Electronically	1
			❖ Establishment of peer-to-peer links	1
			❖ Unfiltered Communication	

❖ Ambiguity in requirements (9) ❖ Human relations knots affecting (6) ❖ Lack of proficiency in language (4) ❖ Reduce mutual understanding (4) ❖ Lack of team spirit (4) ❖ Limited feedback from the remote locations (3) ❖ Mismatch skills (1) ❖ Problem in communication (1) ❖ Lack of shared understanding (1) ❖ Negative impact on the effectiveness of plans (1) ❖ Inconsistency in work practices (1)	**Culture**	❖ Cultural awareness (9) ❖ Eliminate Ambiguity (7) ❖ Present Cultural liaisons (5) ❖ Mutual Respect for each other (5) ❖ Foreign Language courses (2)
❖ Difficulties in resolving unclear messages (1) ❖ Reduce collaboration hours (7) ❖ Delay in response (5) ❖ Synchronization of work (5) ❖ Irregular information flow (4) ❖ Challenge everyday communication (4) ❖ Rely on asynchronous communication (2) ❖ Mutual misunderstanding within and among teams (2) ❖ Problems in the attainment of common understanding among team members (2) ❖ Reduced opportunity for spontaneous interaction (1)	**Temporal Distance**	❖ Email interactions (11) ❖ Presentation of Agile customer (7) ❖ Presentation of Feature owner (3)

This table shows all the identified challenges, threats and the practices from the survey. Furthermore the number of hits for each threat and the practices are also shown in the side with the help of bar diagram. In

this table we count the number of hits for the challenges, practices and threats just to keep the track (information) that how many practitioners experienced which challenges, threats or practices.

4.4.3 Additional practice and threats identified in survey

From the survey results all challenges, associated threats, and practices were experienced by different respondents. All the challenges associated threats to coordination and practices to mitigate them identified from literature were confirmed by industry practitioners through survey. In survey the authors provided a text field to report additional threats and practices. So along with the confirmation of SLR finding from respondents the authors obtained 3 additional practices, one related to culture and language and two related to geographical distance.

In the following paragraph authors explained additional practices identified in the survey. Authors did not modify the sentences provided by the respondents, so they are added in this document without changes. Double quotes are used to show that these statements are used as they are provided from respondents.

One of the respondents reported a practice to overcome culture and language problem in his/her project that is

"*As in our organization we use to send our main experienced person to offshore location to understand team, their culture, their daily norms actions reaction like that to know their body language so it helped us to know some how about offshore team's culture and how they deal things i think it can help to learn culture."*

This practice refers to the presentation of an experienced person to offshore location to learn the culture of that site. If we can go back to our findings from SLR then the authors concluded that this is also same practice like "*Cultural liaison"*.

Another identified practice is related to geographical distance, according to the respondent

"*One appropriate solution to overcome this problem is let the site's work separately and then need to combine collect work from offshore locations and make single working system at head office*"

This practice talk about independent working or somehow to distributed tasks those are independent to each other so that team members need less to coordinate with each other. The last few words of this line give us the information about to work independent and then synchronize them into one system. This is same like "*Synchronization of main milestones*" identified in [P40].

The third and last additional practice identified in survey is also related to geographical distance. According to respondent,

"*Most of work is outsourced, like coding or testing where coder or tester need to communicate with main persons for their confusions otherwise, it goes worst during these activities and any confusion to them make it delay, i think, actually what I did is to visit offshore sites to help and overcome confusions of my offshore team, tester and coders*"

Geographical distance among team members make it difficult to remove ambiguities and confusions, there is a need to overcome this problem. This practice recommends having a proper communication among teams to overcome such geographical distance related threats among team members. This practice is almost same like onsite management visits among team members. So we can conclude that this is the same that we identified in literature.

These three additional identified practices are almost same as the authors identified from the literature. So here we can say that might be respondents not aware of some terms used in survey questioners that are why they reported these three new practices but actually they are already discussed and identified in literature.

4.5 Discussion

The number of respondents in the survey was too low for authors to make any claim. Initially authors obtained 25 responses of both partially and full completed where17 were fully complete and 8 of them were partially filled. Finally 17 those fully completed survey was taken.

All identified practices and threats identified in literature were confirmed by practitioners through survey. Along with confirmation of literature findings, authors identified 3 additional practices reported in this survey. One practice was reported to overcome cultural and language challenge and two of them was to overcome geographical distance.

On the basis of survey results authors provide a list of threats and practices against each challenge. It is noticed that some threats and practices are common regardless of roles and responsibilities of respondents in GSD projects. As some practices and threats are reported by all type of respondents regardless of their roles and responsibilities but there are some practices and threats reported by specific respondents, this means that are faced by specific persons in a team.

Chapter 5

5. Conclusion

In this thesis work we have identified coordination challenges, associated threats and practices to mitigate them. We used two methodology i.e. systematic literature review and Survey. Systematic literature review was conducted on studies published between 2001 and 2011 to identify the challenges associated threats and practices to mitigate them while coordinating work in GSD environment. The challenges, threats and practices identified from the literature are listed in a table. The threats identified for the different challenges are extracted on the basis of our own knowledge and experience. Moreover, the survey was conducted to see whether the challenges, associated threats and practices identified in literature review can be confirmed by industry practitioners or not. From the survey we observed that the challenges, threats and practices of coordination listed from the SLR are also experienced by the practitioner and moreover they have suggested three new practices which are almost similar with the other practices identified from the SLR.

5.1. Answers to the Research Questions

5.1.1. RQ1: What are the coordination related challenges associated threats and practice reported in the literature?

The challenges, associated threats faced by team members to coordinate their work in GSD context and the practices used by them to overcome are discussed here with the help of data collected through the systematic literature review. Kitchenham [33] guidelines are used to identify, collect and evaluate the coordination related challenges, associated threats and practices to mitigate them. The literature published between 2000 and 2011 were used in this process. Specifically this method is used to enrich the knowledge of authors on the current trends and state-of-art of the phenomenon surrounding challenges, associated threats of coordination in GSD and also the mitigating practices reported in the literature.

The total numbers of challenges are 6, associated threats to these challenges are 50 and practices to mitigate these challenges and threats are 52.

The challenges associated threats are discussed in chapter 3 section 3.2 whereas practices to mitigate them are discussed in section 3.3.

5.1.2. RQ2: What are the coordination related challenges and associated threats faced in the industry?

The identified 6 challenges, 50 associated threats and 52 mitigation practices related to coordination in GSD projects are used in making the questionnaire used in survey. The targeted population for this survey was individuals those had been, or is currently involved in GSD projects. The list of number of respondents, their job occupation, rule and responsibilities in the past or in the current project that completely filled and submitted in this survey is provided in chapter 4, section 4.4.1.

The challenges, associated threats, and practices mentioned in the survey are also identified by the respondent. At least 1 hit is experienced by all the challenges, threats and practices. Therefore, it can be concluded that all challenges associated threats identified in literature are prevalent in certain industry

settings. This does not mean that all industrial settings suffer the same number and type of challenges and threats uncovered. The authors also concluded that some threats are common regardless of rule and responsibilities of respondents in GSD projects. As some threats are reported by all type of respondents regardless of their rule and responsibilities but there are some threats reported by some specific respondents. Identified challenges, associated threats are listed in Appendix B and discussed in chapter 4, section 4.4.2

5.1.3. RQ3: What are the practices used in the industry to mitigate coordination challenges and associated threats in GSD?

All the practices mentioned in the survey are confirmed by the respondents. At least one hit is given to each of the practices in survey. This means that the practices identified in the literature are also experienced by the practitioners in the company. Identified practices are listed in Appendix B and discussed in chapter 4, section 4.4.2

Furthermore there are 3 additional practices found to overcome the coordination related challenges. Oout of three additional practices one is related to culture and language and rest two are related to geographical distance.

The authors did not find these additional practices in the literature but somehow these practices are similar to the practice already found in literature. But as they were recommended by practitioners so still they were considered as additional practices. The list of additional practices found in the survey is mentioned in Appendix C.

5.1.4. RQ4: What are the gaps and commonalities between literature results and the results from survey?

As discussed earlier, all the challenges, their associated threats and practices to mitigate them mentioned in the survey were confirmed by the respondents. The authors did not find any additional challenges and threats to coordination during surveys. But 3 additional practices were identified to overcome or mitigate coordination challenges. Respondents proposed these practices on the basis of their experience.

Therefore, the authors can conclude that 3 additional practices identified in the survey are not reported in literature as they are not identified from studied literature. But these additionally reported practices are somehow similar to the practices that are already reported in the literature but still they are considered as additional practices.

