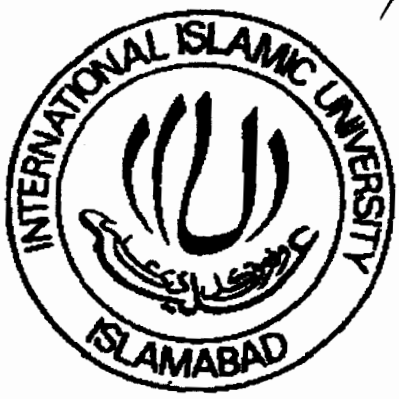
Impact of Communication Modes/Mediums on Success or Failure of Offshore *Software Development*



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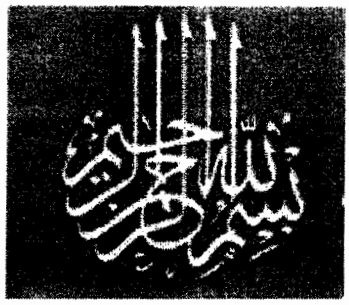

In The Name of ALLAH, the Most Merciful and the Most Beneficent

Master Thesis

Impact of Communication Modes/Mediums on Success or Failure of Offshore Software development:

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January, 2010

Final Approval

Date: _____

It is certified that we have read the thesis report that is to be submitted by Mr. Farrukh Shahzad Ahmed, Registration No. 77-FAS/MSSE/F05. It is our judgment that this thesis is of sufficient standard to be accepted by the International Islamic University Islamabad for Master Degree in Software Engineering (MSSE).

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Declaration

I hereby declare and affirm that this thesis neither as a whole nor as part thereof has been copied out from any source. It is further declared that this study has been completed on the basis of my personal efforts, made under the sincere guidance of my supervisor. If any part of this thesis is proven to be copied out or found to be reproduction of some other, I shall stand by the consequences. No portion of the work presented in this report has been submitted in support of an application for other degree or qualification of this or any other University or institute of learning.

Farrukh Shahzad Ahmed

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Dedication

To My Loving **ALLAH**, Who has given me the brilliant abilities to achieve the targets.

&

To My Loving Prophet Hazrat **MUHAMMAD (PBUH)**, Who is sent as Ramatulilaalaameen for all worlds.

&

To My Loving Quaid Sheikh-ul-Islam Prof. Dr. Muhammad **Tahir-ul-Qadri**, Who is a representative of Islam in the whole the world

&

To My Loving **Teachers** who always guided me

&

To My Loving **Parents** and My **Family**, especially to my **Mother**, whose prayers are reasons of my achievements

Abstract

This study analyzes the communication process in offshore software development. We have presented essential concepts and the theoretical background for our study through a wide literature review in the area of offshore software development, offshore in-sourcing, offshore outsourcing. We have identified common offshore software development activities and the communication modes/mediums used to perform those activities. Some success factors of offshore software development have also been presented in the thesis. The literature review reveals different perspectives and motivators of offshore software development. Some major challenges and limitations of communication process in offshore software development are also presented. After in depth literature review, following research question arises. "What is the impact of communication modes/mediums on success or failure of offshore software development?"

Our study addressed this research question by classifying the offshore software development activities and the communication modes/ mediums used to perform those activities. We have conceptualized a hypothetical framework on the basis of our classification for offshore software activities and communication modes/ mediums used for those activities. In order to address the communication process in offshore software development, we have conducted a survey in offshore software development market of Pakistan. This thesis has presented the findings of our study by analyzing the survey results. The major contribution of this study is to help offshore software development community to understand and improve the communication process between client and offshore vendor.

Finally the thesis presents some future work for the further research in the area of offshore software development.

Acknowledgements

First of all I would like to thank to my **ALLAH** Who is most kind and merciful. Almighty Allah has blessed me brilliant abilities such as knowledge, reasoning power and courage to achieve difficult targets in the life. I have no words to thank my Allah for his unlimited blessings for me.

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Secondly, I am very thankful to my co-supervisor **Mr. Shahbaz Ahmed** (Assistant Professor at IIUI) who has given me the domain knowledge of this research study. He has provided me the solid ideas about software offshore outsourcing. Throughout my research work, he has guided me with critical comments on the study. I am again thankful to Mr. Shahbaz Ahmed for his kind cooperation during my study.

Thirdly I would like to thank **Mr. Zohaib Zafar** (Assistant Professor at IIUI) for his valuable guidance about the research study. I had meetings with him at initial stages of my research. He has provided me base to set my research direction.

Among the other faculty members of CS department at IIUI, I am thankful to **Mr. Muhammad Usman** and **Mr. Usman Nasir** for their support and positive comments about this study.

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Farrukh Shahzad Ahmed

(January 2010)

Thesis in Brief

Thesis Title:	Impact of communication modes/mediums on success or failure of offshore software development
Organization:	International Islamic University Islamabad
Objective:	The objective of the research is to analyze the impact of communication modes/mediums on success or failure of offshore software development and to suggest a better mechanism for communication in offshore software development.
Undertaken By:	Farrukh Shahzad Ahmed
Supervised by:	Prof. Dr. Naveed Ikram (Supervisor) (Chairman Department of software Engineering, IIUI) Mr. Shahbaz Ahmed (Co-supervisor) (Assistant Professor Department of software Engineering, IIUI)
Registration No:	77-FAS/MSSE/F05
Date of Admission:	September 2005
Research Work Start:	September 2006
Research Area:	Communication in Offshore software Development

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Chapter No. 1

Introduction

1.1. Introduction

The world has become a global village due to the rapid development of information technology. In this era of globalization, software engineering trends have been totally changed. Like other communities, software engineering community is also utilizing global resources. Now software projects are being developed through establishing offshoring relationships. Software project offshoring is a rapidly growing trend. With this new trend, researchers are facing many challenges: one of them is client-vendor communication across two different countries. In our research study we have addressed this issue.

This chapter includes the background of the work and some previous related work done in this area of research. Section 1.2 discusses the background of the work. Section 1.3 discusses the previous related work. Section 1.4 presents offshore software development. Section 1.5 describes communication in offshore software development. Section 1.6 describes success of offshore software development projects. In section 1.7, research problem and research question is presented. Section 1.8 deals with the scope and objectives of our research study. The last section of this chapter describes the structure of the rest of the thesis.

1.2. Background

Offshore software development is largely different from co-located software development. This variance in software development nature has introduced many challenges like communication and coordination across the countries. The literature evidences indicate that many problems are directly rooted from this communication gap and some new risks are also introduced by poor communication in offshore software development [5, 7]. In software industry most of the projects fail due to over costing and schedule slipping. Since cost effectiveness has always been an important concern of the business community so software industry is struggling to reduce the cost and to maximize profit and save the time. They are promoting offshore software development because cost effectiveness is the actual objective and theme of project offshoring. But poor client-vendor communication is a hurdle in achieving this prime objective of the OSD.

Offshore software projects suffer an extra cost due to the communication gap between client and offshore vendor [1, 2]. There are many client-vendor considerations in software project offshoring like trust, business understandings, mutual benefits, conflict resolutions, mutual dependency and coordination. All these considerations can be achieved through successful

client-vendor communication. Communication between client and vendor is the most important factor in establishing and maintaining trust between client-vendor relationships [5].

Our research analyzes the communication process in offshore software development. It focuses on different communication modes/mediums used in order to perform different offshore software project development activities. This study deals and focuses on the offshore software project development market of Pakistan.

1.3. Previous Research

There are many research contributions in distributed software development. But none of them has focused on activity specific communication needs of different offshore software development activities. Existing literature deals with how cultural differences such as work ethics, working hours, importance of hierarchy, mode of communication and quality concerns can impact the success [8, 9, 24]. Until now, most of the studies focused on benefits and different models of offshore software development but now there is a serious need to address the challenges of communication and coordination between client and vendor in offshore software developments [25]. Since communication is very important in offshore software development therefore there is a need to analyze the activity-based communication needs for successful offshore software development. In order to improve the communication among different offshore software development stakeholders, an effective communication process and the infrastructure to support it, should be provided [25].

The previous work deals with effectiveness of each communication mode/medium for a particular activity in an outsourcing environment [35]. In this study we have proposed that, activity specific communication modes/mediums should be used in offshore software development. Our research addresses communication needs of individual OSD activities for successful completion of the projects.

1.4. Offshore Software Development

Software industry has rapidly adopted the philosophy of globalization, that's why software development paradigm has shifted from local software development to global software development. One of these new trends is the offshore software project development in which client and vendor are located in different geographical locations.

"The process of shifting service and manufacturing activities of an organization to a foreign country is called as offshoring. Software project offshoring is a common trend and is the symptom of the globalization for software industry [13]. Currently most of the developed countries are closing their in-house software development centers. They are establishing their long-term relationships with offshore vendors in developing countries particularly Asian countries (India, China, Pakistan, and Russia etc). India is the leading offshore market in the world. Their clients are attracted due to cheaper labor and specialized skills available in the developing countries.

1.5. Communication in Offshore Software Development

Although communication is very important in software development and for the success of a software project, successful communication is very essential. But in offshore software development, communication needs become more critical because any miscommunication between client and vendor creates serious problems for the projects like time delays and overspendings. In offshore software development, cost increases significantly due to costly communication infrastructures [2]. For communication in software development, many medium are used like telephones, conference calls and chatting but these mediums are not always appropriate for offshore software development projects due to time zone differences and language barriers [2]. In offshore software development the communication between client and vendor is multifaceted and more complex [1].

1.6. Success of Offshore Software Development Projects

Communication and coordination between client and offshore vendor has more effects on project performance. In traditional project management literature, the software project success is measured in terms of meeting schedules, controlling costs, achieving technical performance and attaining overall results [33][23]. While offshore software outsourcing success factors are on time project delivery, within budget delivery, expected quality and functionality for customers and business satisfaction, and strong client-vendor relationship [33]. The success factors of offshore software development projects are on-time completion of the project, within budget completion, meeting system requirements, system quality, user satisfaction, system user and net system benefits [10]. The poor or ineffective communication between client and offshore vendor

was found to be negatively correlated to success of offshore software development [10]. According to a study, vendors felt that communication, conflict resolution, cooperation and integration are very important for a successful client-vendor relationship [9]. Offshore outsourcing success is usually measured in terms of meeting specification of time, cost, quality, and client-vendor trust [35].

1.7. Research Problem and Research Question

Offshore software development is facing many critical challenges such as geographical distances, cultural differences, linguistic problems, and time zone differences [4, 5, 6, 7, 12, 23, and 39]. But the most serious and fundamental problem is client-vendor communication across two different countries. Although the communication between client and vendor is critical in collocated software development but in offshore software development, communication between client and offshore vendor is more critical and is a major barrier which negatively affect the success of offshore software development projects. Evidences from literature indicate that in offshore software development, communication gap is the major reason of poor relationship between client and offshore vendor [5, 35]. This is a potential research problem which is appealing for a significant attention from the researchers. Since communication between client and offshore vendor is a major challenge due to geographical distances, cultural differences, time zone differences, and language barriers so this challenge justifies a study to find out impact of communication modes/mediums on success or failure of offshore software development. The primary objective and major theme of offshore software development is low cost labor, access to specialized skills, improved time-to-market and high quality products but due to geographical distances, cultural differences, linguistic problems, and time zone differences, these objectives are not achieved as they are expected. Therefore offshore software development community cannot take advantage of offshoring decision due to poor communication. This communication issue raised the question that "What is the impact of communication modes/mediums on offshore software development?" The answer to the question would help offshore software development community to setup an effective communication mechanism and to use effective communication modes/mediums to perform their offshore software development activities.

There is no considerable research on the impact of communication modes/mediums on offshore software development projects. We are still a long way from understanding a detailed way that

which communication modes/mediums are suitable for communication among all the business stakeholders. We need to have a careful analysis of communication needs for various activities in offshore software development. In offshore software development budget, schedule, time-to-market, customer and business satisfaction, and trust between client and offshore vendor are seriously affected due to communication problems. In order to meet the communication challenges, existing research presented many approaches like creation of cross-site social networks, the interaction of communication technologies, explicit control mechanism and models for reducing the need for cross-site communication and coordination [36]. But we are proposing our own approach to meet and address the challenges of communication in offshore software development. We propose the utilization of activity-specific communication modes/mediums in offshore software development in order to complete the project successfully. For this we have proposed a hypothetical framework for communication in OSD". This hypothetical framework for offshore software development is presented in chapter No. 5 in figure. 5.3. Our study deals with the following research question.

Research Question

What is the impact of communication modes/mediums on success or failure of offshore software development projects?

1.8. Scope and Objectives of the Study

Before going towards literature survey into the area of offshore software development, we will define the scope and objectives of our research study.

1.8.1. Scope of the Study

In this section, we will define which subjects are in the scope of our research and which are out of scope? First of all in our study our focus is on the software projects with a clear start and finish because we can measure the project success if and only if it has a clear start and finish. The software product development where new modules and maintenance process continues is not included in the scope of our study. But where there is a new release of a product with clear specification of cost, schedule, and time-to-market is also included in the scope of our research study.

Secondly, our focus is on software project development rather than IT project development. Thirdly our study focuses on just offshore software development which includes three

perspectives. Those three perspectives include software project offshoring where client and vendor are located in two different countries, offshore in-sourcing where vendor company has their own development centers in a foreign country, and offshore outsourcing where vendor company hires a third party for software project development in a foreign country.

Thirdly our thesis is focusing on those situations where the decision to offshore has already been made. The question about whether the software development project should be offshored is not included in the scope of our study. Fifthly multiple sourcing where multiple vendors are selected for a single project is not included in the scope of our study.

An example of an offshore software development project that is in the scope of our study is a fruit product company that has transferred his software development project works within the same company to a foreign country.

The scope of our study is to inform the software offshoring practitioners about the role and importance of communication modes/mediums for various offshore software development communication-intensive activities. In this study we have investigated the communication process in offshore software development and for this we collected data from offshore vendor companies of Pakistan. Basically we want to investigate that which communication modes/mediums are used to perform different activities of offshore software development and what is the impact of communication mode/mediums on the success of offshore software development and how the communication process between client and offshore vendor can be improved?

1.8.2. Objectives of Study

The objective of our study is to highlight the communication needs and challenges in offshore software development. Our study is a step towards addressing these challenges and meeting communication needs of offshore software development practitioners. Our study addresses the significance of client-vendor communication in an offshoring relationship. Most specifically our study investigates that how the utilization of activity specific communication mode/mediums can improve the project performance to achieve the project success. Our research study has following objectives:

1) To investigate the communication modes/mediums used in offshore software development industry of Pakistan.

2) To investigate that how the utilization of different communication modes/mediums affect the success factors of offshore software development projects?
3) To investigate the overall impact of communication modes/mediums on success or failure of offshore software development projects.
4) To improve the communication between client and offshore vendor by proposing a framework for activity-specific communication modes/mediums for offshore software development.

1.9. Structure of the Thesis

Chapter 1 describes the background of the study, this chapter includes introduction, background, previous research, offshore software development, communication in offshore software development, success of offshore software development projects, the research problem and question, the scope and objectives of the of the study, and the structure of thesis.

Chapter 2 presents the literature concerning offshore software development. The literature review in offshore software development (OSD) includes the following topics: Offshore Software Development (OSD), offshoring VS outsourcing, software offshoring motivators, perspectives of offshore software development, major challenges of offshore software development, communication in offshore software development, and impact of communication gap on offshore Software Development.

Chapter 3 discusses the offshore software development activities and communication modes/mediums used to perform OSD activities. This chapter includes need of classification, classification of offshore software development activities, Classification of communication modes/mediums used in offshore software development, and offshore software development success factors.

Chapter 4 discusses research methodology, research method selection, research design, data collection sources and methods, primary data collection, and secondary data collection. This chapter also includes preparation and validation of questionnaire, objectives of the survey, research postulates, our research hypothesis, and our hypothetical framework for OSD.

Chapter 5 presents the survey analysis in order to answer the main research question "What is impact of communication modes/mediums on success or failure of offshore software development" and to investigate the postulates set in chapter 4. This chapter includes introduction, survey analysis and results, demographic analysis, communication mode used in OSD activities, and success and failure of matching and mismatching companies. This chapter also includes detailed analysis of success and failure with respect to cost, success and failure with respect to schedule, success and failure with respect to time-to-market, success and failure with respect to customer and business satisfaction, and success and failure with respect to client-vendor trust. Finally this chapter reviews overall results, and discussion about the survey results.

Chapter 6 concludes overall findings of the study, major contribution and implications of the study. Some benefits and limitations of the study are also described. Finally some future research directions are also presented.

Chapters 7 present references, bibliography, analysis graphs and diagrams, and our survey questionnaire.

Chapter No. 2

Literature Review

2.1. Offshore Software Development

In recent years, software development paradigm has shifted from co-located software development to distributed software development. The nature of software development has changed now. New trends like distributed software development, software project outsourcing, software project offshoring, and even global software development (GSD) have been introduced. In offshore software development (OSD), the development work is usually done at offshore development centers. In offshore software development, a business process done at a local company is transferred to a foreign country in order to take advantage of lower cost labor, regardless of whether the work done in the foreign country is still performed by the local company or a third party [14]. Normally the ratio between onsite and offshore team members is 1 to 5 and the offshore team members usually handle coding and unit testing, while the onsite team's responsibility primarily consists of customer interaction, integration testing and system testing [3].

2.2. Offshoring VS Outsourcing

According to National Academy of Public Administration, the terms offshoring and Outsourcing are defined as follows:

Offshoring: *"The process of shifting service and manufacturing activities of an organization abroad to their own affiliated or unaffiliated firms" [13].*

Outsourcing: *"The process of contracting out service and manufacturing activities to unaffiliated firms co-located or located in foreign countries" [13].*

For offshoring the software project, it is precondition that we shift some of the activities of software development to an offshore vendor. Offshoring is defined as the movement of a business process done at a local company (onshore) to a foreign country to take advantage of lower cost labor, regardless of whether the work done in the foreign country is still performed by the local company or a third party [7, 14].

Offshoring is sometimes termed as outsourcing or offshore outsourcing. The terms outsourcing, offshore outsourcing, and offshoring are usually used interchangeably but they have few slight

technical differences. Outsourcing is a practice that involves the transfer of an organizational function to a third party within the same country or in a foreign country while offshoring involves the transfer of an organizational function to another country, regardless of whether the work remains within the same organization or given to a third party vendor [14].

It is a common misconception that offshoring practice always involves outsourcing. Outsourced processes are always given to a third party vendor but offshore processes can be given to a foreign third-party vendor or it may remain in-house. By summarizing the discussion, we can say that we can have outsourcing without offshoring the process and we can also have offshoring without the outsourcing process [14].

2.3. Software Offshoring Motivators

There are different motivators of offshore software development. These motivators in order of priority include cost reduction, accessing specialized skills and decrease in time-to-market and customer proximity [19]. The primary motivator for offshore software development is cost [1]. The primary motivator for offshore development is cost but it often becomes difficult for offshore development community to reduce cost due to communication problems. There is always an extra cost due to communication gap in off shoring [19]. Lower cost labor is first and most important motivator of offshore software development. In Asian countries, labor cost is very low like in India, the labor wages are less than 50% of their equivalent labor in USA and other European countries [37].

Companies decide to offshore their software development (SD) projects to low wage countries in order to minimize the costs, enter a new labor pool, enter new markets, increase the quality of service, or reduce the time to market [37]. Offshore outsourcing provides a best alternative to implement Distributed Software Development and to take advantage of the lower cost in other markets [23].

The primary motivators of offshore software development are cost savings, accessing specialized skills and increasing development speed [5]. The main purpose of decision for offshoring is to reduce the development cost [8]. Cost savings on large projects from moving operations offshore could be as much as 25% - 50% [14]. Cost saving is not the only benefit of offshoring that makes it attractive. Other benefits such as an educated- English speaking work force and low turnover

rates are all making offshoring more feasible for every one [14]. In recent years, offshore software development is a rapidly growing trend because offshore software development has many benefits like cost, increased flexibility [26].

There are many motivators of offshore software development like access to global expertise, reduced costs, achieve business goals faster, high quality results, benefit of focused employees, competitive advantage, no additional hiring required and sale software ship [17]. Access to global market and improved time-to-market by using time zone differences in "round the clock" are also included in the core advantages and objectives of offshore software development [36]. Communication is the most common reason that, work sent offshore failed to meet project specification [16, 18].

2.4. Perspectives of Offshore Software Development

There are different perspectives of software project outsourcing including Offshore delivery model, Offsite delivery model, Global delivery model, Onsite delivery model, Offshore/Onsite delivery model, Offsite/Offshore delivery model, and Offshore development centers model [13]. In our study, we are interested in offshore software development rather than software outsourcing because in some perspectives of software outsourcing, client and vendor can communicate easily. So we have considered only those perspectives which involve offshoring. For offshore software development, some of the activities are performed at client side and some are performed at offshore site. So, from the above mentioned perspectives of software project outsourcing, we have selected only those perspectives which involve offshoring. Following are some of offshore software development perspectives.

i) Offshore software development
ii) Offshore software in-sourcing
iii) Offshore software outsourcing

Three Perspectives of Offshore Software Development (OSD)

In our research study, we are emphasizing three perspectives of offshore software development as depicted from the table 2.1. Those three offshoring perspectives include software offshoring, offshore outsourcing, and offshore in-sourcing [27].

Software Offshoring: When both client and vendor are geographically located in different countries.

Offshore Outsourcing: When a company transfers its software development work to another company in a foreign country then this is offshore outsourcing.

Offshore In-sourcing: When a company transfers its software business to a foreign country but within the company then this is called as offshore in-sourcing.

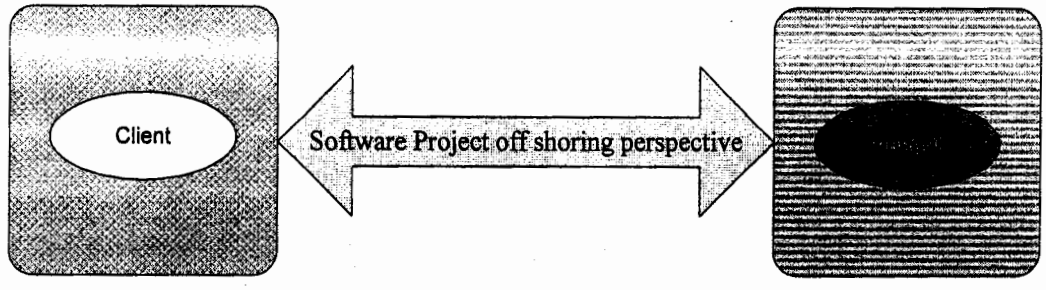
Proper communication is fundamental to organization success [28]. In offshoring context, transferring a software business to a foreign country, the biggest challenge is communication between client and vendor. Since the effective communication is key to success in software development process [29].

Offshoring Perspective	Description
Software project Offshoring	Both client and vendor are geographically located in different countries.
Offshore in-sourcing	Client and vendor have same countries but vendor has its own offshore development center in different country.
Offshore outsourcing	Client and vendor have same country but vendor outsource the project to an offshore company in another country.

Table 2.1: Perspectives of OSD

i) **Software Project Offshoring**

In this perspective of offshore software development, client and vendor are located in different countries as shown in fig. 2.1.

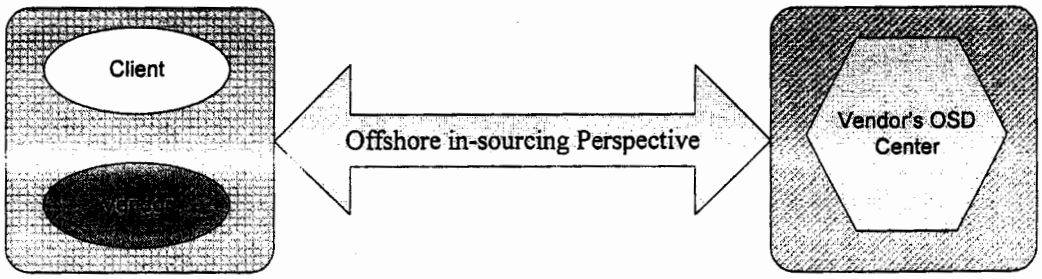


Country A Country B

Fig. 2.1: Software Project off shoring perspective

ii) Offshore In-sourcing

In offshore in-sourcing perspective of offshore software development, both client and vendor are located in the same country as shown in fig. 2.2. But the vendor firm has their own offshore software development centers. In offshore in-sourcing perspective, vendor may carry out some of the activities onsite but most of work is done offshore.



Country A Country B

Fig. 2.2: Offshore in-sourcing Perspective

iii) Offshore Outsourcing

In offshore outsourcing perspective, both client and vendor are located in the same country as shown in fig. 2.3. But the vendor outsources some of the activities or whole of the project to a third party located in another country.

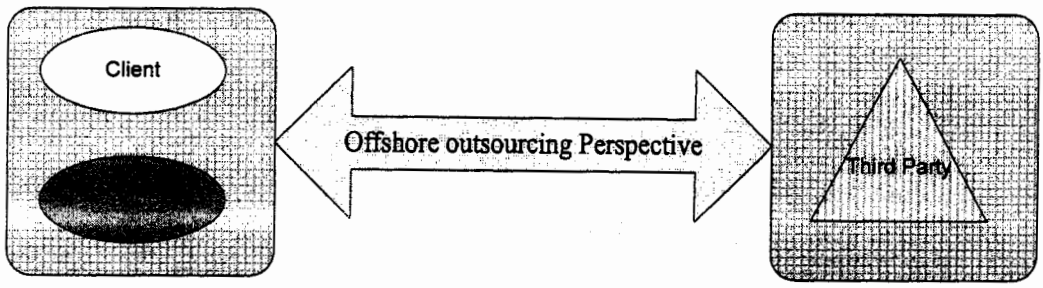


Fig. 2.3: Offshore Outsourcing Perspective

2.5. Major Challenges in Offshore Software Development

In offshore software development, customer and vendor face different challenges like cultural differences, communication and coordination issues, and linguistic problems [9, 30]. Communication and coordination are two major pillars of offshore software development [37]. As it is common that a new challenge for offshore software development community is the offshore communication between client and vendor which co-located software development community does not face. Therefore, to achieve fruitfulness of offshore software development, communication between client and vendor should be improved. One major reason that offshore software development community does not reach their goals is poor communication between client and vendor [37].

Along with the advantages, some challenges of offshore software development are also there, such as scope creeping, within budget completion, poor quality and communication between client and vendor [36]. Some of the well known challenges of offshore software development include communication, transfer of business logics, poorly defined project scope that require a lot of client cooperation, time zone differences, unclear and ambiguous requirements, insufficient customer involvement, cultural differences and geographical distances [36]. The only way to address these challenges is to develop a coordinative, cooperative, informative, and feedback-oriented communication relationship between client and offshore vendor.

The major challenges of offshore software development include long distances, cultural diversity, linguistic problems, and differences in time zones, holiday customs, and limited use of technology as shown in table 2.2. Some other very serious issues include Lack of Direct Communication, Late Response or Non-response, Company's Confidential Business Policy and

offshoring the offshorers as shown in table 2.2. All these challenges directly affect the client-vendor communication in offshore software development. Now we are going to discuss these challenges in detail.

i) Distances

Geographical differences largely affect the communication between client and vendor. As the distance increases, some new communication problems are introduced and it becomes difficult to travel for face-to-face meetings. Long distance introduces new challenges in the regions and frequent communication almost becomes impossible. As the distances increase, communication cost and cultural differences also increase. In offshore software development, change requests are very difficult to handle due to long distances between client sites and offshore vendor sites [4]. In offshore software development, communication between the client and offshore developer sites becomes difficult due to the long distances, time differences, and language barriers despite establishing sophisticated IT technology [39].

ii) Cultural Differences/Cultural Diversity

It depends upon the culture that how people interpret and react to a situation [10]. There are different cultures in different societies. The cultural difference leads to ambiguous requirements analysis and often causes misunderstandings. The only way to reduce cultural diversity and establishing and maintaining a successful client-vendor relationship is to have an effective communication approach. Most of the vendors suggest that frequent communication not only help to avoid misunderstandings but also improves cultural understanding [5]. It is interesting to note that all the vendors consider that communication and cultural understanding are the most crucial factors in maintaining trust relationship with clients [5]. Cultural differences can become a barrier to communication, knowledge exchange [14]. Due to cultural differences, close cooperation between client and vendors is required in offshore software development [23].

iii) Linguistic Problems

Communication gap occurs due to cultural differences and linguistic problems. [4]. Offshoring often includes international teams, so the effects of cultural and linguistic issues on team communication, expectation, etc, should also be addressed [6].

iv) Differences in Time Zones

In offshore software development, time zone difference is also a major barrier to communication

because successful communication is not possible if a time is inconvenient for either of the communicating parties. Difference in time zones limited the ability to communicate in real times [12]. In offshore software development, time zone differences reduce opportunities for real time collaboration and response time increases significantly when working hours in client and vendor countries do not overlap [12].

v) Holiday Customs

Another big reason of communication gap in software project outsourcing is difference in holiday customs. Different countries and business societies have different holiday customs. Due to this difference, communication could not take place at proper times and replies often come the day after tomorrow. Difference in holiday customs bitterly affects the development speed and performance of the development team. Basically, this is the main reason of schedule slippage.

vi) Limited Use of Technology

Another reason of communication problems in software project offshore outsourcing is that, there is limited use of communication technology because most of small vendor companies cannot afford the expensive means of communication technology. If they use advanced means of communication, then it results in a business process overhead in the form of increased cost.

vii) Lack of Direct Communication

Another problem in client-vendor relationship is the lack of direct communication that causes a huge communication gap and has undesirable consequences. In software offshoring relationship, most of the communication occurs through project managers but to achieve the business value of each development activity, it is essential that technical and concerning staff should interact directly by using appropriate communication modes/mediums.

viii) Late Response or Non-response

In indirect communication, responses are often come late and sometimes non-responsive situations occur. So it is also a common reason for communication gap.

ix) Company's Confidential Business Policy

Every organization has some business secretes containing core competencies and organizations make them confidential. These business secretes are kept confidential and usually not communicated to the vendor organizations. Due to such kind of confidential business policies, the business processes are not supported properly and it becomes difficult to capture the actual business scenarios. As a result these business processes, to some extent lose their value and

create ambiguities that lead to quality compromises. So, company's confidential business policy is also a potential reason for communication gap.

x) Offshoring the Offshorers

Another new trend that increases communication gap significantly is offshoring the offshorers. One of leading outsourcing companies like "Tata Consulting" has also started offshoring their own work to other countries in order to take low cost labor advantages [20]. The table 2.2 represents summary of critical challenges of offshore software development.

OSD challenge	Literature
Distances	Erran Carmel, Pamela Abbott 2006,Steven Traser, Lougie Anderson, Ron Crocker 2004, James D. Herbsleb, Danial J. Paulish, Matthew Bass 2005
Cultural differences	Phong Thanh Nguyen, Muhammad Ali Babar, June M. Verner 2006, James D. Herbsleb, Daniel J.Paulish, Matthew Bass 2005, Vibeke Dalberg, Endre Angelvik, Asle Kristian Fossberg 2006, Haiyan Huang, Eilleen M. Trauth 2007
Linguistic problems	Hazel Taylor 2006, Matthew J. Hawthorne, Dewayne E. Perry 2005
Difference in time zones	Monica Adya, Dhruv Nath, Varadharajan Sridhar 2007
Holiday customs	Monica Adya, Dhruv Nath, Varadharajan Sridhar 2007
Company's confidential business policy	Haiyan Huang, Eilleen M. Trauth 2007
Offshoring the offshorers	Benjamin B.M. Shao and Julie Smith David 2007
Limited use of technology	Haiyan Huang, Eilleen M. Trauth 2007
Late response or non-response	Haiyan Huang, Eilleen M. Trauth 2007
Lake of direct communication	Haiyan Huang, Eilleen M. Trauth 2007,

Table 2.2: Summary of critical challenges of OSD

The above discussion shows that offshore software development community is facing many problems like cultural differences, geographical distances, linguistic problems and time zone

differences. To address these challenges, we need to improve the communication process between client and vendor. Our study is addressing this challenge of communication gap by utilizing appropriate communication modes/mediums for each activity of offshore software development. If both client and vendor use the appropriate communication modes/mediums in order to perform offshore development activities, then the risk of miscommunication and need of re-communication can be reduced which ultimately results in better performance required for the project success.