No additional challenges and threats are found during the surveys, this might be because of low number of survey respondents and other possibility is that the respondents may have not been aware of other possible threats or challenges.

We have noted some relation between the role of the respondent and the challenges, threats, and practices while doing the survey. Some of the respondent having same role experience the same challenges, threats and propose same practices as well. So we think that we can also categorize the challenges, threats and practices on the basis of the role. The thing is that we were not in position to categorize the challenges, threats and practices on the basis of roles of respondents as we were concerned on our previous plan, so we have assigned it as a future work.

Finally, we observed that the challenges and related threats that were identified from the literature review were experienced by the almost all the practitioners. The interesting thing is that some of the challenges were also only experienced by the practitioners having the similar role. This helps us to get an idea that there is some connectivity between the roles of practitioners and the challenges, threats, and practices they experience. Moreover, all the practices were also experienced by the practitioners but there were three practices as a suggestion from them. We analyze those practices and finally concluded that those suggested practices resemble with the other practices identified from the literature review.

5.2. Contribution

The main contribution of this study is in the field of coordination in the GSD. We focused on the coordination related challenges, associated threats and mitigation practices. We performed SLR and Survey methodology in this study. During SLR we found lot of articles and from that pile of articles we selected 47 main articles that are required for our study. We conducted our study on these 47 studies. The main contributions of this study are as follows:

- Challenges, threats, and practices are identified from the 47 primary studies. Categorizing threats and practices on the basis of challenges. Differentiating the main challenges and the sub challenges on the basis of numbers of articles it discuss about challenge.
- Threats for the challenges are identified on the basis of our knowledge and understanding. The article does not directly point out the possible threats for the challenges but we tried to find and separate them and categorize.
- Relating the threats and practices with each challenges which can help to find the possible threats and practices for particular challenge in the future.
- Discuss about the relation between the challenge and the roles of respondents.
- Discuss and analyze the least reported and most reported threats and practices.
- Conduct a survey to see the commonalities and the difference between what has been mentioned in literature and what is happening in industry.
- Three additional practices are identified and discussed.
- Develop the list of challenges, threats and the practices are useful to the beginner who wants to learn about the coordination challenges, associated threats and the practices to mitigate them. Furthermore, someone who is working or going to work in GSD environment and having problem related to the coordination can look into it so to identify the types of challenges and possible threats that could be encountered and finally implement the practices to overcome the challenge.

5.3. Future Work

5.3.1 Developing a framework

In this paper we analyze, discuss the findings of the SLR and the survey. Initially we planned to develop a framework of the challenges, associated threats, and related practices of coordination in GSD. This framework will be useful in identifying the types of challenges, threats, and practices of coordination in

GSD. Therefore we kept the framework development as a future work. In this framework each threat will be linked with one or more practices which could mitigate it. It means that each challenge, associated threats and the related practices are kept in one section.

5.3.2 Framework validation

Developing a framework requires the validation of practices that it can mitigate the particular threats to overcome the challenges. Every given threats should be minimized or remove by the practices of framework in order to mitigate the challenges. Framework should be able to show that which practices are able to minimize or remove what threats of which challenge. This relation between the practices, threats and challenge will only form the valid framework. The empirical study will be more helpful in validating the relation between them.

5.3.3 Categorizing the challenges associated threats and practices on the basis of practitioner's role.

While analyzing the survey report we have noted some relation between the role of the respondent and the challenges, threats, and practices. Some of the respondent having same role experience the same challenges, threats and propose same practices as well. So there is possibility that we can also categorize the challenges, threats and practices on the basis of the role.

Chapter 6

6 Validity Threats

It does not matter how well you have done research, there are always some factors that can influence the reliability and accuracy of research results. The authors identified some threats related to systematic literature review and surveys; they tried their best to minimize their influence on research results and reliability. According to Wohlin [37], there are four basic types of validity threats i.e. internal validity, external validity, construct validity and conclusions validity. These four types of validity threats with reference to this research work are discussed below.

6.1. Internal Validity

Internal validity threats are mainly related to design and its execution to avoid systematic errors [33] [56]. The major internal validity threat is the publication bias that refers to "the problem that positive results are more likely to be published than negative results" [33]. To overcome this threat the authors defined a systematic literature review protocol, approved from supervisor and then they strictly followed it in a systematic way. Both the authors followed the defined review protocol and criteria to select the research papers for this study. In case of confusion about the studies inclusion and exclusion the authors discussed it with each other and decision was taken on the basis of mutual understanding and agreement.

Another threat was the huge number of rejected studies then accepted. Only fewer studies were accepted so there is a threat of missing the relevant research papers. The authors set a study selection criterion for the inclusion/exclusion of research studies to overcome this threat.

Another validity threat was related to survey questions asked from respondents. There were two types of questions asked in this survey; one related to demographic information and others related to coordination challenges associated threats and best practices. The section demographic information, it is related to participants personal and their organization information like name, e-mail id and organization name. For some professionals this information is confidential and they do not ready to expose it. Such type of questions might cause them to be reluctant to participate in our survey. To overcome this threat both the authors modified the questionnaire by removing the respective fields.

6.2. External Validity

According to Wohlin [37], external validity is concerned with generalization of the results of a specific research study. External validity threat related to systematic literature review is that the author's only selected articles published between the years 2001-2011 and exclude the articles that were published before year 2001. So there is a threat of missing important articles while considering the articles only from 2001 to 2011. To mitigate this threat the authors run the main query to explore the frequency of published data prior to year 2001. The authors identified that there is no important data published before year 2001 that are relevant to this research.

From the survey we were able to get the 25 responses. Some of the respondents did not fill the survey completely and some of them gave the ambiguous answers those can affect the reliability and accuracy of the final results. To overcome this threat we exclude the partially completed responses.

6.3. Construct Validity

Construct validity appraise the use of precise definition and procedures with the variables [56]. The important threat to construct validity was that there is a chance to miss important publications from the specific databases due to the construction of inappropriate search string. In order to overcome this threat both the authors consulted with the university librarians who are professionals when it comes to dealing

with the search engines, they guided the authors to refine and apply the search string on different databases.

6.4. Conclusion Validity

Conclusion validity is more concern about the research results/output. According to Wohlin [37] conclusion validity makes it sure that collected research results lead to appropriate and reliable conclusions.

To overcome the threat of missing coordination challenges associated threats and best practices in GSD projects from primary studies, the authors constructed a comprehensive study selection criteria and a data extraction form that was followed during the literature review. Furthermore, if there is a confusion or point of difference related to findings both the authors made a thorough discussion to reach an agreement.

Another threat related to conclusion validity was misinterpretation of survey questions. There might be a chance that respondents misunderstand or misinterpret the survey question's and give inappropriate answers, as it might can affect the study results.

To minimize this threat, the authors contacted two professionals from GSD field and requested them to fill their survey and ask for feedback on it. The feedback obtained from the professionals greatly helped the authors to determine that which question is easy to understand, which are difficult to understand and ambiguous. On the basis of feedback obtained from professionals, the authors made some modifications on the structure of survey questions to make them easy to understand. Finally, survey questionnaire was sent to university supervisor for further suggestions and improvements.

Further, modifications were made according to his feedback and it was resent to him for final approval.

Chapter 7

7. Lessons Learned

Survey and literature review suggest that the coordination in the GSD or Distributed environment are challenged by six main factors namely geographical distance, temporal distance, cultural distance, communication, trust and software architecture. All together we have identified 50 threats and 52 practices for the 6 challenges of coordination. We depict the number of threats and practices for each individual challenge in the tabular form.

Table 35: Learned Challenges, Threats and Practices

	Communication	Trust	Software Architecture	Geographical Distance	Culture & Language	Temporal Distance
Threats	**6**	3	4	17	11	10
Practices	**8**	6	3	26	5	3

These listed threats and practices are also reported by the respondent which were either found and implement in the past or are currently being found and implemented in the GSD projects. This result shows that the identified challenges have some associated threats and practices to mitigate the challenges. In SLR, we have seen that the three challenges were discussed by many articles so they are taken as major challenges. These challenges are geographical distance, temporal distance, and cultural and language distance. Furthermore, the respondent had more responses on the threats and practices of these challenges. On the basis of respondent and the SLR we rate them as major challenges. Whereas the communication, trust and software architecture are also reported by respondent and are also discussed in articles but comparatively few in numbers so we said them as minor challenges.

With the help of threats a list is prepared where the threats are categorized on the basis of challenges. Whenever the threats are obtained this list helps threats to identify in which challenge it falls and furthermore the possible practices to mitigate it. All the challenges, associated threats and the practices in the list are also reported by practitioners in the survey.