2.6. Communication in Offshore Software Development

Communication is very essential for exchanging day-to-day information between client and vendor [10]. Communication and coordination between client and vendor has complex effects on OSD project performance and better communication and coordination mechanisms in offshore software development reduce project uncertainties and improve performance of the project [1]. In offshore software development, usually a small team of developers located at client side handles the system integration, system testing, and installation [1, 3, and 6]. The proper communication and coordination in offshore software development reduces project risks and improves the performance of the project [1]. There are many risks of producing infeasible, unrealistic, ambiguous, incomplete, wrong and incomplete requirements in offshore requirements analysis even with a best communication infrastructure [2]. In offshore software development, the negotiations caused by the time delays create needs for extra communication [39]. The experts say that in offshore software development scope creeps due to communication issues [4]

A software project which involves multiple offshore software development companies suffers extra cost for communication setups with each of them and this risk of extra cost is more than production cost savings through offshoring the project [2]. A potential difficulty is faced by the offshore developers is the development delay due to doubt in requirements specifications [3]. Miscommunication between client and vendor creates problems for the projects and results in project delays and overspendings [4]. According to an offshore software development professional "*don't rely on emails, communicate face-to-face as much as possible*" [6].

2.7. Impact of Communication Gap on OSD

Today, software development is a global business. Software industry is earning billions of dollars per year. To maximize the income and profit, software research community is introducing new paradigms and surprising methods for software development. Adopting these innovations make it possible to save time and minimize development cost. Every new approach is developed for business community to enhance the value of business process. Software project offshoring is also such an innovation. In OSD, the communication gap between client and offshore vendor has serious impact on the success of OSD projects as depicted from the table 2.3.

I) Cost Overhead

In software offshoring process, our prime business objective is to reduce cost. Literature evidence indicates that in software project offshoring, cost increased due to reduced level of communication. We often suffer increased cost due to the communication gap and it has serious impact on the business value of offshoring process. Therefore, it is better to concentrate solely on communication in offshore software development that strongly addresses the business concerns as well as the other aspects of business community. The communication cost is also a big risk in offshoring relationship. This risk of communication cost is more than production cost savings through offshoring. Miscommunication between client and offshore vendor creates project troubles resulting time delays and overspendings [4, 19].

ii) Schedule Delays

Another business objective of project offshoring is to reduce development time but in OSD, there is a delay due to communication gap. In offshore software development, it is observed that quality and schedule consciousness among the offshore team is very low [3]. Software developers spend a lot of time in communication and coordination activities because communication is the glue that ties client and vendor [12].

By the above discussion, it is strongly justified that communication has a serious impact on business objectives of software project outsourcing, so there is a need to reduce the communication gap and to fulfill the communication needs of all the business stakeholders. Vendors believe that effective and frequent communication between client and offshore vendors at different levels of the organizational hierarchy is necessary for managing strong trust relationships [5].

III) Trust Between Client and Vendor

In offshore software development, trust is an important success factor but due to communication gaps between client and offshore vendors, it is very difficult to establish trust relationship between them. Having a trust relationship with the customer is very important in order to understand the business requirements. Communication and contract conformance are most important factors in establishing and maintaining trust between client and vendor in offshore outsourcing because contract conformance is essential to protect clients trust [30]. Communication gap between client and vendor seriously destroys the trust between client and vendor.

IV) Increased Time to Market

In a competitive environment, time-to-market is an important success factor when task durations are very short [31]. Due to time-to-market pressure, delay cost per day is always intentionally high [31]. The communication gap between client and vendor increases time-to-market leading to project failure because sometimes entering first in the market is considered as the major success factor for a software development project. Time-to-market can be reduced by utilizing appropriate communication mode/medium in offshore software development to reduce miscommunication and re-communication.

V) Customer and User Satisfaction

In offshore software development, customer and business satisfaction is very important. Customer and business satisfaction is a major challenge for the offshore vendor. If proper communication pattern is not established between client and offshore vendor then customer requirements cannot be implemented properly which leads customer and business dissatisfaction. In offshore software development, proper communication can increase the satisfaction level of both customer/end user and vendor party.

Critical communication factor	Business Impact
Distances	Face-to-face meetings become difficult, communication cost increases, expensive technology is required for communication
Cultural difference	Interpretations changes, misunderstandings, poor client-vendor relationship, dissimilar conversational style, expectations cannot meet
Linguistic Problems	Direct communication becomes difficult, only formal methods can be used, misunderstandings, misconceptions, misinterpretations, translators required, cost increases
Difference in time zones	Direct communication becomes difficult, development speed reduces, schedule always slip due to delays
Holiday customs	Wastage of time, huge delays, late responses, schedule slippage
Company's business confidential policy	Incomplete information, ambiguous requirements, frequent changes, business process lose their value
Offshoring the offshorers	Communication gap increase largely, direct communication difficult
Limited use of technology	Development speed reduces, requirement are not fulfilled
Late response or non-response	Time delays, schedule slippage
Lake of direct communication	Misinterpretation of context, wrong implementation of requirements, vendor cannot fulfill their promises

Table 2.3: Impact analysis of communication factors in outsourcing

Chapter No. 3

Classification of OSD Activities and Communication Modes/Mediums

3.1. Offshore Software Development Activities

The offshore software development lifecycle activities are same as activities in non-offshore or co-located software development but they are very difficult and complex to perform due to their offshore nature. Based on the offshore software development models [13] and the literature in the area of offshore software development, there are various common offshore software development communication-intensive activities which are contract negotiation, requirements elicitation, requirements verification & validation, requirements specification, resolving ambiguities from requirements document, requirements change, scope change, design communication, resolving design conflicts, client's acceptance testing, client-vendor artifacts review, code walkthroughs and inspections, initiating software maintenance, budget and schedule tracking, user support, status review meetings, top management reviews and service level audits [1, 4, 12, 13, 14, 35]. These offshore software development activities are list in the given below Table 3.1.

3.2. Communication Modes/mediums Used in Offshore Software Development

The cultural differences greatly complicate communication process and leads to frustration and misconceptions [6, 8]. When all the project stakeholders speak the common language e.g. when client and offshore vendor speak English, then chances of misunderstanding are greatly reduced because language is usually culture-based [4]. "M*ulti-site software developments have to deal with the frustration of communicating with remote workers in different time zones, difficulties of language and culture and lack of trust that restrict communication* [36]". The time zone differences in offshore software development create communication delays and reduce opportunities for real time collaborations [12]. It is very difficult to have real time communication. Therefore we can say that time zone differences in offshore settings increase communication gaps. The geographical distance between client and offshore vendor reduces informal communication across the sites [8]. "*The most persistent problem seems to be the greatly reduced communication in multisite projects as compared to single site projects* [6]". To address these challenges, offshore development community uses different communication modes/mediums (e.g.) like face-to-face (FF), email (EM), telephone and fax (TF), video conferencing (VC), teleconferencing (TC), chatting (CH), instant messaging (IM), voice mail

(VM), text messaging (TM), Online discussion forums (ODF), web interactive TV (WITV), and web repository (WR) [2, 3,12, 16, 35]. These communication modes/mediums are listed in the given below Table 3.2. Videoconferencing provides a better alternative of face-to-face which provides a human touch and gives a better feel of customer requirements by the offshore team [3]. Email is a text-based communication mode; therefore sometimes it is considered most appropriate for communication in offshore settings [35]. Although face-to-face communication is a gold standard and it provides greater feedback to the sender, and fewer sensory cues to the receiver than all other communication modes [35]. But frequent face-to-face communication is difficult to manage at every time in offshore settings. Email and computer conferencing are not good because messages sent through email and computer conferencing are not modifiable and trust cannot establish between client and offshore vendor [35].

OSD Activity
Contract negotiation
Top management reviews
Acceptance testing
Design communication
Status review meetings
Requirements elicitation
Resolving design conflicts
Resolving ambiguities from requirements
Scope change
Requirements change
User support
Client-vendor artifacts review
Requirements verification and validation
Requirements specification
Software maintenance
Budget and schedule tracking
Service level audits
Code walk through and inspection

Table 3.1: OSD Activities

Communication Mode/Medium
Face-to-face
Video conferencing
Email
Discussion forum
Shared data repository
Web Interactive TV
Net meeting
Teleconferencing
Phone and Fax
Chatting
Others

Table 3.2: Communication Modes

3.3. Need of Classification

During the last decade, the software development paradigm has shifted from co-located software development to offshore software development. This paradigm shift has given birth to many new challenges for the software development community. These challenges directly affect the communication between client and offshore vendor. Therefore, we need to address the communication issues in offshore software development. The existing literature tells that different communication modes/mediums are used for different offshore software development activities [1, 2, 3, 6, 12]. According to Dave Thomas, "*offshore outsourcing creates an increased need for communication of requirements, acceptance testing, and most importantly communication of architecture [19]*". For requirements change face-to-face communication is usually preferred and IM and email is on second and third preference respectively [12]. Initial requirements elicitation is usually conducted on client side and detailed specifications are completed offshore [1]. Email document are not good for architectural design [6]. A potential difficulty is that of time delays when a developer gets ambiguity in the specifications [3]. In offshore software development, user interface design is facilitated through a shared data repository [2]. In offshore software development design and coding activities are conducted on offshore sites so an excellent communication and coordination mechanism is essential for communication needs in order to manage evolving changes [2].

The above discussion shows that different offshore software development activities have different communication needs. We have analyzed that in order to communicate; offshore software development practitioners use different communication modes/mediums for different offshore software development activities. There is no existing study dealing with the question that which communication mode/medium is most appropriate for a specific activity. This is a question mark which creates the need to study communication needs of different offshore software development activities. Therefore it is very important to see the relationship between an offshore software development activity and the communication mode/medium used to perform that activity.

3.4. Classification of OSD Activities

Communication is considered as the running blood of software development process, doesn't matter, it is co-located software development or distributed. But when we shift from co-located software development to offshore software development, communication issues increase significantly and become more critical. In offshore software development, communication is such a serious issue, that if we do not take into account of it properly, the core advantages of offshore software development, such as access to specialized skills, flexible resource availability, and cheaper labor will be lost in the communication overhead [23]. The offshore outsourced projects are frequently prone to failures [4] and the only reason behind this is miscommunication and poor communication between client and offshore vendor. Due to miscommunication, most of the offshore software development projects complicate the transmission process of the actual set of requirements which leads to frequent change requests [4]. According to [1], seamless communication oils the project speed. Therefore, effective communication between client and offshore vendor is primary success factor for offshore software development.

According to literature evidence, a coordinative and cooperative environment is precondition for successful offshore software development [13]. Awareness about the activities, regular feedbacks, and proper response against the inquiries are essential to achieve the objectives of OSD effectively. Unfortunately, there is no research on activity specific communication mode/medium selection for an offshore software development environment. There is a need to investigate that, which communication mode/medium is appropriate for a specific offshore software development activity. Since appropriate communication mode/medium is essential to perform any activity in offshore software development. So, we have categorized the offshore software development activities in five categories with respect to their communication needs as depicted from the Table 3.3.

i) Coordinative offshore software development activities
ii) Cooperative offshore software development activities
iii) Informative offshore software development activities
iv) Feedback-oriented offshore software development activities
v) Inquiry based offshore software development activities

3.4.1. Coordinative Offshore Software Development Activities

Coordination means the act of integrating each task and organizational unit so that it contributes to the overall objectives [23]. The coordination between client and offshore vendor is very essential in offshore software development activities. There are some activities in offshore software development which require strong coordination between client and vendor. We named this type of activities as coordinative offshore software development activities. These activities include contract negotiation, top management reviews, acceptance testing, design communication [35], and status review meeting.

For architectural design communication, email and documents sharing is not good, this type of activity requires physical presence of the key players responsible for the design activity [6]. Architectural design is a very critical activity, since making a decision by using email or teleconferencing is very difficult [6]. The project status review meetings are coordination mechanism used in offshore software development activities and take place through video conferencing [1]. At the time of contract negotiation, face-to-face communication is very essential because face-to-face communication increases trust between client and offshore vendor [35]. Acceptance testing is usually carried out by onsite team members and face-to-face communication is usually preferred [1]. In offshore software development, top management reviews are most effectively conducted through face-to-face and through video conferencing [35]. In offshore software development, we can only be able to perform the activities successfully if we encourage discussions in group meetings to jointly analyze and find out the barriers in the coordination process, minimize them and improve communication. Some studies reveal that cross-site communication and coordination issues can cause a substantial loss of development speed [25]. In offshore software development, coordination is very difficult and expensive. But some activities of offshore software development are strongly coordinative which require the strong coordination between client and vendor [31]. Coordination in offshore software development is more critical and important than in co-located software development.

3.4.2. Cooperative Offshore Software Development Activities

Each activity in offshore software development requires effective communication between client and vendor for its completion which is usually difficult. In offshore software development, client

side members and offshore member cannot communicate effectively due to time zone differences, linguistic problems and cultural differences. Effective and regular communication is the only way to shorten the distance, covering the cultural gaps and resolving the conflicts and other problems [22]. Therefore, effective communication between client and vendor is necessary which is not possible without cooperation between client and vendor. Due to cultural differences, offshore software development requires close cooperation between client and vendor [23]. In offshore software development, some activities require close cooperation between client and vendor. These activities include requirements elicitation, resolving design conflicts, scope change, and resolving ambiguities from requirements [35]. For scope change, email is usually used for communication between client and vendor [12]. For requirements elicitation, discussion forums are usually used [6]. For resolving requirements and design ambiguities and conflicts email is used [6].

3.4.3. Informative Offshore Software Development Activities

The offshore software development activities, where public information is required to be exchanged /shared between client and offshore vendor are called informative offshore vendor. Awareness about the project is very essential for client and offshore vendor because, due to lack of awareness software development mum effect increases which results in project failure. Without effective information and knowledge sharing mechanism, it is difficult to exploit the benefits of offshore sourcing [23]. In offshore software development, some activities are strongly information oriented. These activities include requirements change [12], user support, and client-vendor artifacts review [35]. For client-vendor artifacts review, usually web repository is used [35]. For documents sharing and requirements change data repository is used [12]. For user support, web interact TV is a best option in an offshore environment.

3.4.4. Feedback-Oriented Offshore Software Development Activities

Most of the activities in offshore software development are interdependent, so they need feedback from other activities. If proper feedback-orientation is not implemented in offshore software development process, we cannot successfully perform the interdependent activities that cause failure of the project. These activities include software maintenance, requirements

verification and validation, and requirements specifications. Software maintenance is demanded while giving the feedback of the system after using it. Feedback is given through net meetings. For requirements verification and validation, and requirements specification, teleconferencing is usually used.

3.4.5. Inquiry-Based Offshore Software Development Activities

In inquiries, client and vendor share very small but technical issues. Usually these issues include business secretes of the companies. It often happens that business secretes are not conveyed to the offshore vendors which causes serious problems for the developers. Especially in public documents, it is avoided to convey the business secrets of the company. One thing more is that the onshore workers often avoid sharing knowledge because of the fear that this might threaten their own jobs in the future [32]. These activities include budget and schedule tracking, service level audits and code walk through and inspections. Telephone is usually used for budget and schedule tracking, and service level audits. For code walk through and inspections, chatting is usually used.

OSD Activity Category/Class	OSD Activity
Coordinative	Contract negotiation
	Top management reviews
	Acceptance testing
	Design communication
	Status review meetings
Cooperative	Requirements elicitation
	Resolving design conflicts
	Resolving ambiguities from requirements
	Scope change

Informative	Requirements change
	User support
	Client-vendor artifacts review
Feedback-oriented	Requirements verification and validation
	Requirements specification
	Software maintenance
Inquiry-based	Budget and schedule tracking
	Service level audits
	Code walk through and inspection

Table 3.3: Classification of offshore software development Activities

3.5. Classification of Communication Modes/Mediums Used in OSD

Communication techniques and tools are more important to offshore software development efforts than technologies and programming skills and companies that are doing offshore software development efforts can verify the fact that OSD projects do not fail because of technology or programming skills, but because of communication issues [24].After complete literature survey of communication modes/mediums used in offshore software development, we have classified OSD communication modes/mediums into five categories as depicted from the Table 3.4.

i) Coordinative communication modes/mediums
ii) Cooperative communication modes/mediums
iii) Informative communication modes/mediums
iv) Feedback-oriented communication modes/mediums
v) Inquiry-based communication modes/mediums

3.5.1. Coordinative Communication Modes/Mediums

Cost cut without compromising on quality is the key objective of offshore software development and to achieve this objective, there has to be a smooth coordination between offshore client and the software vendor. Once the project starts, both the offshore client and the software vendor should coordinate on regular basis on the project flow [21]. Establishing and maintaining a strong coordination process between client and offshore is very important in order to efficiently utilize the offshore team [26]. If you do not focus on efficient and effective coordination from the very beginning, you may encounter many serious problems [5]. In offshore software development we can only be able to perform the activities successfully if we have a strong coordination mechanism. Some studies reveal that cross-site communication and coordination issues can cause a substantial loss of development speed [25]. An effective coordinative environment among the client and offshore vendor is extremely important for OSD [25]. To ensure effective coordination in OSD, coordinative communication modes/mediums (e.g. face-to-face, video conferencing, etc.) should be utilized. According to [1], communication and coordination has complex effects on overall project performance. Coordination is very expensive, so we need to do careful analysis in order to know that how different coordination mechanisms are different from each other with respect co-located and offshore settings.