In the list we have seen that one threat can be the issue in more than one challenge. Similarly, there are some practices which fall or are the practices of more than one challenge. In this case we refer to the papers that discuss this context for that very threats and practices.

Here are some threats and practices that are the issues of more than one practice. The threats are *lack of shared understanding* that is the issue of geographical distance, and cultural and language. Similarly *reduced opportunity for spontaneous interaction is a threat that occurs in both the communication and temporal distance challenges. Furthermore some practices like Weekly meetings and email interactions* are also solution for 2 challenges.

Furthermore, we have seen that the respondents were not familiar to the keywords we used for the threats and practices in the survey. Therefore some of the respondents suggest some practices which were already existed. The keywords we used from the articles explain the same thing the respondents suggested in the

survey. Here we learned that it would be better if we kept the threats and practices in simpler form instead of keeping it as like in articles. However, the respondent select all the threats and practices kept in the survey. The list of challenges, associated threats and the related practices will be helpful and can be valuable in identifying challenges and the probable mitigation strategies for coordination.

Reference

[1] A. Mathrani, D. Parsons, and R. Stockdale, "Workgroup structures in offshore software development projects: A vendor case study," in *Enterprise Distributed Object Computing Conference Workshops, 2009. EDOCW 2009. 13th*, 2009, pp. 344-351.

[2] J. D. Herbsleb, "Global Software Engineering: The Future of Socio-technical Coordination," in *2007 Future of Software Engineering*, Washington, DC, USA, 2007, pp. 188–198.

[3] M. J. Monasor, A. Vizcaíno, and M. Piattini, "A training tool for Global Software Development," in *2010 9th International Conference on Information Technology Based Higher Education and Training (ITHET)*, 2010, pp. 9-16.

[4] T. Nguyen, T. Wolf, and D. Damian, "Global Software Development and Delay: Does Distance Still Matter?," in *IEEE International Conference on Global Software Engineering, 2008. ICGSE 2008*, 2008, pp. 45-54.

[5] M. Bass, J. D. Herbsleb, and C. Lescher, "A Coordination Risk Analysis Method for Multi-site Projects: Experience Report," in *Global Software Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2009, vol. 0, pp. 31-40.

[6] P. Sooraj and P. K. . Mohapatra, "Developing an Inter-site Coordination Index for Global Software Development," in *IEEE International Conference on Global Software Engineering, 2008. ICGSE 2008*, 2008, pp. 119-128.

[7] S. S. M. Fauzi, P. L. Bannerman, and M. Staples, "Software Configuration Management in Global Software Development: A Systematic Map," in *Asia-Pacific Software Engineering Conference*, Los Alamitos, CA, USA, 2010, vol. 0, pp. 404-413.

[8] P. J. \AAgerfalk, B. Fitzgerald, H. Holmström, B. Lings, B. Lundell, and E. Ó. Conchúir, "A framework for considering opportunities and threats in distributed software development," in *International Workshop on Distributed Software Development*, 2005, pp. 47–61.

[9] R. Jabangwe and I. Nurdiani, "Global Software Development Challenges and Mitigation Strategies: A Systematic Review and Survey Results," Blekinge Tekniska Högskola, Karlskrona, sweden, 2010.

[10] I. Omoronyia, J. Ferguson, M. Roper, and M. Wood, "A review of awareness in distributed collaborative software engineering," *Software: Practice and Experience*, vol. 40, no. 12, pp. 1107–1133, 2010.

[11] M. Bass, J. D. Herbsleb, and C. Lescher, "A Coordination Risk Analysis Method for Multi-site Projects: Experience Report," in *Global Software Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2009, vol. 0, pp. 31-40.

[12] E. Carmel and R. Agarwal, "Tactical approaches for alleviating distance in global softwaredevelopment," *IEEE Software*, vol. 18, no. 2, pp. 22-29, Apr. 2001.

[13] O. Ishenko, "Outsourcing Of Software Development," 2005.

[14] J. D. Herbsleb and D. Moitra, "Global software development," *IEEE Software*, vol. 18, no. 2, pp. 16-20, Apr. 2001.

[15] H. Holmström, B. Fitzgerald, P. J. Ågerfalk, and E. Ó. Conchúir, "Agile Practices Reduce Distance in Global Software Development," *Information Systems Management*, vol. 23, pp. 7-18, Jun. 2006.

[16] P. Sooraj and P. K. . Mohapatra, "Developing an Inter-site Coordination Index for Global Software Development," in *IEEE International Conference on Global Software Engineering, 2008. ICGSE 2008*, 2008, pp. 119-128.

[17] D. E. Perry, N. A. Staudenmayer, and L. G. Votta, "People, organizations, and process improvement," *IEEE Software*, vol. 11, no. 4, pp. 36-45, Jul. 1994.

[18] D. Šmite, N. B. Moe, and R. Torkar, "Pitfalls in Remote Team Coordination: Lessons Learned from a Case Study," in *Product-Focused Software Process Improvement*, vol. 5089, A. Jedlitschka and O. Salo, Eds. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 345-359.

[19] H. Mintzberg, *Mintzberg on management: Inside our strange world of organizations*. Free Pr, 1989.

[20] C. Ebert, “Global Software Engineering,” *IEEE ReadyNote (e-Book), IEEE Computer Society, Los Alamitos, USA*, 2006.
[21] D. Šmite, “What Happens, When Software Product Development Companies Go Global?,” in *Global Software Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2010, vol. 0, pp. 319-320.
[22] M. Cataldo, P. A. Wagstrom, J. D. Herbsleb, and K. M. Carley, “Identification of coordination requirements: implications for the Design of collaboration and awareness tools,” in *Proceedings of the 2006 20th anniversary conference on Computer supported cooperative work*, New York, NY, USA, 2006, pp. 353–362.
[23] E. Carmel, *Global software teams: collaborating across borders and time zones*. Prentice Hall Upper Saddle River, NJ, 1999.
[24] R. E. Kraut and L. A. Streeter, “Coordination in software development,” *Commun. ACM*, vol. 38, no. 3, pp. 69–81, Mar. 1995.
[25] K. Crowston and E. E. Kammerer, “Coordination and collective mind in software requirements development,” *IBM Systems Journal*, vol. 37, no. 2, pp. 227-245, 1998.
[26] A. Sarma and A. van der Hoek, “Palant?r: Coordinating Distributed Workspaces,” in *Computer Software and Applications Conference, Annual International*, Los Alamitos, CA, USA, 2002, vol. 0, p. 1093.
[27] A. Ş. A. L. E. UNIVERSITĂŢII, A. I. CUZA, and D. IAŞI, “ISSUES OF COMMUNICATION AND COOPERATION IN OFFSHORE SOFTWARE DEVELOPMENT.”
[28] M. Bass, J. D. Herbsleb, and C. Lescher, “A Coordination Risk Analysis Method for Multi-site Projects: Experience Report,” in *Global Software Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2009, vol. 0, pp. 31-40.
[29] M. Jiménez and M. Piattini, “Problems and Solutions in Distributed Software Development: A Systematic Review,” in *Software Engineering Approaches for Offshore and Outsourced Development*, vol. 16, K. Berkling, M. Joseph, B. Meyer, and M. Nordio, Eds. Berlin, Heidelberg: Springer Berlin Heidelberg, 2009, pp. 107-125.
[30] A. López, J. Nicolás, and A. Toval, “Risks and Safeguards for the Requirements Engineering Process in Global Software Development,” in *Global Software Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2009, vol. 0, pp. 394-399.
[31] D. Šmite, C. Wohlin, T. Gorschek, and R. Feldt, “Empirical evidence in global software engineering: a systematic review,” *Empirical Software Engineering*, vol. 15, pp. 91-118, Dec. 2009.
[32] S. Rajiv, “The evolution of coordination in outsourced software development projects: a comparison of client and vendor perspectives,” *Information and Organization*, vol. 13, no. 3, pp. 153-202, Jul. 2003.
[33] B. Kitchenham and S. Charters, “Guidelines for performing Systematic Literature Reviews in Software Engineering,” *Engineering*, vol. 2, no. EBSE 2007-001, p. 65, 2007.
[34] P. Cronin, F. Ryan, and M. Coughlan, “Undertaking a literature review: a step-by-step approach,” *British Journal of Nursing*, vol. 17, no. 1, pp. 38–43, 2008.
[35] B. Paterson, C.-J. Dubouloz, J. Chevrier, B. Ashe, J. King, and M. Moldoveanu, “Conducting Qualitative Metasynthesis Research: Insights from a Metasynthesis Project,” *International Journal of Qualitative Methods*, vol. 8, no. 3, pp. 22-33, Oct. 2009.
[36] J. Strobel and A. van Barneveld, “When is PBL More Effective? A Meta-synthesis of Meta-analyses Comparing PBL to Conventional Classrooms,” *Interdisciplinary Journal of Problem-based Learning*, vol. 3, no. 1, Mar. 2009.
[37] C. Wohlin, *Experimentation in software engineering: an introduction*. Springer, 2000.
[38] K. B. M. Noor, “Case study: a strategic research methodology,” *American Journal of Applied Sciences*, vol. 5, no. 11, pp. 1602–1604, 2008.
[39] M. Staples and M. Niazi, “Experiences using systematic review guidelines,” *Journal of Systems and Software*, vol. 80, no. 9, pp. 1425-1437, Sep. 2007.

[40] W. Afzal, R. Torkar, and R. Feldt, "A systematic review of search-based testing for non-functional system properties," *Information and Software Technology*, vol. 51, no. 6, pp. 957-976, Jun. 2009.
[41] H. Holmstrom, E. O. Conchuir, P. J. Agerfalk, and B. Fitzgerald, "Global Software Development Challenges: A Case Study on Temporal, Geographical and Socio-Cultural Distance," in *Global Software Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2006, vol. 0, pp. 3-11.
[42] B. Nicholson and S. Sahay, "Some political and cultural issues in the globalisation of software development: case experience from Britain and India," *Information and Organization*, vol. 11, no. 1, pp. 25-43, Jan. 2001.
[43] P. \AAGERFALK and B. Fitzgerald, "OLD PETUNIAS IN NEW BOWLS?," *Communications of the ACM*, vol. 49, no. 10, p. 27, 2006.
[44] A. Mockus and J. Herbsleb, "Challenges of global software development," in *Software Metrics Symposium, 2001. METRICS 2001. Proceedings. Seventh International*, 2001, pp. 182-184.
[45] A. Boden, G. Avram, L. Bannon, and V. Wulf, "Knowledge Management in Distributed Software Development Teams - Does Culture Matter?," in *Global Software Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2009, vol. 0, pp. 18-27.
[46] J. M. Bhat, Mayank Gupta, and S. N. Murthy, "Overcoming Requirements Engineering Challenges: Lessons from Offshore Outsourcing," *IEEE Software*, vol. 23, no. 5, pp. 38-44, Oct. 2006.
[47] A. Piri, T. Niinimäki, and C. Lassenius, "Descriptive Analysis of Fear and Distrust in Early Phases of GSD Projects," in *Global Software Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2009, vol. 0, pp. 105-114.
[48] D. Damian, S. Marczak, and I. Kwan, "Collaboration Patterns and the Impact of Distance on Awareness in Requirements-Centred Social Networks," in *Requirements Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2007, vol. 0, pp. 59-68.
[49] B. Bruegge, A. H. Dutoit, and T. Wolf, "Sysiphus: Enabling informal collaboration in global software development," in *Global Software Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2006, vol. 0, pp. 139-148.
[50] J. Cusick and Alpana Prasad, "A Practical Management and Engineering Approach to Offshore Collaboration," *IEEE Software*, vol. 23, no. 5, pp. 20-29, Oct. 2006.
[51] G. A. Dafoulas, K. Swigger, R. Brazile, F. N. Alpaslan, V. L. Cabrera, and F. C. Serce, "Global Teams: Futuristic Models of Collaborative Work for Today's Software Development Industry," in *Hawaii International Conference on System Sciences*, Los Alamitos, CA, USA, 2009, vol. 0, pp. 1-10.
[52] B. Lutz, "Linguistic Challenges in Global Software Development: Lessons Learned in an International SW Development Division," in *Global Software Engineering, IEEE International Conference on*, Los Alamitos, CA, USA, 2009, vol. 0, pp. 249-253.
[53] J. D. Herbsleb, D. J. Paulish, and M. Bass, "Global software development at siemens: experience from nine projects," in *Proceedings of the 27th international conference on Software engineering*, New York, NY, USA, 2005, pp. 524–533.
[54] M. E. Conway, "How do committees invent?," *Datamation*, vol. 14, no. 4, pp. 28-31, 1968.
[55] J. S. Olson and S. Teasley, "Groupware in the wild: lessons learned from a year of virtual collocation," in *Proceedings of the 1996 ACM conference on Computer supported cooperative work*, New York, NY, USA, 1996, pp. 419–427.
[56] J. W. Creswell, *Research design*. Sage Publications, 2003.
[57] T. L. Friedman, *The world is flat: A brief history of the twenty-first century*. Picador USA, 2007.

Selected Primary Studies

[P1]. E. Hossain, “Coordinating mechanism for Agile Global Software Development”, 2008 IEEE International Conference on Global Software Engineering

[P2]. A. Mathrani, D. Parsons and R. Stockdale, “Workgroup Structures in Offshore Software Development Projects: a Vendor Case Study,” 2009 IEEE.

[P3]. J. D. Herbsleb, “Global Software Engineering: The Future of Socio-technical Coordination”, Future of Software Engineering (FOSE'07), 2007 IEEE.

[P4]. M. J. Monasor, A. Vizcaíno and M. Piattini, “A Training Tool for Global Software Development”, 2010 IEEE

[P5]. R. M. Lotlikar, R. Polavarapu, S. Sharma and B. Srivastava, “Towards Effective Project Management across Multiple Projects with Distributed Performing Centers”, 2008 IEEE International Conference on Services Computing

[P6]. J. M. Carroll, M. B. Rosson, G. Convertino and C. H. Ganoe, “Awareness and teamwork in computer-supported collaborations”, Interacting with Computers 18 (2006) 21–46, IEEE

[P7]. K. Dullemond, B. van Gameren, and R. van Solingen. How Technological Support Can Enable Advantages of Agile Software Development in a GSE Setting. 2009 Fourth IEEE International Conference on Global Software Engineering. IEEE computer society, 2009.

[P8]. H. Holmstrom, E. Ó Conchúir, P.J Ågerfalk, and B. Fitzgerald. Global Software Development Challenges: A Case Study on Temporal, Geographical and Socio-Cultural Distance. IEEE International Conference on Global Software Engineering (ICGSE'06). IEEE computer society, 2009.

[P9]. V. S. Sinha, B. Sengupta, and S. Ghosal. An Adaptive Tool Integration Framework to Enable Coordination in Distributed Software Development. International Conference on Global Software Engineering (ICGSE 2007). IEEE computer society, 2007.

[P10]. R.R. Palacio, A. Vizcaı´no, A.L. Mora´n, and V.M. Gonza´ lez. Tool to facilitate appropriate interaction in global software development. IET Softw, 2011, Vol. 5, Iss. 2, pp. 157–171

[P11]. K. Liukkunen, K. Lindberg, J. Hyysalo, and J. Markkula. Supporting collaboration in the geographically distributed work with communication tools in the remote district SME´s. IEEE computer society, 2010.

[P12]. H. Klein, A. Rausch, and E. Fischer. Towards Process-based Collaboration in Global Software Engineering. 2009 35th Euromicro Conference on Software Engineering and Advanced Applications. IEEE computer society 2009.

[P13]. A. Avritzer, D. Paulish, and Y. Cai. Coordination Implications of Software Architecture in a Global Software Development Project. Seventh Working IEEE/IFIP Conference on Software Architecture. IEEE computer society 2008.

[P14]. S. Lasser, and M. Heiss. Collaboration Maturity and the Offshoring Cost Barrier: The Trade-Off between Flexibility in Team Composition and Cross-Site Communication Effort in Geographically

Distributed Development Projects. 2005 IEEE International Professional Communication Conference Proceedings.

[P15]. P. J Ågerfalk, B. Fitzgerald and H. Holmström. A FRAMEWORK FOR CONSIDERING OPPORTUNITIES AND THREATS IN DISTRIBUTED SOFTWARE DEVELOPMENT.

[P16]. p.Sooraj, and P. K. J. Mohapatra. Developing an Inter-site Coordination Index for Global Software Development. 2008 IEEE International Conference on Global Software Engineering. IEEE computer society, 2008.

[P17]. Carmel E & Agarwal R (2001) Tactical approaches for alleviating distance in global software development. Software, IEEE. Software, IEEE 18.

[P18]. G. Fischer, Cases and experiences: Social Creativity: Turning Barriers into Opportunities for Collaborative Design. AMC Press, Proceedings of the eighth conference on Participatory design: Artful integration: interweaving media, materials and practices, 2004.