3.5.2. Cooperative Communication Modes/Mediums

In offshore software development, the offshore client faces many challenges like poor transfer of business logic understanding, unknown and ambiguous requirements and lack of customer involvement, differences between customer and vendor, geographical distance, and many more. To address these challenges, mutual cooperation and proper coordination from both the software vendor and the offshore client is essential to achieve the objectives [21]. For mutual cooperation between client and offshore vendor, the roles and responsibilities of each party should be clearly defined at the begging of the project [26]. In order to fulfill the mutual cooperation needs of both clients and offshore vendors, we need to use cooperative communication modes/mediums (e.g. email, discussion forum etc). Communication has to be transparent between the both [21]. Informal communication between client and vendor is very important for cooperative software development [8].

3.5.3. Informative Communication Modes/Mediums

For successful offshore software development, everyone associated with the project should be informed about all the activities of the project. Without effective information and knowledge sharing mechanisms, it is very difficult to achieve the benefits of software offshore sourcing [23].

Everyone should be aware of the communication going on between the two parties [21]. Practically there are rare offshore software development companies which are utilizing informative communication modes/mediums (e.g. shared data repository, web interactive TV etc). Most of the companies rely just on emails and instant messages (IM) but most of the project activities are boasted by awareness. So it is necessary to utilize informative communication tools to overcome this lack of awareness.

3.5.4. Feedback-oriented communication Modes/Mediums

Software development is a feedback-oriented process. The method of continuous feedback and communication helps for the success in the offshore development process [27]. Most of the activities in software development are interdependent, so they need feedback from other activities. If proper feedback-orientation is not implemented in software development process, we cannot successfully perform the interdependent activity that causes failure of the project. In offshore software development where there are geographical and time zone differences, feedback requirements are more critical. Without clear feedback, teams facing ambiguities in different tasks are often unable to assess progress and thus may find it difficult to meet their performance goals [35]. One of the major challenges in offshore software development is information bottlenecks. These information bottlenecks can be minimized by having regular communication in the project development process [38]. The regular feedback ensures that the offshore team is synchronized with onsite team and the business requirements and information was transferred adequately. With e-mail communication feedback circles become slow down and communicator have to wait for feedback. The continuous feedback provided through daily communication would help in better team coordination and minimizes differences in team cultures which results in project success [38]. The feedback-oriented communication modes/mediums include teleconferencing and net meeting.

3.5.5. Inquiry-based communication Modes/Mediums

In inquiries we ask technical questions from the client which we require to understand business logics of the company. But usually the business secrets are not conveyed to the offshore vendors which cause serious problems for the developers. Especially in public documents it is avoided to convey the business secrets of the company. In the same way public communication modes/mediums (e.g. phone and fax and chatting etc), are avoided to convey such kind of information. So business secrets are conveys privately in inquiries and for this we need to utilize only inquiry-based communication modes/mediums (e.g. telephone and fax, and chatting etc). If you are efficient in communicating your ideas and business requirements then you will get better results from your provider [26].

Communication Modes/Mediums Category	Communication Modes/Mediums
Coordinative	Face-to-face
	Video conferencing
Cooperative	Email
	Discussion forum
Informative	Shared data repository
	Web Interactive TV
Feedback oriented	Net meeting
	Telcconferencing
Inquiry-based	Phone and Fax
	Chatting

Table 3.4: Classification of communication modes/mediums used in OSD

3.6. Offshore Software Development Success Factors [36]

In offshore software development, successful communication between client and vendor is key to project success. The communication between client and offshore vendor has the largest impact on the success of offshore software development projects [19]. In traditional project

management literature, the software project success is measured in terms of meeting schedules, controlling costs, achieving technical performance and attaining overall results [33][23]. While offshore software outsourcing success factors are on time project delivery, within budget delivery, expected quality and functionality for customers and business satisfaction, and strong client-vendor relationship [33].

Offshore software development is quite different from onsite software development [18, 33]. According to (Delone et al. 2005) the measures of IS project success are on-time completion of the project, within budget completion, meeting system requirements, system quality, user satisfaction, system user and net system benefits [10]. The poor or ineffective communication between client and offshore vendor was found to be negatively correlated to success of offshore software development [10]. According to a study, vendors felt that communication, conflict resolution, cooperation and integration are very important for a successful client-vendor relationship [9]. Offshore outsourcing success is usually measured in terms of meeting specification of time, cost, quality, and client-vendor trust [35]. In our study, we have analyzed the impact of communication mode/medium on the following success factors of offshore software development.

1) Schedule
2) Budget
3) Time-to-market
4) Customer and business satisfaction
5) Client-vendor trust

3.6.1. Schedule

Usually client requires quality deliverable, completed within schedule. This is the major demand of any client. The development speed is significantly reduces due to poor communication and coordination in an offshore software development environment [36].

3.6.2. Budget

Within budget completion is a very basic success factor of any software project. Since cost effectiveness is the primary objective of offshoring the software projects, so, we can say that, it is the most critical and challenging success factor. For offshore software outsourcing success factors are on time project delivery, within budget delivery, expected quality and functionality for customers and business satisfaction, and strong client-vendor relationship [33].

3.6.3. Time-to-Market

In offshore software development environment, time-to-market is also an important factor. Of course time-to-market has always been a key business driver and is still important goal for most of the offshore software development shareholders. Access to global market and improved time-to-market by using time zone differences in "round the clock" are the core advantages and objectives of offshore software development [36]. In a competitive environment, time-to-market pressure often increases cost because there are tradeoffs between task duration cost [31]. Improved time-to-market is also an important motivational factor of offshore software development. The time-to-market in offshore software can be improved by using time zone differences through round the clock development [23].

3.6.4. Customer and Business Satisfaction

Offshore outsourcing success is usually measured in terms of meeting specification of time, cost, quality, customer satisfaction, and client-vendor trust [35]. Customer satisfaction often reduces after project kickoff, as the customer feels that he does not know what status of the project is. Offshore interaction would be little complicated and longer compared to onshore interaction due to information overhead.

3.6.5. Client-Vendor Trust

In offshore software development, trust between clients and offshore vendor is also an important success factor. Communication and contract conformance are most important factors in establishing and maintaining trust between client and vendor in offshore outsourcing because contract conformance is essential to protect clients' intellectual property (IP) [30]. If vendor is

able to fulfill the contract then there will establish a strong client-vendor trust relationship and client-vendor trust is very important factor in offshore software development success. It is very difficult to establish and maintain trust relationship between onshore and offshore team member because the onshore workers often avoid sharing knowledge because of the fear that this might threaten their own jobs in the future [32]. In offshore software development, lack of trust made it very difficult to find out the appropriate person to answer the queries and coordinate the activities [32]. Trust is an interpersonal or an inter-group construct. Trust between a trustier and trustee [32].

Chapter No. 4

Research Methodology

4.1. Research Methodology

This section deals with the selection of research approach and research method for our research problem. The purpose of this section is to understand how we have conducted our research and why the selected research method is suitable for our research.

4.2. Research Approach

There are two major research approaches including deductive and inductive. In deductive approach a hypothesis is generated from a theoretical framework and then an experiment is conducted to test the hypothesis. In inductive method researcher starts to know the reality and identify the phenomenon. For this purpose he uses analytical tools such as theories, questionnaires, and interviews and so on. This analysis provides a new theoretical framework with understanding of the phenomenon. We will use deductive approach for our research problem.

4.3. Research Method Selection

According to Yin (1994), there are five research methods: experiment, survey, history, archival analysis, and the case study [39]. Each method is a different from each other in data collection and follows its own procedures. Different research methods are applied to answer different research questions and they have their own time focus and control. A case study is usually applied when "how" and "why" types of questions are required to be answered. A survey is adopted research strategy when "what" and "which" types of questions are required to be answered in research problem [39]. Our research problem deals with the "what" and "which" type of questions, so we will use survey as our research method.

4.4. Research Design

Our research design will be questionnaire based, since questionnaire is a best approach in a survey to collect the data. Our research deals with "what" and "which "type of questions so a questionnaire based survey is an appropriate research design to carry out. To conduct the survey a questionnaire was designed to collect data from offshore software development practitioners. Our survey questionnaire was consisted on the following themes.

- Communication modes/mediums and offshore software development activities
- Communication modes/mediums and cost of offshore software development

- Communication modes/mediums and schedule in offshore software development
- Communication modes/mediums and offshore software project development time-to-market
- Communication modes/mediums and customer and business satisfaction in offshore software development
- Communication modes/mediums and client-vendor trust in offshore software development

Our questionnaire was consisted on two parts. First part was to investigate that which communication modes/mediums are used in offshore software development. The second part of questionnaire was to investigate the success story by different offshore software development activities. The success story was investigated through five success factors including cost, schedule, time-to-market, customer and business satisfaction, and client-vendor trust.

Pilot Testing:

The survey questionnaire was floated for pilot testing before full launching. Among the targeted companies, eight companies responded. Changes and some corrections are also made on the basis of analysis of pilot responses.

4.5. Data Collection Sources and Methods

We have conducted the survey very carefully. Only those practitioners were approached for data collection those are involved in offshore communication and working on senior positions. Since data collection phase has some ethical and legal matters. So, all the responses were guaranteed to be kept confidential. To avoid unethical situations, no personal information was collected about company and the respondent. It was highly ensured that data will be kept confidential and only aggregate results will be published. Most of the respondents were interested to participate in the study because they were motivated that results and findings of the research study will be provided to them once it is completed. Data collection is usually divided into two categories, primary and secondary data [39]. The primary data is gathered by the researcher in order to address the problem at hand for the specific purpose. Secondary data is that data which has already been collected and is available in research journals, literature, papers, etc.

4.5.1. Primary Data

The primary data was collected from offshore software development companies of Pakistan to address the problem at hand. Our instrument for data collection was questionnaire distributed to the offshore software development companies of Pakistan. Our data collection source was the local software industry. We had a list of more than seventy software development companies which are engaged in offshore software development in Pakistan. For primary data collection we have targeted all these software companies. Since the intent of our study is to understand the impact of communication modes/mediums on success or failure of offshore software development, so those people are targeted in the survey who are involved in offshore communication with the client organizations. And for this, we have selected only those software companies of Pakistan which are doing offshore software development. For each of software Development Company, same questionnaire was distributed.

4.5.2. Secondary Data

The secondary data that we have used was collected from research papers, Internet sources, surveys conducted by other researchers, and journals.

4.6. Preparation and Validation of Questionnaire

We have prepared our survey questionnaire by following some general principles which are given below.

1) The length of questionnaire was very short so it was easy for the respondents to entertain the questionnaire.
2) The wording of questions was very simple so it was understandable for every respondent equally.
3) The questionnaire was designed in such a way that every respondent has same meaning and understanding of the questions.
4) Close ended questions were offered to the respondents in order to take very clear and precise answers.
5) Questionnaires were sent to respondents through emails so it was convenient for everybody to reply.

6) Questionnaire was designed as a word document, so there was no problem to open that file.

4.6.1. Reliability of Data

We have collected data from offshore software development companies of Islamabad, Rawalpindi, Lahore, and Karachi to cover the major cities of Pakistan where offshore software development projects are being developed. Questionnaire was sent through email therefore it was easy and flexible for the respondents to respond the questionnaire properly because they were given enough time to respond.

4.7. Objectives of the Research Survey

To conduct our research survey, we designed a questionnaire. This questionnaire contained closed ended questions. Following were the objectives of our research survey.

1) To identify most frequently used communication modes/mediums in offshore software development?
2) To investigate that overall how much offshore development companies are successful with respect to cost, schedule, time-to-market, customer and business satisfaction, and client-vendor trust?
3) To investigate the success of those companies which are using communication modes/mediums according to the classification given in chapter no. 3 (matching companies)?
4) To investigate the success of those companies which are not using communication modes/mediums according to the classification given in chapter no. 3 (mismatching companies)?
5) What is the impact of communication modes/mediums on success or failure of offshore software development?

4.8. Our Research Postulates

We have the following research postulate and five sub postulates to conduct our research study.

Our Postulate

The categorical mismatches between offshore software development activities and the communication modes/mediums used to perform those activities, negatively affect the success of offshore software development projects.

Our Sub Postulates

P1: The categorical mismatches between offshore software development activities and the communication modes/mediums used to perform those activities, negatively affect the **cost** of offshore software development projects.

P2: The categorical mismatches between offshore software development activities and the communication modes/mediums used to perform those activities, negatively affect the **schedule** of offshore software development projects.

P3: The categorical mismatches between offshore software development activities and the communication modes/mediums used to perform those activities, negatively affect the **time-to-market** of offshore software development projects.

P4: The categorical mismatches between offshore software development activities and the communication modes/mediums used to perform those activities, negatively affect the **customer and business satisfaction** of offshore software development projects.

P5: The categorical mismatches between offshore software development activities and the communication modes/mediums used to perform those activities, negatively affect the **client-vendor trust** of offshore software development projects.

4.9. Our Research Hypothesis

On the basis of our research postulates, we have established the following hypothesis

Hypothesis 1 for Success Comparison of Cost

Null Hypothesis Ho: The success of matching companies is less than mismatching companies with respect to cost.

Alternative Hypothesis H1: The success of matching companies is greater than mismatching companies with respect to cost.

Hypothesis 1 for Failure Comparison of Cost

Null Hypothesis Ho: The failure of matching companies is less than mismatching companies with respect to cost.

Alternative Hypothesis H1: The failure of matching companies is greater than mismatching companies with respect to cost.

Hypothesis 2 for Success Comparison of Schedule

Null Hypothesis Ho: The success of matching companies is less than mismatching companies with respect to schedule.

Alternative Hypothesis H1: The success of matching companies is greater than mismatching companies with respect to schedule.

Hypothesis 2 for Failure Comparison of Schedule

Null Hypothesis Ho: The failure of matching companies is less than mismatching companies with respect to schedule.

Alternative Hypothesis H1: The failure of matching companies is greater than mismatching companies with respect to schedule.

Hypothesis 3 for Success Comparison of Time-to-Market

Null Hypothesis Ho: The success of matching companies is less than mismatching companies with respect to time-to-market.

Alternative Hypothesis H1: The success of matching companies is greater than mismatching companies with respect to time-to-market.

Hypothesis 3 for Failure Comparison of Time-to-Market

Null Hypothesis Ho: The failure of matching companies is less than mismatching companies with respect to time-to-market.

Alternative Hypothesis H1: The failure of matching companies is greater than mismatching companies with respect to time-to-market.

Hypothesis 4 for Success Comparison of Customer and Business Satisfaction

Null Hypothesis Ho: The success of matching companies is less than mismatching companies with respect to customer and business satisfaction.

Alternative Hypothesis H1: The success of matching companies is greater than mismatching companies with respect to customer and business satisfaction.

Hypothesis 4 for Failure Comparison of Customer and Business Satisfaction

Null Hypothesis Ho: The failure of matching companies is less than mismatching companies with respect to customer and business satisfaction.

Alternative Hypothesis H1: The failure of matching companies is greater than mismatching companies with respect to customer and business satisfaction.

Hypothesis 5 for Success Comparison of Client-Vendor

Null Hypothesis Ho: The success of matching companies is less than mismatching companies with respect to client-vendor trust.

Alternative Hypothesis H1: The success of matching companies is greater than mismatching companies with respect to client-vendor trust.

Hypothesis 5 for Failure Comparison of Client-Vendor

Null Hypothesis Ho: The failure of matching companies is less than mismatching companies with respect to client-vendor trust.

Alternative Hypothesis H1: The failure of matching companies is greater than mismatching companies with respect to client-vendor trust.

4.10. Our Hypothetical Framework for OSD

In order to meet the communication challenges, existing research presented many approaches like creation of cross-site social networks, the interaction of communication technologies, explicit control mechanism and models for reducing the need for cross-site communication and coordination [36]. But here we have established an activity specific hypothetical framework to meet and address the challenges of communication in offshore software development. According to our hypothetical framework, activity-specific communication modes/mediums should be utilized in offshore software development in order to complete the project successfully. This hypothetical framework deals with offshore development activities and communication modes/mediums used to perform those activities. This hypothetical framework is established in order to investigate the impact of communication mode/mediums on success or failure of offshore software development. The following figure 4.1 shows our hypothetical framework.