[P19]. K. SRIKANTH, and P.PURANAM. INTEGRATING DISTRIBUTED WORK: COMPARING TASK DESIGN, COMMUNICATION, AND TACIT COORDINATION MECHANISMS. Strategic Management Journal Strat. Mgmt. J., 32: 849–875 (2011). John Wiley & Sons, Ltd.

[P20]. J. A. Espinosa, and E. Carmel. The Impact of Time Separation on Coordination in Global Software Teams: a Conceptual Foundation. SOFTWARE PROCESS IMPROVEMENT AND PRACTICE Softw. Process Improve. Pract. 2003; 8: 249–266. John Wiley & Sons, Ltd.

[P21]. M. Bass, J. D. Herbsleb and C. Lescher, "Collaboration in Global Software Projects at Siemens: An Experience Report," icgse, pp.33-39, International Conference on Global Software Engineering (ICGSE 2007), 2007

[P22]. Begel. “Effecting change: coordination in large-scale software development”, Proceedings of the 2008 international workshop on Cooperative and human aspects of software engineering, pages 17–20, New York, NY, USA, 2008. ACM

[P23]. R. Hekkala, N. Iivari and R. Halonen. "Too Many Cooks Spoiling a Soup"? Making Sense of a Distributed, Multi-party IS Project. In Proceedings of HICSS'2008.

[P24]. W. Williams and M. Stout, "Colossal, Scattered, and Chaotic (Planning with a Large Distributed Team)," agile, pp.356-361, Agile 2008, 2008

[P25]. A. Boden, B. Nett and V. Wulf, “Articulation work in small-scale offshore software development projects” , Proceedings of the 2008 international workshop on Cooperative and human aspects of software engineering, p.21-24, May 13-13, 2008, Leipzig, Germany [doi>10.1145/1370114.1370120]

[P26]. L. Natalia and E. Vaast “Innovating or Doing as Told? Status Differences and Overlapping Boundaries in Offshore Collaboration,” MIS Quarterly (32:2), Special Issue on Offshoring, June 2008, pp. 307-332

[P27]. N. Mullick, M.Bass, Z.Houda, R. Sangwan, D.J.Paulish, M. Cataldo, J.D.Herbsleb, and L. Bass (2006). "Siemens Global Studio Project: Experiences adopting an integrated GSD infrastructure", In *Proceedings, International Conference on Global Software Engineering,* pp.203-212.

[P28]. M. Cataldo , M. Bass , J. D. Herbsleb and L. Bass, "On Coordination Mechanisms in Global Software Development", Proceedings of the International Conference on Global Software Engineering, p.71-80, August 27-30, 2007 [doi>10.1109/ICGSE.2007.33]

[P29]. L. D. Panjer, D. Damian and M.A.Storey: "Cooperation and coordination concerns in a distributed software development project", CHASE 2008: 77-80

[P30]. M. Bass, J. D. Herbsleb and C. Lescher, "A Coordination Risk Analysis Method for Multi-site Projects: Experience Report," icgse, pp.31-40, 2009 Fourth IEEE International Conference on Global Software Engineering, 2009

[P31]. J. D. Herbsleb and D. Moitra, "Global Software Development" *IEEE Software,* vol. 18, no. 2, Mar./Apr. 2001.

[P32]. R. D. Battin , R. Crocker , J. Kreidler and K. Subramanian. "Leveraging Resources in Global Software Development", IEEE Software, v.18 n.2, p.70-77, March 2001 [doi>10.1109/52.914750]

[P33]. K. E. Madsen. "Collaboration Strategies for Distributed Teams: A Case Study of CAD Systems Integration". In Proceedings of ICONS'2009. pp.222~227

[P34]. E. Carmel and R. Agarwal, "Tactical Approaches for Alleviating Distance in Global Software Development". IEEE Software, v.18 n.2, p.22-29, March 2001 [doi>10.1109/52.914734]

[P35]. D. Raffo and S. Setamanit , "A Simulation Model for Global Software Development Project". In The International Workshop on Software Process Simulation and Modeling. St. Louis, MO2005).

[P36]. P. Sooraj and K .J.P. Mohapatra, "Developing an Inter-site Coordination Index for Global Software Development". Proceedings of the 2008 IEEE International Conference on Global Software Engineering, p.119-128, August 17-20, 2008 [doi>10.1109/ICGSE.2008.30]

[P37]. S.S.M. Fauzi, P.L. Bannerman and M. Staples, "Software Configuration Management in Global Software Development: A Systematic Map", in Proc. APSEC, 2010, pp.404-413.

[P38]. T. Nguyen, T. Wolf and D. Damian, "Global Software Development and Delay: Does Distance Still Matter?," icgse, pp.45-54, 2008 IEEE International Conference on Global Software Engineering, 2008

[P39]. G. Kiely, T. Butler and P. Finnegan, "Coordinating Global Virtual Teams: Building Theory from a Case Study of Software Development", CAiSE 2010: 281-295

[P40]. M. PAASIVAARA and C. LASSENIUS, "Collaboration Practices in Global Inter-organizational Software Development Projects, Software Process Improvement and Practice", Vol. 8, pp. 183-199. (2004)

[P41]. G. O. Wiredu, "Understanding the functions of teleconferences for coordinating global software development projects", *Information Systems Journal* 2011; **21**: 175.

[P42]. P. Ovaska, M. Rossi and P. Marttiin, "Architecture as a coordination tool in multi-site software development. Software Process Improvement and Practice", 8:4, pp. 233-247. (2003)

[P43]. H. Holmström, B. Fitzgerald, P. J. Ågerfalk, and E. Ó. Conchúir. "CONTEMPORARY PRACTICES IN SYSTEMS DEVELOPMENT- AGILE PRACTICES REDUCE DISTANCE IN GLOBAL SOFTWARE DEVELOPMENT". INFORMATIONSYSTEMS MANAGEMENT SUMMER 2006.

[P44]. J. A. Espinosa and C. Pickering. The Effect of Time Separation on Coordination Processes and Outcomes: A Case Study. Proceedings of the 39th Hawaii International Conference on System Sciences – 2006, IEEE, 2006.

[P45]. R. E. Grinter, J. D. Herbsleb, and D. E. Perry. The Geography of Coordination: Dealing with Distance in R&D Work. GROUP 99 Phoenix Arizona USA. ACM 1999 1-58113-065-1/99/11

[P46]. J. Noll, S. Beecham, and I. Richardson, "Global software development and collaboration: barriers and solutions," ACM Inroads, vol. 1, pp. 66–78, August 2010

[P47]. D. Šmite, N. B. Moe, and R. Torkar. Pitfalls in Remote Team Coordination: Lessons Learned from a Case Study. A. Jedlitschka and O. Salo (Eds.): PROFES 2008, LNCS 5089, pp. 345–359, 2008. Springer-Verlag Berlin Heidelberg 2008

Appendix A Selected Primary Studies

P.ID	Publication Name	Author Name	Publication Year	Study Type	Application Domain
P1	Coordinating mechanisms for Agile Global Software Development	✓ Emam Hossain	2008	Case study	Unclear
P2	Workgroup Structures in Offshore Software Development Projects: A Vendor Case Study	✓ Anuradha Mathran ✓ David Parsons ✓ Rosemary Stockdale	2009	Case study	Software development projects
P3	Global Software Engineering: The Future of Socio-technical Coordination	✓ James D. Herbsleb	2007	Industry report	Unclear
P4	A Training Tool for Global Software Development	✓ Miguel J. Monasor ✓ Aurora Vizcaíno ✓ Mario Piattini	2010		Simulating GSD scenarios
P5	Towards Effective Project Management across Multiple Projects with Distributed Performing Centers	✓ Rohit M. Lotlikar ✓ Ramana Polavarapu ✓ Sadhika Sharma	2008	Industrial report	Services Computing