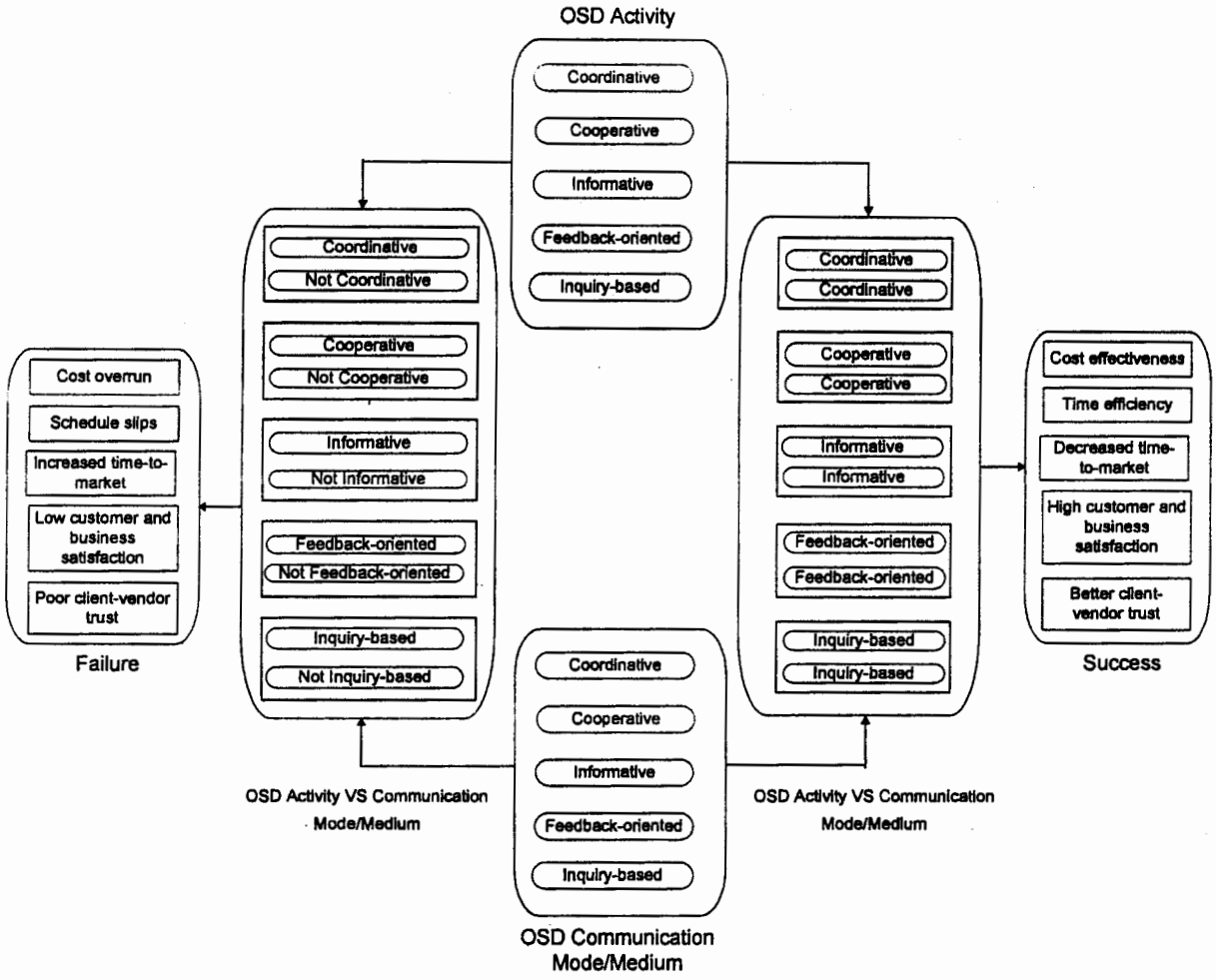


Figure.4.1. Hypothetical Framework for OSD

According to this framework, offshore software development has five success factors including cost effectiveness, timeliness, customer and business satisfaction, time-to-market, and trust between client and vendor.

This framework is established on the basis of individual communication needs of offshore software development activities. To find out the individual communication needs of offshore software development activities, we have categorized the communication modes/mediums and offshore software development activities in five categories. These categories include coordinative, cooperative, informative, feedback-oriented and inquiry-based.

Our framework represents that for successful OSD, each OSD activity should have a categorically correspondence with the communication modes/mediums, and otherwise we will lose the fruitfulness of offshoring the software projects. According to our framework, for successful offshore software development, a coordinative communication mode/medium for coordinative activities, a cooperative communication mode/medium for cooperative activities, an informative communication mode/medium for informative activities, a feedback-oriented communication mode/medium for feedback-oriented activities, and an inquiry-based communication mode/medium for inquiry-based activities should be used. In case of categorical non-correspondence between OSD activities and communication modes/mediums, our offshore success factors will be affected negatively, which results OSD failure.

Chapter No. 5

Survey Analysis

5.1. Introduction

In this chapter, we analyzed the survey data and drew some findings. In our analysis, we have tested our research postulate. Our research postulate describes that " the categorically mismatches between offshore software development activities and the communication modes/mediums used to perform those activities, negatively affect the success of offshore software development projects". This postulate is established on the basis of our classification of offshore software development activities (given in Table 3.3) and classification of communication modes/mediums (given in Table 3.4). To test the hypothesis we have specified five success factors of offshore software development. These factors include cost, schedule, time-to-market, customer and business satisfaction, and trust between client and vendor. On the basis of these success factors, we have established our sub postulates for the study. We have partially tested our sub postulates and analyzed the impact of communication modes/mediums on success or failure of offshore software development. For our survey we have specified 18 common offshore software development activities. These offshore software development activities are given in Table 3.1. In our study we have specified 10 communication modes/mediums along with an eleventh mode named as "others" which are commonly used in offshore software development. Those communication modes/mediums are given in Table 3.2.

5.2. Survey Analysis and Results

This chapter presents the survey analysis of the investigated companies of Pakistan. The survey analysis has been performed based on the classification of offshore software development activities and communication modes/mediums used to perform these activities given in chapter no. 3. In order to achieve the objectives of the survey, initially the data collected from all of the respondents was organized. In this section firstly, the demographic analysis of all the companies and the respondents is presented. Secondly, an analysis of offshore software development activities and communication modes/mediums is presented in tabular and graphical form. Thirdly the success and failure analysis of matching companies and mismatching companies is presented in the graphical form. Finally, success and failure comparison of matching companies and mismatching companies is presented in the results and discussion.

5.3. Demographic Analysis

In this section we have presented the demographic analysis of respondents. An overview of respondent designations is also presented in figure 5.1. We sent our survey questionnaire to seventy people of different companies. We got response from forty two respondents and the response rate was 60%. The average number of employees in an offshore software development company is 155. The average number of years of experience of a software development company in software development is 9 and the average number of years of experience of the software development company in offshore software development is 8. Among the respondents, almost all the respondents were experienced. Among the respondents, there were seven project managers, two Software designers/architects, twelve Senior Software Engineers, nine QA Mangers, six Team leads, one Database manager, one director technical , one CEO, one Manager Maintenance, one CTO and one PS Consultant. The average number of years of experience of a respondent is 6 and the average number of years of experience of a respondent in offshore software development is 5. The table 5.1 contains the demographic analysis of respondents and table 5.2 contains analysis of company experience and respondent experience in software development and in offshore software development. The respondents' statistics is represented by the following pi chart shown in fig. 5.1.

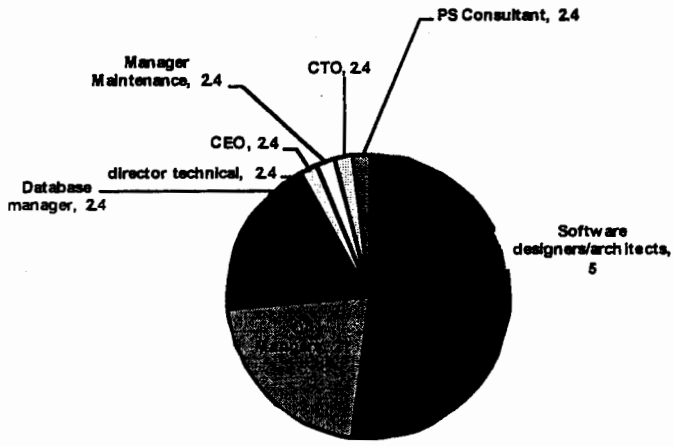


Figure 5.1: Demographic Analysis of the Respondents

Respondent	Frequency	Percentage
Project Managers	7	17
Software Designers/Architects	2	5
Senior Software Engineers	12	29
QA Mangers	9	21
Team leads	6	14
Database Manager	1	2.4
Director Technical	1	2.4
CEO	1	2.4
Manager Maintenance	1	2.4
CTO	1	2.4
PS Consultant	1	2.4

Table 5.1: Respondents Demo Graphic Table

Company/Respondent	Avg. S/W Development Experience	Average OSD Experience
Company	9	6
Respondent	8	5

Table 5.2: Company and Respondents Experience

5.4. Communication Modes/mediums Used in OSD Activities

In this section an analysis is given about the offshore software development activities and the communication modes/mediums used to perform those activities. The table 5.3 shows the frequencies of communication modes/mediums used for different offshore software development activities. The data presented in this table is collected through the questions (Q1, Q2, Q3... Q17, Q18) of the questionnaire. This table shows the most commonly used and least commonly used communication modes/mediums used for the individual offshore software development activities. The frequencies of communication modes/mediums used for various offshore software development activities are also graphical represented in the graph 5.2(a), 5.2 (b) and 5.2 (c).

The Figure 5.2 (a) shows that most commonly used communication mode/mediums for contract negotiation is email, face-to-face, and phone and fax respectively and the least commonly used communication mode is web repository. For requirement elicitation the most commonly used communication modes are email, face-to-face, and phone and fax respectively and the least commonly used communication mode is web interactive TV. For requirement verification and validation the most commonly used communication modes/mediums are email, face-to-face, and phone and fax respectively and the least commonly used communication mode is net meeting. For requirement specification the most commonly used communication modes/mediums are email, chatting, and face-to-face respectively and the least commonly used communication mode is web interactive TV. For resolving ambiguities from requirements document the most commonly used communication modes/mediums are email, teleconferencing, and chatting respectively and the least commonly used communication mode is net meeting. For requirement change the most commonly used communication modes/mediums are email, phone and fax, and teleconferencing respectively and the least commonly used communication mode is web interactive TV.

Communication Modes/mediums Used in OSD Activities

Offshore Software Development Activities	Communication Modes/mediums										
	Face-to-face	Videoconferencing	Teleconferencing	Email	Discussion Board	Chatting	Web-based Collaborative Tools	Web-repository	Phone & fax	Net meeting	Any others
Contract negotiation	24	5	12	30	5	5	0	2	14	3	0
Requirements elicitation	24	4	15	33	8	5	2	9	12	4	0
Requirements verification & validation	14	3	10	35	7	13	1	8	12	9	0
Requirements specification	17	3	11	37	8	18	1	10	13	4	1
Resolving ambiguities from requirements document	9	7	16	35	7	15	2	6	15	7	0
Requirements change	11	3	14	35	5	10	0	8	14	5	2
Scope change	12	4	12	30	7	12	2	8	17	5	2
Design communication	11	5	11	27	9	8	5	10	12	2	1
Resolving design conflicts	12	3	13	23	9	9	1	3	13	8	5
Client's acceptance testing	12	2	11	24	6	12	0	7	7	6	3
Client-vendor artifacts review	11	3	10	28	7	8	1	14	11	3	2
Code walkthroughs and inspections	20	1	7	23	7	13	2	8	6	4	3
Initiating software maintenance	8	0	6	32	6	11	6	6	8	3	1
Budget and schedule tracking	9	2	7	25	9	12	1	4	15	5	1
User support	12	5	15	34	6	19	8	7	13	4	2
Status review meetings	13	2	15	26	5	9	2	10	14	5	0
Top management reviews	20	4	10	25	5	8	3	6	13	3	0
Service level audits	14	4	7	20	6	12	1	8	11	5	2

Table 5.3: OSD Activities Vs Communication Modes/Mediums

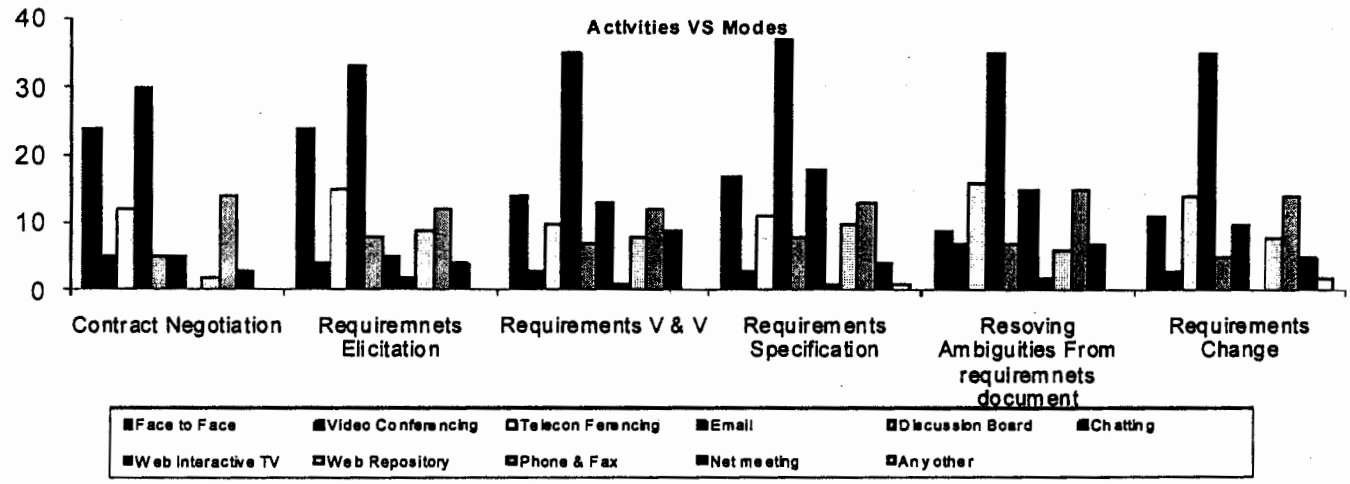
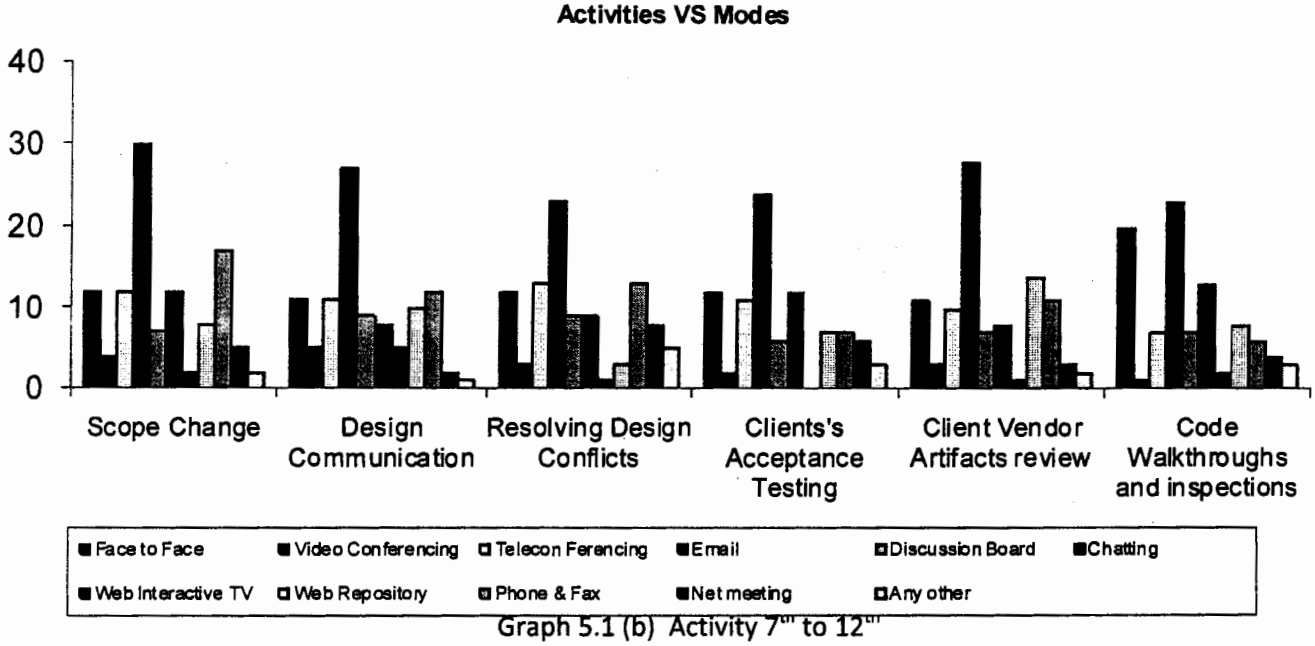


Figure 5.2 (a): Activity (1st to 6th) Vs Communication Modes/mediums

The figure 5.2 (b) shows that most commonly used communication mode for scope change is email, phone and fax, and face-to-face respectively and the least commonly used communication mode is web interactive TV. For design communication the most commonly used communication modes/mediums are email, phone and fax, and face-to-face respectively and the least commonly used communication mode is net meeting. For resolving design conflicts and validation the most commonly used communication modes/mediums are email, phone and fax, and teleconferencing respectively and the least commonly used communication mode is web interactive TV. For client's acceptance testing the most commonly used communication modes/mediums are email, face-to-face, and chatting respectively and the least commonly used communication mode is web interactive TV. For client-vendor artifacts review the most commonly used communication modes/mediums are email, web repository, and phone and fax respectively and the least commonly used communication mode is web interactive TV. For code walkthroughs and inspections the most commonly used communication modes/mediums are email, face-to-face, and chatting respectively and the least commonly used communication mode is videoconferencing.