		✓ Biplav Srivastava			
P6	Awareness and teamwork in computer-supported collaborations	✓ John M. Carroll ✓ Mary Beth Rosson ✓ Gregorio Convertino ✓ Craig H. Ganoe	2005	Survey	Emergency management
P7	How Technological Support Can Enable Advantages of Agile Software Development in a GSE Setting	✓ Kevin Dullemond ✓ Ben van Gameren ✓ Rini van Solingen	2009	Industrial report	Unclear
P8	Global Software Development Challenges: A Case Study on Temporal, Geographical and Socio-Cultural Distance	✓ Helena Holmstrom Eoin Ó Conchúir ✓ Pär J Ågerfalk ✓ Brian Fitzgerald	2006	Case study	Software Development projects
P9	An Adaptive Tool Integration Framework to Enable Coordination in Distributed Software Development	✓ Vibha S Sinha ✓ Bikram Sengupta ✓ Sugata Ghosal	2007	Industrial report	Software Development projects
P10	Tool to facilitate appropriate interaction in global software development	✓ R.R. Palacio ✓ A. Vizcaı´no ✓ A.L. Mora´ n ✓ V.M. Gonza´ lez	2009	Experiment	Software Management
P11	Supporting collaboration in the geographically distributed work with communication tools in the remote district SME´s	✓ Kari Liukkunen ✓ Kai Lindberg ✓ Jarkko Hyysalo ✓ Jouni Markkula	2010	Interviews	Software Development projects
P12	Towards Process-based Collaboration in Global Software Engineering	✓ Harald Klein ✓ Andreas Rausch ✓ Edward Fischer	2009	Industry report	Unclear
P13	Coordination Implications of Software Architecture in a Global Software Development Project	✓ Alberto Avritzer ✓ Daniel Paulish ✓ Yuanfang Cai	2008	Case study	Software Development projects
P14	Collaboration Maturity and the Off-shoring Cost Barrier: The Trade Off between flexibility in Team Composition and Cross-Site Communication Effort in Geographically Distributed Development Projects	✓ Stefan Lasse ✓ Michael Heis	2005	Industrial report	Information System Management
P15	A FRAMEWORK FOR CONSIDERING OPPORTUNITIES AND THREATS IN DISTRIBUTED SOFTWARE DEVELOPMENT	✓ Pär J Ågerfalk ✓ Brian Fitzgerald ✓ Helena Holmström ✓ Brian Lings ✓ Björn Lundell ✓ Eoin Ó Conchúir	2005	Industrial report	Unclear
P16	Developing an Inter-site Coordination Index for Global Software Development	✓ Sooraj P ✓ Pratap K. J. Mohapatra	2008	Industrial Report	Software Management

P18	Turning Barriers into Opportunities for Collaborative Design	✓ Gerhard Fischer	2004	Report	Unclear
P19	INTEGRATING DISTRIBUTED WORK: COMPARING TASK DESIGN, COMMUNICATION, AND TACIT COORDINATION MECHANISMS	✓ Kannan Srikantha ✓ Phanish Puranam	2008	Survey	Business Process Off-shoring
P20	The Impact of Time Separation on Coordination in Global Software Teams: a Conceptual Foundation	✓ J. Alberto Espinosa ✓ Erran Carmel	2004	Industrial report	Software Development projects
P21	Collaboration in Global Software Projects at Siemens	✓ Matthew Bass ✓ James D. Herbsleb ✓ Christian Lescher	2007	Case study	Software Management
P22	Coordination in Large-Scale Software Development	✓ Andrew Begel ✓ Redmond ✓ WA, USA	2008	Interview based	Software Management
P23	'Too Many Cooks Spoiling a Soup'? Making Sense of a Distributed, Multiparty IS Project	✓ Riitta Hekkala ✓ Netta Iivari ✓ Raija Halonen	2008	Industrial Report	Information System Development
P24	Colossal, Scattered, and Chaotic (Planning with a Large Distributed Team)	✓ Wes Williams ✓ Mike Stout	2008	Surveys	Air-line solution(data management application)
P25	Articulation Work in Small-Scale Offshore Software Development Projects	✓ Alexander Boden ✓ Bernhard Nett ✓ Volker Wulf	2008	Cast Study	Unclear
P26	INNOVATING OR DOING AS TOLD? STATUS DIFFERENCES AND OVERLAPPING BOUNDARIES IN OFFSHORE COLLABORATION	✓ Natalia Levina ✓ Emmanuelle Vaast	2008	Case Study	Unclear
P27	Siemens Global Studio Project: Experiences[1] Adopting an Integrated GSD Infrastructure	✓ Mullick, N. ✓ Bass, M. ✓ El Houda, Z. ✓ Paulish, D.J. ✓ Cataldo, M. ✓ Herbsleb, J.D ✓ Sangwan, R. ✓ Bass, L.	2006	Experiment	Tools and processes for GSD
P28	On Coordination Mechanisms in Global Software Development	✓ Marcelo Cataldo ✓ Matthew Bass1 James D. ✓ Herbsleb1 Len Bass2	2007	Case Study	Research corporate
P29	Cooperation and Coordination Concerns in a Distributed Software Development Project	✓ Lucas D. Panjer ✓ Daniela Damian ✓ Margaret-Anne Storey	2008	interviews	Software management
P30	Coordination Risk Analysis Method for Multi-Site Projects	✓ Matthew Bass ✓ James D. Herbsleb ✓ Christian Lescher	2009	Industrial report	Software management
P31	Global Software Development	✓ James D. Herbsleb ✓ Deependra	2001	Survey	Unclear

		Moitra			
P32	Leveraging Resources in Global Software Development	✓ Robert D. Battin, ✓ Ron Crocker, ✓ Joe Kreidler	2001	Industrial report	Telecommunications
P33	Collaboration Strategies for Distributed Teams *A Case Study of CAD Systems Integration*	✓ Kurt E. Madsen	2009	Case study	Computer based software
P34	Tactical Approaches for Alleviating Distance in Global SoftwareDevelopment	✓ Erran Carmel ✓ Ritu Agarwal	2001	Industrial report	Unclear
P35	A Simulation Model for Global Software Development Project	✓ David Raffo ✓ Siri-on Setamanit		Industrial report	Computer based software
P36	Developing an Inter-site Coordination Index for Global Software Development	✓ Sooraj P ✓ Pratap K. J. Mohapatra	2008	Survey	Computer based software
P37	Software Configuration Management in Global Software Development: A Systematic Map	✓ S.S.M. Fauzi ✓ P.L. Bannerman ✓ M. Staples	2010	Experience Report	Unclear
P38	Global software development and delay: Does distance still matter?	✓ Thanh Nguyen, ✓ Timo Wolf, ✓ Daniela Damian	2008	Survey	Computer based software
P39	Coordinating Global Virtual Teams: Building Theory from a Case Study of Software Development	✓ Gaye Kiely ✓ Tom Butler ✓ Patrick Finnegan2	2010	Case study	Telecommunications
P40	Collaboration Practices in Global Inter-organizational Software Development Projects	✓ Maria Paasivaara ✓ Casper Lassenius	2003	Industry report	Software management
P41	Understanding the functions of teleconferences for coordinating global software development projects	✓ Gamel O. Wiredu	2010	Case study	Information System Development
P42	Architecture as a Coordination Tool in Multi-site Software Development	✓ P¨aivi Ovaska ✓ Matti R ✓ Pentti Marttiin	2004	Case study	unclear
P43	AGILE PRACTICES REDUCE DISTANCE IN GLOBAL SOFTWARE DEVELOPMENT	✓ Helena Holmström, ✓ Brian Fitzgerald, ✓ Pär J. Ågerfalk ✓ Eoin Ó. Conchúir	2006	Case study	Software development projects
P44	The Effect of Time Separation on Coordination Processes and Outcomes: A Case Study	✓ J. Alberto Espinosa ✓ Cynthia Pickering	2006	Case study	Unclear
P45	The Geography of Coordination: Dealing with Distance in R&D Work	✓ R. E. Grinter ✓ J. D. Herbsleb ✓ D. E. Perry.	2001	Case Study	Unclear
P46	GLOBAL SOFTWARE DEVELOPMENT AND COLLABORATION: BARRIERS AND SOLUTIONS	✓ John Noll ✓ Sarah Beecham ✓ Ita Richardson	2010	survey	Global software development
P47	Pitfalls in Remote Team Coordination: Lessons Learned from a Case Study	✓ Darja Šmite ✓ Nils Brede Moe	2008.	Case study	Distributed software development

		✓ Richard Torkar3			

Appendix B: Identified Challenges, Threats and Practices from Survey

Sr. No	Challenges	Associated Threats	Organization Type	Count
01	Communication	No common language for communication	D,H	3
		No readiness for communication	D,H,I	5
		Inadequate informal communication	B,D,E,H,I	7
		Loss of communication richness	B,C,D,G,I	7
		Lean communication media	D	2
		Reduce opportunities for spontaneous interaction	A,C,D,F,H,I	9
02	Trust	Uncommitted and avoids responsibilities	A,B,C,D,E,I	10
		Reduce trust	I	2
		Doubtful about others capability	A,B,D,F,G,H,I	12
03	Software Architecture	Development site infrastructure	B,D,H	6
		Product architecture	A,B,F,I	8
		Development strategy	B,C,D,F,G,I	9
		Process interdependency	E,H,I	3

		Misunderstandings of intent of requirements	H	1
04	Geographical Distance	Infrastructure management	D,**B**	2
		To manage software quality	D,G	2
		Reliance on documentation as a coordination mechanism	D,H,G,I	6
		Frequent Re-planning required	I,**B**	2
		Interdependence of tasks	D,H,F,I	6
		Much longer development time	B,G,H	5
		Integration of work	B	1
		Distribution of work	H,	1
		Unclear role to team members	B	1
		Hard to conduct efficient and effective meetings	H,	1
		Lack of "Teamness"	B,H	2
		Lack of shared understanding	H,I	2
		Lack of Trust on other team member	G	1
		Reduces communication frequency and richness	F,H	2
		Lack of task awareness	B,D,I	5
		Less opportunity to form personal relations	AB,C,D,E,H,I	13
05	Culture and language	Ambiguity in requirements	B,D,E,F,H,I	9
		Human relations knots affecting	A,B,D,G,I	6
		Lack of proficiency in language	B,D,I	4
		Limited feedback from the remote locations	H,I	3
		Negative impact on the effectiveness of plans	C	1
		Mismatch skills	H	1
		Reduce mutual understanding	F,H,I	4
		Problem in communication	H	1
		Lack of shared understanding	H	1
		Lack of team spirit	B,H,I	4
		Inconsistency in work practices	D	1
06	Temporal Distance	Problems in the attainment of common understanding among team members	B,I	2
		Difficulties in resolving unclear messages	A,C,D,H,I	7
		Reduced opportunity for spontaneous interaction	A	1
		Irregular information flow	B,D,H	4
		Rely on asynchronous communication	D,H	2
		Challenge everyday communication	D,H	2
		Reduce collaboration hours	A,C,D,E,	5
		Delay in response	A,G,H,I	5
		Synchronization of work	D,F,I	4
		Mutual misunderstanding within and among teams	D,I	2

Sr. No	Challenges	Practices to mitigate them	Organization Type	Count
01	Communication	Documents to show how to use documents (For Non- Native Language Persons)	B,D	2

		Foreign Language courses	I	1
		Work packages	C,G,	2
		Bulletin Boards and E-mail Lists	C,H,	2
		Problem E-mailbox	D	1
		Weekly Meeting	A,B,C,D,E,H,I	9
		Progress Reports	B,D,F,I	5
		Intranet connectivity	B,D,E,H,I	6
02	**Trust**	Face- to- face Meetings	A,B,C,D,E,F,G,H,I	14
		Hold frequent, regularly scheduled status meetings	D,E,H,I	7
		Co-located analysis phase	D,H	3
		Give Faces	B,C,D,H	7
		Organizational Chart	H,I	3
		Frequent Deliveries	D,E,H	4
03	**Software Architecture**	Measuring architectural/organizational fit	A,B,C,D,G,I	6
		Improve Architecture Understanding	D,H,I	3
		Tactics for improving architecture/organization fit	C,D,E,F,I	5
04	**Geographical Distance**	Unfiltered Communication	B	1
		Video Conferences	A,B,C,D,E,F,G,H,I	9
		Conference Calls	A,B,D,E,G,H,I	8
		Scrum of Scrums	D,H	2
		Use of Instant Messenger	B,G,H	3
		Phone Based Meetings	B,H,I	3
		Email interactions	B,E,GH,	4
		Early Identification of Dependencies and their management	D,	1
		Daily Builds	D,	1
		Periodic Meetings	B	1
		Use of E-Mail Aliases and Shared calendars	C,E	2
		Ad-hoc phone calls between team members	D,I	2
		Let the sites operate independently working	E	1
		Incremental integration plan	E	1
		Synchronization of main milestones	C	1
		Traveling Steering Group	D,	1
		Shared Practice's	H,	1
		Central version control system	D	1
		Documentation	B	1
		Urgent Request	I	1
		Distributed pair programming	G,H	2
		Onsite Management Visits	C	1
		Cross Site Delegation	E	1
		Send Status updates Electronically	E	1
		Weekly Meeting	A,B,G,H,I	5
		Establishment of peer-to-peer links	H	1
05	**Culture and Language**	Eliminate Ambiguity	A,G,H,I	7
		Foreign Language courses	C	1
		Cultural liaison	B,E	5
		Cultural awareness	B,C,D,F,H,I	9
06	**Temporal Distance**	Presentation of Agile customer	B,D,G	7
		Presentation of Feature owner	D,I	3
		Email interactions	A,B,C,E,F,H,I	11

Appendix C: Survey Questionnaire

BLEKINGE TEKNISKA HÖGSKOLA

www.bth.se

We are Software Engineering Students at BTH and currently working on the Thesis as a part of course on title - Coordination challenges, associated threats and their mitigation strategies. In order to gather coordination challenges, associated threats as well as their mitigation strategies in global software development (GSD), we are conducting this survey. The other reason behind this survey is to validate literature findings with practitioner's.

After a clear analysis of the Coordination challenges, associated threats and their mitigation strategies, we will develop a framework that will help practitioners to understand the situation where the challenges can occur and how to mitigate then in GSD. We will come back to you with our findings that may help you to take good actions when dealing with coordination issues in GSD project's.

This survey is designed for those practitioners who are current in GSD projects. Your contribution in this research study will be highly appreciated. The demographic information will be used for statistical purpose in our thesis work and it will be kept confidential. Initially we have performed literature review as a participant of this survey you can have a detail document of our findings.

We are taking survey of those who doing outsourcing/ offshoing. Your all personal information will be used for statistical purpose of this thesis and will be kept confidential.
It will take about 10-15 mints. Your help can be great asset for us. It is requested to please fill these questionnaires and in case of any confusion, please contact the following personals.

Nazam Aslam
nazam_aslam@hotmail.com
skype id (janatgar)

Mod Nath Acharya
acharyamod@gmail.com

Demographic Information-1

* 1. Which type of organization do you work for?

2. What type of application domain does your organization belong to?

- Telecommunication
- Web development
- Software development
- Automation

Reset

If other (please specify)

3. Is your organization working in globally distributed environment? If so, is it a globally distributed organization from the beginning or it moved from in-house development to globally distributed development? Also explain the reasons of this trend shift in your organization?

4. Specify the location of your head office and globally distributed offices?

Demographic Information-2

[Thanks for providing some information about your organization and office's. Now coming back to you, please tell us,]

* 1. How long have you been working for this organization? (Years)

2. What is your current designation in the organization?

3. What are the roles and responsibilities you are assigned under the said designation in the organization?

4. How many projects have you taken part with this organization up to date?

5. How many of these projects were done in Globally distributed environment?

6. What was the nature of the projects you mentioned in the last query? (type of the project? Duration, number of teams involved in it, success rate)

7. What are your roles and responsibilities in the current project/ projects?

8. If you are working in more than one project, then how do you manage the coordination issues?

Identification of Coordination Challenge's and associated threats

1. Which of the following communication problems are encountered during coordination in GSD projects?

☐ No common language of communication	☐ No readiness for communication
☐ Inadequate informal communication	☐ Loss of communication richness
☐ Lean communication media	☐ Reduces opportunities for spontaneous interaction

Reset

If Else (please specify)

2. Which of the following trust related problems are encountered during coordination in GSD projects?

☐ Uncommitted and avoids responsibilities	☐ No collaboration despite numerous meetings
☐ Reduce trust as time passes	☐ Doubtful about others capability

Reset
If Else (please specify)

3. Which of the following Software Architecture related problems are encountered during coordination in GSD projects?

☐ Development site Infrastructure	☐ Product architecture
☐ Development strategy	☐ Misunderstanding of design internet
☐ Process interdependency	

Reset
If Else (please specify)

4. Which of the following Geographical Distance related problems are encountered during coordination in GSD projects?

☐ Infrastructure Management	☐ Software Quality Management
☐ Reliance on documentation as a coordination mechanism	☐ Frequent Re-planning Required
☐ Interdependence of tasks	☐ Much longer development time
☐ Integration of work	☐ Distribution of work practice's
☐ Unclear role's to team member's	☐ Hard to conduct efficient and effiective meetings
☐ Lack of "teamness"	☐ Lack of shared understanding
☐ Reduces communication frequency and richness	☐ Lack of trust on other team members

☐ Reduced informal contacts can lead to lack of task awareness	☐ Less opportunity to form personal relationships

Reset
If Else (please specify)

5. Which of the following Language & Cultural Distance problems are encountered during coordination in GSD projects?

☐ Interpersonal relation of team members can affect	☐ Ambiguity in requirements
☐ Lack of proficiency in working language	☐ Limited feedback from remote locations
☐ Negative impact on the effectiveness of plans	☐ Skills of team members not match with each other
☐ Reduce mutual understanding	☐ Problems in communication with each other
☐ Lack of shared understanding	☐ Lack of team spirit
☐ Inconsistency in work practices	

Reset
If Else (please specify)

6. Which of the following Temporal Distance related problems are encountered during coordination in GSD projects?

☐ Problems in the attainment of common understanding among team members	☐ Irregular information flow
☐ Reduces collaboration hours	☐ Delay in response
☐ Mutual misunderstanding within and among teams	☐ Difficulties in resolving unclear messages
☐ Reduced opportunities for spontaneous interaction	☐ Reduces communication frequency and richness

☐ Rely on Asynchronous communication	☐ Synchronization of work
☐ Challenge everyday communication	

Reset
If Else (please specify)

Identification of best Practice's

1. Which of the following appropriate practices can be adapted to overcome the communication problems to coordinate in GSD?