Graph 5.1 (b) Activity 7th to 12th

Figure 5.2 (b): Activity (7th to 12th) Vs Communication Modes/mediums

The figure 5.2 (c) shows that most commonly used communication mode for initiating software maintenance is email, chatting, and phone and fax respectively and the least commonly used communication mode is videoconferencing. For budget and schedule tracking the most commonly used communication modes/mediums are email, phone and fax, and chatting respectively and the least commonly used communication mode is web interactive TV. For user support and validation the most commonly used communication modes/mediums are email, chatting, and teleconferencing respectively and the least commonly used communication mode is net meeting. For status review meeting the most commonly used communication modes are email, teleconferencing, and phone and fax respectively and the least commonly used communication mode is videoconferencing. For top management review the most commonly used communication modes/mediums are email, face-t-face, and phone and fax respectively and the least commonly used communication mode is net meeting. For service level audits the most

commonly used communication modes/mediums are email, face-to-face, and chatting respectively and the least commonly used communication mode is web interactive TV.

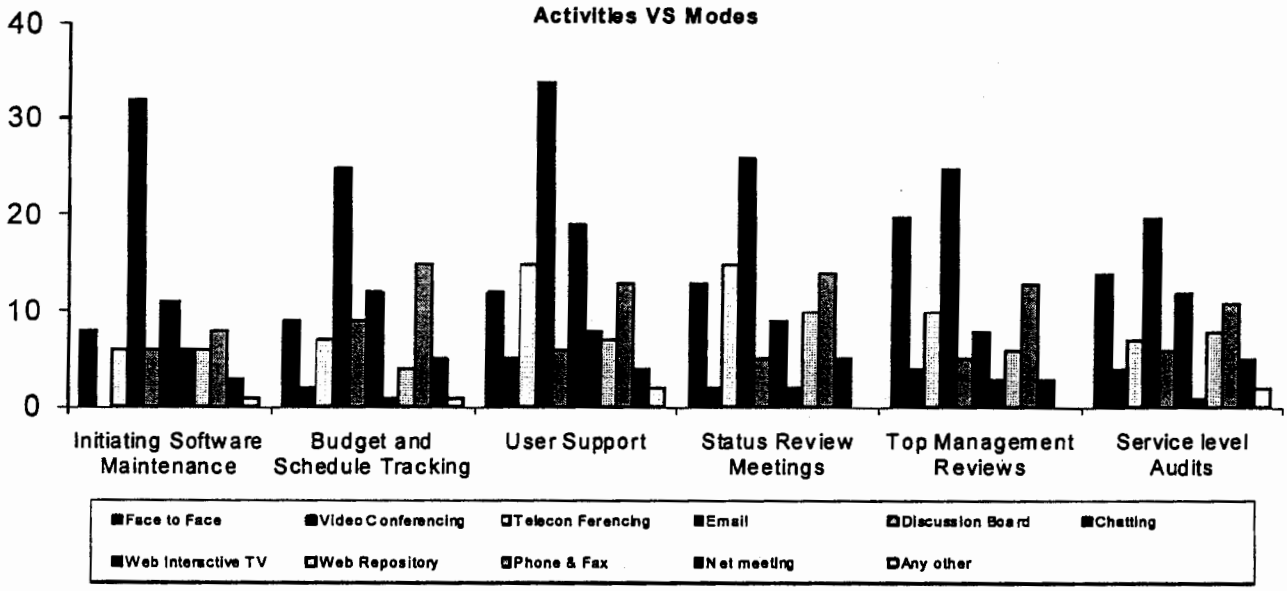


Figure 5.2 (c): Activity (13^{th} to 18^{th}) Vs Communication Modes/mediums

On the basis of the above graphs and the data presented in the table 5.3, we have categorized our respondent companies into two categories.

I) Matching companies

II) Mismatching companies

The companies which are using communication modes/mediums according to the classification given in chapter no. 3 are called matching companies and the companies which are not using communication modes/mediums according to the classification given in chapter no. 3 are called mismatching companies. From the above data collected from the respondents we found that there are 19 matching companies and 23 mismatching companies.

5.5. Success and Failure of Matching and Mismatching Companies

In this section an overview of success and failure of matching companies and an overview of success and failure of mismatching companies is presented. The success of matching companies

and mismatching companies is studied and investigated with respect to five parameters including cost, schedule, time-to-market, customer and business satisfaction, and client-vendor trust. The figure 5.3 (a) shows the success and failure of matching and mismatching companies with respect to cost, figure 5.3 (b) shows the success and failure of matching and mismatching companies with respect to schedule, figure 5.3 (c) shows the success and failure of matching and mismatching companies with respect to time-to-market, figure 5.3 (d) shows the success and failure of matching and mismatching companies with respect to customer and business satisfaction, and figure 5.3 (e) shows the success and failure of matching and mismatching companies with respect to client-vendor trust.

In the given below tables, Q19, Q20, Q21... Q42, Q43 are referring to the questions of the questionnaire regarding cost, schedule, time-to-market, customer and business satisfaction, and client-vendor trust in offshore software development.

5.5.1. Success and Failure with Respect to Cost

The graph in the figure 5.3 (a) shows the mean of success frequency and mean of failure frequency of matching and mismatching companies with respect to cost. According to the table 5.4 the mean success frequency of matching companies is 2.53 and mismatching companies is 2.0 which are showing that matching companies are more successful than mismatching companies with respect to cost. In the same way we have investigated the failure frequency of matching and mismatching companies with respect to cost. According to table 5.6 and table 5.7 the mean failure frequency of matching companies is 2.53 and mismatching companies is 3.04 which are showing that failure rate of matching companies is less than failure of mismatching companies with respect to cost. The success and failure frequencies of matching and mismatching companies are also represented graphically in the figure 5.3 (a).

Success frequencies of Matching and Mismatching Companies with respect to cost

Company Type	Q19	Q20	Q21	Q34	Q39	Total
Matching	12	15	6	0	15	48
Mismatching	6	18	6	3	13	46

Table 5.4

Total no. of matching companies = 19

Mean success frequency of matching companies = 48/19 = 2.53

Total no. of mismatching companies = 23

Mean success frequency of mismatching companies = 46/23 = 2.00

Failure frequencies of Matching and Mismatching Companies with respect to cost

Company Type	Q19	Q20	Q21	Q34	Q39	Total
Matching	7	4	13	19	5	48
Mismatching	17	5	17	20	11	70

Table 5.5

Total no. of matching companies = 19

Mean failure frequency of matching companies = 48/19 = 2.53

Total no. of mismatching companies = 23

Mean failure frequency of mismatching companies = 70/23 = 3.04

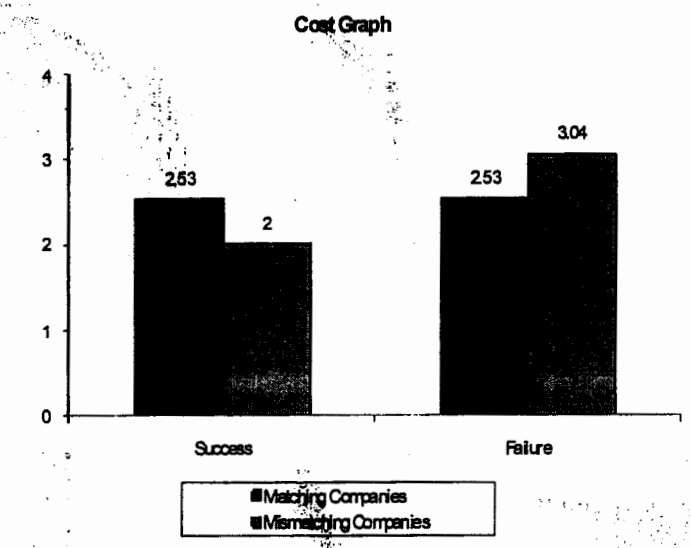


Figure 5.3 (a): Cost Analysis

In order to investigate the success and failure of matching and mismatching companies with respect to cost, we have applied a statistical test "Z-test" on the data given in table 5.4 and table 5.5. For this test we have established the following hypothesis for success comparison.

Null Hypothesis Ho: The success of matching companies is less than mismatching companies with respect to cost.

Alternative Hypothesis H1: The success of matching companies is greater than mismatching companies with respect to cost.

For this test we got the value of Z= 2.0.

We set level of significance $\alpha = 0.05$. We have $1- \alpha = 1-0.05 = .95$

We got the value of Z from the value table as $Z_{.95} = 1.645$

Since the value of Z=2.0 which is greater than 1.645 so we reject the null hypothesis Ho and accept alternative hypothesis H1.

For failure comparison of matching and mismatching companies we have established the following hypothesis.

Null Hypothesis Ho: The failure of matching companies is less than mismatching companies with respect to cost.

Alternative Hypothesis H1: The failure of matching companies is greater than mismatching companies with respect to cost.

For this test we got the value of Z= -6.38.

We set level of significance $\alpha = 0.05$. We have $1- \alpha = 1-0.05 = .95$

We got the value of Z from the value table as $Z_{.95} = 1.645$

Since the value of Z=-6.38 which is less than 1.645 so we accept the null hypothesis Ho and reject the alternative hypothesis H1

The success and failure of matching and mismatching companies with respect to cost differed significantly.

5.5.2. Success and Failure with Respect to Schedule

The graph in the figure 5.3 (b) shows the mean of success frequency and the mean of failure frequency of matching and mismatching companies with respect to schedule. According to the table 5.6 the mean success frequency of matching companies is 2.26 and mismatching companies is 2.09 which are showing that matching companies are more successful than mismatching companies with respect to schedule. In the same way we have investigated the failure frequency

of matching and mismatching companies with respect to schedule. According to table 5.7 the mean failure frequency of matching companies is 2.84 and mismatching companies is 3.0 which are showing that failure rate of matching companies is less than failure of mismatching companies with respect to schedule. The success and failure frequencies of matching and mismatching companies with respect to schedule are also represented graphically in the figure 5.3 (b).

Success frequencies of Matching and Mismatching Companies with respect to Schedule

Company Type	Q22	Q23	Q24	Q35	Q40	Total
Matching	7	14	9	2	11	43
Mismatching	11	16	4	1	16	48

Table 5.6

Total no. of matching companies = 19

Mean success frequency of matching companies = 43/19 = 2.26

Total no. of mismatching companies = 23

Mean success frequency of mismatching companies = 48/23 = 2.09

Failure frequencies of Matching and Mismatching Companies with respect to Schedule

Company Type	Q22	Q23	Q24	Q35	Q40	Total
Matching	12	6	10	17	9	64
Mismatching	12	7	19	22	9	69

Table 5.7

Total no. of matching companies = 19

Mean failure frequency of matching companies = 64/19 = 2.84

Total no. of mismatching companies = 23

Mean failure frequency of mismatching companies = 69/23 = 3.00

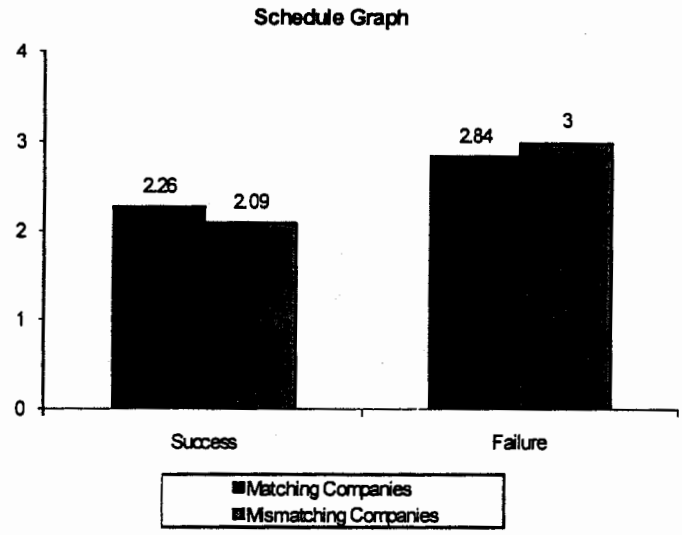


Figure 5.3 (b): Schedule Analysis

In order to investigate the success and failure of matching and mismatching companies with respect to schedule, we have applied a statistical test "Z-test" on the data given in table 5.6 and table 5.7. For this test we have established the following hypothesis for success comparison.

Null Hypothesis Ho: The success of matching companies is less than mismatching companies with respect to schedule.

Alternative Hypothesis H1: The success of matching companies is greater than mismatching companies with respect to schedule.

For this test we got the value of Z= 1.83

We set level of significance $\alpha = 0.05$. We have $1-\alpha = 1-0.05 = .95$

We got the value of Z from the value table as $Z_{.95} = 1.645$

Since the value of Z= 1.83 which is greater than 1.645 so we reject the null hypothesis Ho and accept alternative hypothesis H1.

For failure comparison of matching and mismatching companies we have established the following hypothesis.

Null Hypothesis Ho: The failure of matching companies is less than mismatching companies with respect to schedule.

Alternative Hypothesis H1: The failure of matching companies is greater than mismatching companies with respect to schedule.

For this test we got the value of Z= -2.04

We set level of significance $\alpha = 0.05$. We have $1-\alpha = 1-0.05 = .95$

We got the value of Z from the value table as $Z_{.95} = 1.645$

Since the value of Z=-2.04 which is less than 1.645 so we accept the null hypothesis Ho and reject the alternative hypothesis H1

The test result shows that the difference of success and failure of matching and mismatching companies with respect to schedule is significant.

5.5.3. Success and Failure with Respect to Time-to-Market

The graph in the figure 5.3 (c) shows the mean of success frequency and the mean of failure frequency of matching and mismatching companies with respect to time-to-market. According to the table 5.8 the mean success frequency of matching companies is 2.16 and mismatching companies is 2.13 which are showing that matching companies are more successful than mismatching companies with respect to time-to-market. In the same way we have investigated the failure frequency of matching and mismatching companies with respect to time-to-market. According to table 5.9 the mean failure frequency of matching companies is 2.84 and mismatching companies is 2.91 which are showing that failure rate of matching companies is less than failure of mismatching companies with respect to time-to-market. The success and failure frequencies of matching and mismatching companies with respect to time-to-market are also represented graphically in the figure 5.3 (c).

Success frequencies of Matching and Mismatching Companies with respect to Time-to-market

Company Type	Q25	Q26	Q27	Q36	Q41	Total
Matching	11	11	6	1	12	41
Mismatching	14	14	6	4	11	49

Table 5.8

Total no. of matching companies = 19

Mean success frequency of matching companies = 41/19 = 2.16

Total no. of mismatching companies = 23

Mean success frequency of mismatching companies = 49/23 = 2.13

Failure frequencies of Matching and Mismatching Companies with respect to Time-to-market

Company Type	Q25	Q26	Q27	Q36	Q41	Total
Matching	8	8	13	18	7	54
Mismatching	10	8	17	19	13	67

Table 5.9

Total no. of matching companies = 19

Mean failure frequency of matching companies = 54/19 = 2.84

Total no. of mismatching companies = 23

Mean failure frequency of mismatching companies = 67/23 = 2.91

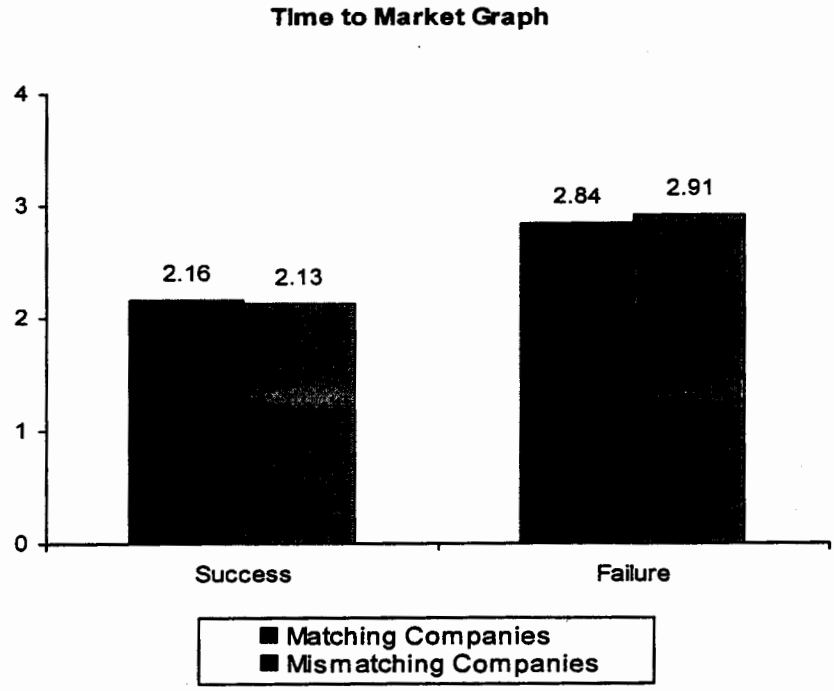


Figure 5.3 (c): Time-to-Market Analysis

In order to investigate the success and failure of matching and mismatching companies with respect to time-to-market, we have applied a statistical test "Z-test" on the data given in table 5.8 and table 5.9. For this test we have established the following hypothesis for success comparison.

Null Hypothesis Ho: The success of matching companies is less than mismatching companies with respect to time-to-market.

Alternative Hypothesis H1: The success of matching companies is greater than mismatching companies with respect to time-to-market.

For this test we got the value of Z= 0.61

We set level of significance $\alpha = 0.05$. We have $1-\alpha = 1-0.05 = .95$

We got the value of Z from the value table as $Z_{.95} = 1.645$

Since the value of Z= 0.61 which is less than 1.645 so we accept the null hypothesis Ho and reject alternative hypothesis H1.

For failure comparison of matching and mismatching companies we have established the following hypothesis.

Null Hypothesis Ho: The failure of matching companies is less than mismatching companies with respect to time-to-market.

Alternative Hypothesis H1: The failure of matching companies is greater than mismatching companies with respect to time-to-market.

For this test we got the value of Z= -1.27

We set level of significance $\alpha = 0.05$. We have $1-\alpha = 1-0.05 = .95$

We got the value of Z from the value table as $Z_{.95} = 1.645$

Since the value of Z=-1.27 which is less than 1.645 so we accept the null hypothesis Ho and reject the alternative hypothesis H1

The test result shows that the difference of success and failure of matching and mismatching companies with respect to time-to-market is insignificant.

5.5.4. Success and Failure with Respect to Customer and Business Satisfaction

The graph in the figure 5.3 (d) shows the mean of success frequency and the mean of failure frequency of matching and mismatching companies with respect to customer and business satisfaction. According to the table 5.10 the mean success frequency of matching companies is 2.74 and mismatching companies is 2.04 which are showing that matching companies are more successful than mismatching companies with respect to customer and business satisfaction. In the same way we have investigated the failure frequency of matching and mismatching companies with respect to customer and business satisfaction. According to table 5.11 the mean failure frequency of matching companies is 2.58 and mismatching companies is 3.04 which are

showing that failure rate of matching companies is less than failure rate of mismatching companies with respect to customer and business satisfaction. The success and failure frequencies of matching and mismatching companies with respect to customer and business satisfaction are also represented graphically in the figure 5.3 (d).

Success frequencies of Matching and Mismatching Companies with respect to customer & business satisfaction

Company Type	Q28	Q29	Q30	Q37	Q42	Total
Matching	13	9	7	9	14	52
Mismatching	10	11	5	10	11	47

Table 5.10

Total no. of matching companies = 19

Mean success frequency of matching companies = 52/19 = 2.74

Total no. of mismatching companies = 23

Mean success frequency of mismatching companies = 47/23 = 2.04

Failure frequencies of Matching and Mismatching Companies with respect to customer & business satisfaction

Company Type	Q28	Q29	Q30	Q37	Q42	Total
Matching	6	10	12	16	5	49
Mismatching	12	9	18	21	10	70

Table 5.11

Total no. of matching companies = 19

Mean failure frequency of matching companies = 49/19 = 2.58

Total no. of mismatching companies = 23

Mean failure frequency of mismatching companies = 70/23 = 3.04

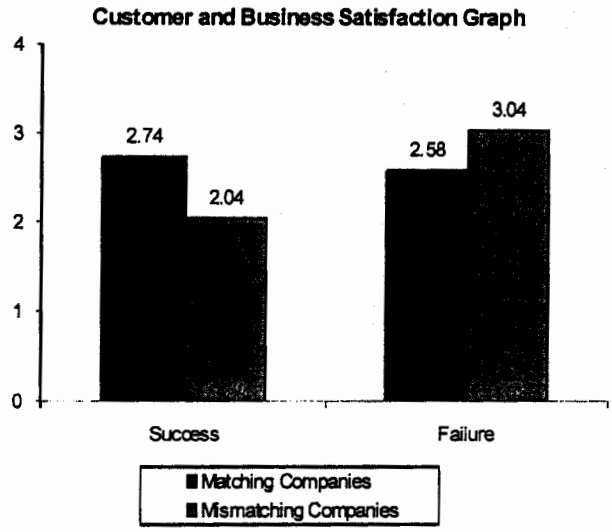


Figure 5.3 (d): Customer and Business Satisfaction Analysis

In order to investigate the success and failure of matching and mismatching companies with respect to customer and business satisfaction, we have applied a statistical test "Z-test" on the data given in table 5.6 and table 5.7. For this test we have established the following hypothesis for success comparison.

Null Hypothesis Ho: The success of matching companies is less than mismatching companies with respect to customer and business satisfaction.

Alternative Hypothesis H1: The success of matching companies is greater than mismatching companies with respect to customer and business satisfaction.

For this test we got the value of Z= 1.66

We set level of significance $\alpha = 0.05$. We have $1- \alpha= 1-0.05= .95$

We got the value of Z from the value table as $Z_{.95}= 1.645$

Since the value of Z= 1.66 which is greater than 1.645 so we reject the null hypothesis Ho and accept alternative hypothesis H1.

For failure comparison of matching and mismatching companies we have established the following hypothesis.

Null Hypothesis Ho: The failure of matching companies is less than mismatching companies with respect to customer and business satisfaction.

Alternative Hypothesis H1: The failure of matching companies is greater than mismatching companies with respect to customer and business satisfaction.

For this test we got the value of Z= -2.58

We set level of significance $\alpha = 0.05$. We have $1-\alpha = 1-0.05 = .95$

We got the value of Z from the value table as $Z_{.95} = 1.645$

Since the value of Z=-2.58 which is less than 1.645 so we accept the null hypothesis Ho and reject the alternative hypothesis H1

The test result shows that the difference of success and failure of matching and mismatching companies with respect to customer and business satisfaction is significant.

5.5.5. Success and Failure with Respect to Client-Vendor Trust

The graph in the figure 5.3 (e) shows the mean of success frequency and the mean of failure frequency of matching and mismatching companies with respect to client-vendor trust. According to the table 5.12 the mean success frequency of matching companies is 2.90 and mismatching companies is 2.39 which are showing that matching companies are more successful than mismatching companies with respect to client-vendor trust. In the same way we have investigated the failure frequency of matching and mismatching companies with respect to client-vendor trust. According to table 5.13 the mean failure frequency of matching companies is 2.11 and mismatching companies is 2.35 which are showing that failure rate of matching companies is less than failure rate of mismatching companies with respect to client-vendor trust. The success and failure frequencies of matching and mismatching companies with respect to client-vendor trust are also represented graphically in the figure 5.3 (e).

Success frequencies of Matching and Mismatching Companies with respect to client-vendor trust

Company Type	Q31	Q32	Q33	Q38	Q43	Total
Matching	13	15	8	4	15	55
Mismatching	12	13	12	8	10	55

Table 5.12

In order to investigate the success and failure of matching and mismatching companies with respect to client-vendor trust, we have applied a statistical test "Z-test" on the data given in table 5.12 and table 5.13. For this test we have established the following hypothesis for success comparison.

Null Hypothesis Ho: The success of matching companies is less than mismatching companies with respect to client-vendor trust.

Alternative Hypothesis H1: The success of matching companies is greater than mismatching companies with respect to client-vendor trust.

For this test we got the value of Z= 1.96

We set level of significance $\alpha = 0.05$. We have $1-\alpha = 1-0.05 = .95$

We got the value of Z from the value table as $Z_{.95} = 1.645$

Since the value of Z= 1.96 which is greater than 1.645 so we reject the null hypothesis Ho and accept alternative hypothesis H1.

For failure comparison of matching and mismatching companies we have established the following hypothesis.

Null Hypothesis Ho: The failure of matching companies is less than mismatching companies with respect to client-vendor trust.

Alternative Hypothesis H1: The failure of matching companies is greater than mismatching companies with respect to client-vendor trust.

For this test we got the value of Z= -0.35

We set level of significance $\alpha = 0.05$. We have $1-\alpha = 1-0.05 = .95$

We got the value of Z from the value table as $Z_{.95} = 1.645$

Since the value of Z=-0.35 which is less than 1.645 so we accept the null hypothesis Ho and reject the alternative hypothesis H1

The test result shows that the difference of success and failure of matching and mismatching companies with respect to client-vendor trust.

5.6. Covariance between Offshore Software Development Success Factors

Before covariance analysis of offshore software development success factors, we discuss about covariance and its types.

Covariance:

For two random variables A1 and A2 having means E(A1) and E(A2), the covariance is defined as follows.

$$\text{Cov}(A1, A2) = E[\{A1-E(A1)\}\{A2-E(A2)\}]$$

The covariance is calculated with pairs of A1 and A2, takes their differences from their mean values and multiplies their differences. For instance, if for A11 and A21 this product is positive, for that pair of data points the values of A1 and A2 have varied together in the same direction from the means. If the product is negative, they have varied in opposite directions. The larger the magnitude of the product, the stronger the strength of the relation. The covariance is defined as the mean value of this product, calculated using each pair of data A1i and A2j. If the covariance is zero, then the cases in which the product was positive were offset by those in which it was negative, and there is no linear relationship between the two random variables. Computationally, it is more efficient to use the following formula to calculate the covariance.

$$\text{Cov}(A1, A2) = E(A1A2)-E(A1)(A2)$$

The value of covariance is interpreted as:

Positive Covariance:

Indicates the higher than average values of one variable tend to be paired with higher than average values of the other variable.

Negative Covariance:

Indicates the higher than average values of one variable tend to be paired with lower than average values of the other variable.

Zero Covariance:

If the two random variables are independent, the covariance will be zero. However a variance of zero does not necessarily means that the variables are independent. A nonlinear relationship can exist that still would result in covariance value of zero.

5.6.1. Covariance Analysis of Success Factors for Successful Cases

We have assumed the codes for different success factors. Let A1 for cost, A2 for schedule, A3 for time-to-market, A4 for customer and business satisfaction, and A5 for client-vendor trust. Following are the frequencies of different success factors in successful cases.

A1	A2	A3	A4	A5
18	16	25	27	37
30	27	28	37	38
11	12	12	25	31
19	16	19	21	26
15	15	16	15	18

Table 5.14: Frequencies of different success factors in successful cases

Now we have a detailed covariance analysis of all the success factors with other factors individually.

1) Covariance between Cost and Schedule in Offshore Software Development Projects

Cov (A1, A2) = E (A1A2) – E (A1) E (A2)

E (A1A2) = (18 X 16 +30X27+11X12+19X16+15X15)/5

= (288+810 +132+304+225) / 5

= 1759/5

= 351.8

E (A1A2) = 16.6 X17.2

= 319.92

Cov (A1, A2) = E (A1A2)-E (A1) E (A2)

=351.8-319.92

Cov (A1, A2) =31.88

The above result shows that cost and schedule in offshore software development projects has a linear relationship.

2) Covariance between Cost and Time-to-Market in Offshore Software Development Projects

Cov (A1, A3) = E (A1A3) – E (A1) E (A3)

E (A1A3) = (18X25+30X28+11X12+19X19+15X16)/5

= (450+840+132+361+240)/5

= 2023/5

= 404.6

E (A1) E (A3) = 18.6X20

= 372

Cov (A1, A3) = E (A1A3)-E (A1) E (A3)

= 404.6-372

Cov (A1, A3) = 32.6

The above result shows that cost and time-to-market in offshore software development projects has a linear relationship.

3) Covariance between Cost and Customer and Business Satisfaction in Offshore Software Development Projects

Cov (A1, A4) = E (A1A4) – E (A1) E (A4)

E (A1A4) = (18X27+30X37+11X25+19X21+15X15)/5

= (486+110+275+399+225)/5

= 2495/5

= 499

E (A1) E (A4) =18.6X25

= 465

Cov (A1, A4) = E (A1A4)-E (A1) E (A4)

=499-465

Cov (A1, A4) =34

The above result shows that cost and customer and business satisfaction in offshore software development projects has a linear relationship.

4) Covariance between Cost and Client-vendor Trust in Offshore Software Development Projects

Cov (A1, A5) = E (A1A5) – E (A1) E (A5)

E (A1A5) = (18X37+30X38+11X31+19X26+15X18)/5

= (666+1140+341+494+270)/5

= 2911/5

= 582.2

E (A1) E (A5) =18.6X30

= 558

Cov (A1, A5) = E (A1A5)-E (A1) E (A5)

= 582.2-558

Cov (A1, A5) = 24.2

The above result shows that cost and client-vendor trust in offshore software development projects has a linear relationship.

5) Covariance between Schedule and Time-to-market in Offshore Software Development Projects

Cov (A2, A3) = E (A2A3) – E (A2) E (A3)

E (A2A3) = (16X25+27X28+12X12+16X19+15X16)/5

= (400+756+144+304+240)/5

= 1844/5

= 368.8

E (A2) E (A3) = 17.2X20

= 344

Cov (A2, A3) = E (A2A3)-E (A2) E (A3)

=368.8-344

Cov (A2, A3) = 24.8

The above result shows that schedule and time-to-market in offshore software development projects has a linear relationship.

6) Covariance between Schedule and Customer and Business Satisfaction in Offshore Software Development Projects

Cov (A2, A4) = E (A2A4) – E (A2) E (A4)

E (A2A4) = (16X27+27X37+12X25+16X21+15X15)/5

= (432+999+300+336+225)/5

= 2292/5

= 458.4

E (A2A4) = 17.2X25

= 430

Cov (A2, A4) = E (A2A4)-E (A2) E (A4)

= 458.4-430

Cov (A2, A4) = 28.4

The above result shows that schedule customer and business satisfaction in offshore software development projects has a linear relationship.

7) Covariance between Schedule and Client-Vendor Trust in Offshore Software Development Projects

Cov (A2, A5) = E (A2A5) – E (A2) E (A5)

E (A2A5) = (16X37+27X38+12X31+16X26+15X18)/5

= (592+1026+372+416+225)/5

= 2651/5

= 530.2

E (A2A5) = 17.2X30

= 516

Cov (A2, A5) = E (A2A5)-E (A2) E (A5)

= 530.2-516

Cov (A2, A5) = 14.2

The above result shows that schedule and client-vendor trust in offshore software development projects has a linear relationship.

8) Covariance between Time-to-Market and Customer and Business Satisfaction in Offshore Software Development Projects

Cov (A3, A4) = E (A3A4) – E (A3) E (A4)

E (A3A4) = (25X27+28X37+12X25+19X21+16X15)/5

= (675+1036+300+399+240)/5

= 2650/5

= 530

E (A3) E (A4) = 20X25

= 500

Cov (A3, A4) = E (A3A4)-E (A3) E (A4)

= 530-500

Cov (A3, A4) = 30

The above result shows that time-to-market, and customer and business satisfaction in offshore software development projects has a linear relationship.