☐ Solution Providers	☐ Documents to show how to use Documents
☐ Foreign Language courses	☐ Language Training
☐ Work Packages	☐ Use of liaisons
☐ Bulletin Boards and E-mail Lists	☐ Problem E-mailbox
☐ Weekly meeting	☐ Progress reports
☐ Intranet connectivity	

Reset
If Else (please specify)

2. Which of the following appropriate practices can be adapted to overcome the trust related problems to coordinate in GSD?

☐ Face- to- face Meetings	☐ Onsite Management visits
☐ Cross-site delegation	☐ Hold frequent, regularly scheduled status meetings
☐ Co-located analysis phase	☐ Organization Chart

☐ Frequent Deliveries	☐ Face-to-Face meeting (Give Face's)

Reset

If Else (please specify)

3. Which of the following appropriate practices can be adapted to overcome the spatial distance related problems to coordinate in GSD?

☐ Video Conferences	☐ Conference Calls
☐ Scrum of Scrums	☐ Use of Instant Messenger
☐ Phone Based Meetings	☐ Email Interactions
☐ Early Identification of Dependencies and Their Management	☐ Daily Builds
☐ Periodic Meetings	☐ Use of mail Aliases and Shared Calendars
☐ Ad-hoc phone calls between team members	☐ Let the sites Operate independently working
☐ Incremental integration plan	☐ Synchronization of Main Milestones
☐ Traveling Steering Group	☐ Offshore–Onshore Bridgehead (75/25 Rule of Thumb)
☐ Distribute the Tasks having less Dependency	☐ Shared Practice's
☐ Renegotiating Boundaries and Status Differences	☐ Central version control system
☐ Change, Configuration and Integration Management Processes Use of Documentation	☐ Handle Urgent Request First
☐ Distributed pair programming	☐ Unfiltered Communication
☐ On-Site Management Visits	☐ Cross-Site Delegation

- [ ] Send Status Update's Electronically
- [ ] Weekly Status Meetings
- [ ] Establishment of Peer-to-Peer links

Reset
If Else (please specify)

4. Which of the following appropriate practices can be adapted to overcome the cultural distance problems to coordinate in GSD?

- [ ] Eliminate Ambiguity
- [ ] Foreign Language Courses
- [ ] Cultural liaison
- [ ] Cultural Awareness

Reset
If Else (please specify)

5. Which of the following appropriate practices can be adapted to overcome the Temporal distance problems to coordinate in GSD?

- [ ] Presentation of Agile customer
- [ ] Presentation of Feature owner
- [ ] E-Mail Interactions

Reset
If Else (please specify)

6. Which of the following appropriate practices can be adapted to overcome the software architecture problems to coordinate in GSD?

- [ ] Measuring architectural/organizational fit
- [ ] Tactics for improving architecture/organization fit

Reset
If Else (please specify)

APPENDIX D: Kappa Coefficient Method

Kappa coefficient method was used to calculate the nominal scale of agreement between a fixed pairs of researchers [33U].

"*Agreement can be considered as i.e. if a fixed number of researchers allocate numerical ratings to a number of categories or subjects then Kappa statistical method will provide a calculation for how reliable the ratings are*".

The Kappa k, can be measured as,

$$K = \frac{Pr(a) - Pr(e)}{1 - Pr(e)}$$

Where,

Pr (a) = Relative observed agreement among the raters
Pr (e) = Hypothetical probability of chance agreement

And

K = kappa coefficient (Agreement level between the raters)

The value of K determines the strength of agreement between researchers. If the value of K = 1, this indicates a strong agreement between the researchers. But if the value of K is less then equal to 1, then it shows no agreement. Koch and Landis [U34] shows the information regarding the different values of K and their level of agreement.

S. No	Kappa Statistic	Strength of Agreement
1	**0.81 – 1.00**	**Almost Perfect**
2	**0.61 – 0.80**	**Substantial**
3	**0.41 – 0.60**	**Moderate**
4	**0.21 – 0.40**	**Fair**
5	**0.00 – 0.20**	**Slight**
6	**<0.00**	**Poor**

For each category we applied the following defined formula and obtained the following results.

A. Study Method

No. Of papers	Interviews	Surveys	Case study	Experiments	Others	Total	Pi
1	0	0	2	0	0	2	1
2	0	0	2	0	0	2	1
3	1	0	1	0	0	2	0
4	0	0	0	2	0	2	1
5	0	0	1	1	0	2	0
6	0	0	0	2	0	2	1
7	0	0	2	0	0	2	1
8	0	0	2	0	0	2	1
Total	1	0	10	5	0	16	
Pi	0.5	0	0.45	0.05	0		

K= 0.633

B. Research Background

No. Of papers	Industry	Laboratory	Academia	Total	Pi
1	1	1	0	2	0
2	0	0	2	2	1
3	0	2	0	2	1
4	0	1	1	2	0
5	0	2	0	2	1
6	2	0	0	2	1
7	2	0	0	2	1
8	0	1	1	2	0
Total	5	7	4	16	
Pi	.45	.35	.2		

K= 0.528

C. Empirical Focus

No. Of papers	Empirical Based	Empirical Evaluated	Total	Pi
1	0	2	2	1
2	0	2	2	1
3	1	1	2	0
4	1	1	2	0
5	2	0	2	1
6	1	1	2	0
7	0	2	2	1
8	0	2	2	1
Total	5	11	16	
Pi	.65	.35		

K= 0.341

D. Subject of investigation

No. Of papers	Student	Industry	Total	Pi
1	0	2	2	1
2	0	2	2	1
3	0	2	2	1
4	1	1	2	0
5	2	0	2	1
6	2	0	2	1
7	1	1	2	0
8	2	0	2	1
Total	8	8	16	
Pi	.4	.6		

K = 0.583

E. Mode of collaboration

No. Of papers	Intra-org.	Inter-org.	Unclear	Total	Pi
1	0	2	0	2	1
2	0	2	0	2	1
3	0	1	1	2	0
4	1	1	0	2	0
5	0	2	0	2	1
6	0	2	0	2	1
7	0	1	1	2	0
8	0	2	0	2	1
Total	1	13	2	16	
Pi	.05	.65	.3		

K= .588

F. Project type

No. Of papers	Industry	Non-industry	Total	Pi
1	2	0	2	1
2	2	0	2	1
3	0	2	2	1
4	1	1	2	0
5	2	0	2	1
6	0	2	2	1
7	2	0	2	1
8	2	0	2	1
Total	11	5	16	
Pi	.65	.35		

K = 0.780

G. Coordination practices discussed

No. Of papers	Yes	No	Total	Pi
1	2	0	2	1
2	2	0	2	1
3	2	0	2	1
4	2	0	2	1
5	0	2	2	1
6	2	0	2	1
7	1	1	2	0
8	2	0	2	1
Total	13	3	16	
Pi	.85	.15		

K= 0.608

H. Coordination challenges discussed

No. Of papers	Yes	No	Total	Pi
1	2	0	2	1
2	1	1	2	0
3	0	2	2	1
4	2	0	2	1
5	0	2	2	1
6	2	0	2	1
7	1	1	2	0
8	2	0	2	1
Total	10	4	16	
Pi	.55	.45		

K = 0.394

I. Coordination threats discussed

No. Of papers	Yes	No	Total	Pi
1	2	0	2	1
2	1	1	2	0
3	2	0	2	1
4	2	0	2	1
5	0	2	2	1
6	2	0	2	1
7	1	1	2	0
8	2	0	2	1
Total	12	4	16	
Pi	.65	.35		

K = .341