9) Covariance between Time-to-Market and Client-Vendor Trust in Offshore Software Development Projects

Cov (A3, A5) = E (A3A5) – E (A3) E (A5)

E (A3A5) = (25X37+28X38+12X31+19X26+16X18)/5

= (925+1064+372+494+288)/5

= 3143/5

= 628.6

E (A3A5) = 20X30

= 600

Cov (A3, A5) = E (A3A5)-E (A3) E (A5)

= 628.6-600

Cov (A3, A5) = 28.6

The above result shows that time-to-market and client-vendor trust in offshore software development projects has a linear relationship.

10) Covariance between Customer and Business Satisfaction and Client-Vendor Trust in Offshore Software Development Projects

Cov (A4, A5) = E (A4A5) – E (A4) E (A5)

E (A4A5) = (27X37+37X38+25X31+21X26+15X18)/5

= (999+1406+775+546+270)/5

= 3996/5

= 798.4

E (A4A5) = 25X30

= 750

Cov (A4, A5) = E (A4A5)-E (A4) E (A5)

= 798.4-750

Cov (A4, A5) =48.4

The above result shows that customer and business satisfaction and client-vendor trust in offshore software development projects has a linear relationship.

5.6.2. Covariance Analysis of Success Factors for Failure Cases

We have assumed the codes for different success factors in order to have covariance analysis in failure cases. Let B1 for cost, B2 for schedule, B3 for time-to-market, B4 for customer and business satisfaction, and B5 for client-vendor trust. Following are the frequencies of different success factors in failure cases.

B1	B2	B3	B4	B5
24	26	17	19	15
12	15	14	20	10
31	31	30	31	20
23	26	23	21	30
27	27	26	27	25

Table 5.15: Frequencies of different success factors in failure cases

Now we have a detailed covariance analysis of all the success factors with other factors individually.

11) Covariance between Cost and Schedule in Offshore Software Development Projects

Cov (B1, B2) = E (B1B2) – E (B1) E (B2)

E (B1B2) = (24X26+12X15+31X31+23X26+27X27)/5

= 3092/5

= 618.4

E (B1) E (B2) = 23.4X25

= 585

Cov (B1, B2) = E (B1B2)-E (B1) E (B2)

= 618.4-585

Cov (B1, B2) = 33.4

The above result shows that cost and schedule in offshore software development projects has a linear relationship.

12) Covariance between Cost and Time-to-market in Offshore Software Development Projects

Cov (B1, B3) = E (B1B3) – E (B1) E (B3)

E (B1B3) = (24X17+12X14+31X30+23X23+27X26)/5

= 2737/5

= 547.4

E (B1) E (B3) = 23.4X22

= 514.8

Cov (B1, B3) = E (B1B3)-E (B1) E (B3)

= 547.4-514.8

Cov (B1, B3) = 32.6

The above result shows that cost and time-to-market in offshore software development projects has a linear relationship.

13) Covariance between Cost and Customer and Business Satisfaction in Offshore Software Development Projects

Cov (B1, B4) = E (B1B4) – E (B1) E (B4)

E (B1B4) = (24X19+12X20+31X31+23X21+27X27)/5

= 2869/5

= 573.8

E (B1) E (B4) = 23.4X23.6

= 552.24

Cov (B1, B4) = E (B1B4)-E (B1) E (B4)

= 573.8-552.24

Cov (B1, B4) = 21.56

The above result shows that cost and customer and business satisfaction in offshore software development projects has a linear relationship.

14) Covariance between Cost and Client-Vendor Trust in Offshore Software Development Projects

Cov (B1, B5) = E (B1B5) – E (B1) E (B5)

E (B1B5) = (24X15+12X10+31X20+23X30+27X25)/5

= 2465/5

= 493

E (B1) E (B5) = 23.4X20

= 468

Cov (B1, B5) = E (B1B5)-E (B1) E (B5)

= 493-468

Cov (B1, B5) = 25

The above result shows that cost and client-vendor trust in offshore software development projects has a linear relationship.

15) Covariance between Schedule and Time-to-market in Offshore Software Development Projects

Cov (B2, B3) = E (B2B3) – E (B2) E (B3)

E (B2B3) = (26X17+15X14+31X30+26X23+27X26)/5

= 2882/5

= 576.4

E (B2) E (B3) = 25X22

= 550

Cov (B2, B3) = E (B2B3)-E (B2) E (B3)

= 576.4-550

Cov (B2, B3) = 26.4

The above result shows that schedule and time-to-market in offshore software development projects has a linear relationship.

16) Covariance between Schedule and Customer and Business Satisfaction in Offshore Software Development Projects

Cov (B2, B4) = E (B2B4) – E (B2) E (B4)

E (B2B4) = (26X19+15X20+31X31+26X21+27X27)/5

= 3030/5

= 606

E (B2) E (B4) = 25X23.6

= 590

Cov (B2, B4) = E (B2B4)-E (B2) E (B4)

= 606-590

Cov (B2, B4) = 16

The above result shows that schedule and customer and business satisfaction in offshore software development projects has a linear relationship.

17) Covariance between Schedule and Client-Vendor Trust in Offshore Software Development Projects

Cov (B2, B5) = E (B2B5) – E (B2) E (B5)

E (B2B5) = (26X15+15X10+31X20+26X30+27X25)/5

= 2615/5

= 523

E (B2) E (B5) = 25X20

= 500

Cov (B2, B5) = E (B2B5)-E (B2) E (B5)

= 523-500

Cov (B2, B5) = 23

The above result shows that schedule and client-vendor trust in offshore software development projects has a linear relationship.

18) Covariance between Time-to-Market and Customer and Business Satisfaction in Offshore Software Development Projects

Cov (B3, B4) = E (B3B4) – E (B3) E (B4)

E (B3B4) = (17X19+14X20+30X31+23X21+26X27)/5

= 2718/5

= 543.6

E (B3) E (B4) = 22X23.6

= 519.2

Cov (B3, B4) = E (B3B4)-E (B3) E (B4)

= 543.6-519.2

Cov (B3, B4) = 24.4

The above result shows that time-to-market, and customer and business satisfaction in offshore software development projects has a linear relationship.

19) Covariance between Time-to-Market and Client-Vendor Trust in Offshore Software Development Projects

Cov (B3, B5) = E (B3B5) – E (B3) E (B5)

E (B3B5) = (17X15+14X10+30X20+23X30+26X25)/5

= 2335/5

= 467

E (B3) E (B5) = 22X20

= 440

Cov (B3, B5) = E (B3B5)-E (B3) E (B5)

= 467-440

Cov (B3, B5) = 27

The above result shows that time-to-market and client-vendor trust in offshore software development projects has a linear relationship.

20) Covariance between Customer and Business Satisfaction and Client-Vendor Trust in Offshore Software Development Projects

Cov (B4, B5) = E (B4B5) – E (B4) E (B5)

E (B4B5) = (19X15+20X10+31X20+21X30+27X25)/5

= 2410/5

= 482

E (B4) E (B5) = 23.6X20

= 472

Cov (B4, B5) = E (B4B5)-E (B4) E (B5)

= 482-472

Cov (B4, B5) = 10

The above result shows that customer and business satisfaction and client-vendor trust in offshore software development projects has a linear relationship.

The above covariance analysis shows that all the success factors are dependent on each other. The above results show that there is a linear relationship between all the offshore software development success factors cost, schedule, time-to-market, customer and business satisfaction, and client-vendor trust.

5.7. Results

In order to analyze our survey data, we have applied statistical test on data. First of all, we have applied test to analyze cost of different offshore software development companies of Pakistan. According to the test results, the matching companies are more successful with respect to *cost* than mismatching companies. Similarly, we have also applied test on failure rate of both type of companies with respect to cost. The test applied to investigate the failure rate showed that with respect to *cost*, the failure rate of matching companies is less than the mismatching companies.

The above results show that the utilization of appropriate and adequate communication modes/mediums has a significant impact on success or failure of offshore software development with respect to *cost*.

Secondly, we have applied test to investigate schedule of different offshore software development companies of Pakistan. According to the test results, matching companies are more successful with respect to *schedule* than mismatching companies. In the same way, we have also applied test on failure rate of both type of companies with respect to *schedule*. The test results represents that with respect to schedule, the failure rate of matching companies is less mismatching companies.

The above result shows that the utilization of appropriate and adequate communication modes/mediums has a significant impact on success or failure of offshore software development with respect to *schedule*.

Thirdly, we have applied test to analyze time-to-market of different offshore software development companies of Pakistan. According to the test results, matching companies are little

bit more successful with respect to *time-to-market* than mismatching companies. Similarly, we have also applied test to analyze failure rate of both companies with respect to time-to-market. The test applied to investigate the failure rate showed that with respect to *time-to-market*, the failure rate of matching companies is little bit less than mismatching companies.

The above results represent that the utilization of appropriate and adequate communication modes/mediums has not a significant impact on success or failure of offshore software development with respect to *time-to-market.*

Fourthly, we have applied test to analyze *customer and business satisfaction* of different offshore software development companies of Pakistan. According to the test results, matching companies are more successful with respect to *customer and business satisfaction* mismatching companies. Similarly, we have also applied test on failure rate of both type of companies with respect to *customer and business satisfaction.* The test applied to investigate the failure rate showed that with respect to customer and business satisfaction, the failure rate of matching companies is less than mismatching companies.

The above results show that the utilization of appropriate and adequate communication modes/mediums has a significant impact on success or failure of offshore software development with respect to *customer and business satisfaction.*

Finally, we have applied test to analyze *client-vendor trust* of different offshore software development companies of Pakistan. According to the test results, matching companies are more successful with respect to *client-vendor trust* than mismatching companies. In the way, we have also applied test on failure rate of both companies with respect to *client-vendor trust.* The test applied to investigate the failure rate showed that with respect to client-vendor trust, matching companies is less mismatching companies.

The above results represents that the utilization of appropriate and adequate communication modes/mediums has a significant impact on success or failure of offshore software development with respect to *client-vendor trust.*

5.8. Discussion

In success and failure analysis of matching and mismatching companies with respect to cost, the survey results show that with respect to cost, success rate of matching companies is greater than success rate of mismatching companies and failure rate of matching companies is less than failure rate of mismatching companies. But it is interesting to note that mean frequency of success and failure of matching companies is equal (i.e.) 2.53 as depicted in fig 5.2 (a). Similarly for mismatching companies the failure rate is greater than the success rate but a great number of mismatching companies are successful too. This finding represents that success and failure ratio of matching and mismatching is alarming.

In success and failure analysis of matching and mismatching companies with respect to schedule, the test results show that with respect to schedule, success rate of matching companies is greater than success rate of mismatching companies and failure rate of matching companies is less than failure rate of mismatching companies. But it is interesting to note that the difference between mean frequency of success and failure of matching companies is very small as depicted in Fig 5.2 (b). Similarly the difference between mean frequency of success and failure of mismatching companies is also very small as depicted from the Fig 5.2 (b). These results show that a great number of matching companies fall in failure category and great number of mismatching companies are successful too and this is question mark.

In success and failure analysis of matching and mismatching companies with respect to time-to-market, the test results show that with respect to time-to-market success rate of matching companies is greater than success rate of mismatching companies and failure rate of matching companies is less than failure rate of mismatching companies. But it is interesting to note that the difference between mean frequency of success and failure of matching companies is minor as depicted from the Fig. 5.2 (c). Similarly the difference between mean frequency of success and failure of mismatching companies is also very minor as depicted from the Fig. 5.2 (c). This finding shows that there is no significant difference of success and failure of matching and mismatching companies which is a surprising fact because it negates the common sense.

In success and failure analysis of matching and mismatching companies with respect to customer and business satisfaction, the test results show that with respect to customer and business

satisfaction, success rate of matching companies is greater than success rate of mismatching companies and failure rate of matching companies is less than failure rate of mismatching companies. But it is interesting to note that the difference between mean frequency of success and failure of matching companies is very small as depicted from the fig. 5.2 (d). Similarly the difference between mean frequency of success and failure of mismatching companies is very small as depicted from the fig.5.2 (d).

In success and failure analysis of matching and mismatching companies with respect to client-vendor trust, the test results show that with respect to client-vendor trust, success rate of matching companies is greater than success rate of mismatching companies and failure rate of matching companies is less than failure rate of mismatching companies. But it is interesting to note that the difference between mean frequency of success and failure of matching companies is very small as depicted from the fig. 5.2 (e). Similarly the difference between mean frequency of success and failure of mismatching companies is very small as depicted from the fig. 5.2 (e).

Chapter No. 6

Findings and Conclusions

6.1. Introduction

This chapter presents the overall findings and conclusion of the study. Section 7.1 briefly discusses the conclusion of the study. The major contributions and implications of the study are described in section 7.2. In section 7.3, the benefits and limitations of the study are discussed in detail. In section 7.4, the future research directions are highlighted on the basis of research findings.

6.2. Findings and Conclusion

We have conducted detailed literature review, and literature review reveals that there is limited existing research on communication process in offshore software development. The purpose of this research study is to improve the communication process in offshore software development and to analyze the impact of communication modes/mediums on success or failure of offshore software development. To answer this research question, a survey has been conducted in order to analyze all the involved factors. The conducted survey addresses the following issues.

(i) What are major activities in OSD?
(ii) Which communication modes/mediums are used to perform different offshore software development activities?
(iii) What is impact of communication modes / mediums on success factors of OSD?

Our research study has addressed the following research question: *What is the impact of communication modes/mediums on success or failure of offshore software development?*
From the literature we have specified five success factors of offshore software development. These success factors include *cost, schedule, time-to-market, customer and business satisfaction, and trust between client and vendor.*
In our study we found that the offshore software development companies which are not using the appropriate communication modes/mediums in order to perform their offshore software development activities are least successful with respect to cost, schedule, time-to-market, customer and business satisfaction, and client-vendor trust. On the other hand the offshore software development companies which are using appropriate communication modes/mediums in order to perform their offshore software development activities are more successful with respect to cost, schedule, time-to-market, customer and business satisfaction, and client-vendor

trust. An interesting finding of the study is that with respect to time-to-market, there is no significant difference in success and failure of matching and mismatching companies. This finding negates common sense and arises a question that why communication modes/mediums do not have an impact on time-to-market of offshore software development?

The study results indicate that communication is very critical for every activity of offshore software development. Therefore, there is a need to utilize the activity-specific communication modes/mediums in order to have successful communication in such a situation where client and vendor are far from each other, and they have cultural, lingual and time zone differences as well.

6.3. Major Contributions and Implications

There are many research studies on offshore software development. Our study specifically addressed the communication issue between client and vendor in offshore software development. Our research study contributes to the understanding of offshore software development process by focusing on the major OSD activities and the communication modes used to perform these activities and the impact of communication modes/mediums on different offshore software development activities.

The study is helpful to better understand communication in offshore software development environment. Through a detailed literature review this study has investigated major offshore software development activities, and communication modes / mediums used in OSD projects. This investigation is particularly important to discover the communication needs of different individual offshore software development activities. This helps us to understand how communication needs of different activities can be fulfilled. The research study highlighted many challenges of OSD which are associated with the communication between client and offshore vender. Our study has discussed different offshore software development perspectives. The impact of communication gap on offshore software development has also been discussed in this study.

Secondly we have identified the major reasons of communication gap between client and offshore vendor. Through in depth investigation and analysis, it is concluded that for better management of offshore software development projects, better communication between client and offshore vendor is required. For better communication in offshore software development,

we have categorized the OSD activities and communication modes/mediums used to perform these activities in five categories: coordinative, cooperative, informative, feedback-oriented and inquiry based. This study suggested that communication between client and vendor can be improved in the following ways.

i) Use coordinative communication modes/mediums for coordinative offshore software development activities.
ii) Use cooperative communication modes/mediums for cooperative offshore software development activities.
iii) Use informative communication modes/medium for informative offshore software development activities.
iv) Use feedback-oriented communication modes/mediums for feedback-oriented offshore software development activities.
v) Use inquiry-based communication modes/medium for inquiry-based offshore software development activities.

Our classification of OSD activities and communication modes/mediums has established a specific and unique way for client-vendor communication which demonstrates that the proper utilization of communication modes/mediums for OSD activities can facilitate the OSD projects for their success. Our classification demonstrates ,that most of offshore software development objectives like cost effectiveness, time efficiency, reduced time-to-market, better client vendor trust can be achieved through proper utilization of communication modes/mediums for offshore software development. Our study proposed an activity-specific communication modes/mediums framework for offshore software development. Since successful client-vendor communication is necessary for successful offshore software development. Therefore it is essential for offshore software development companies to gain an understanding of their communication needs for better offshore software development. Our communication framework provides a comprehensive understanding of the communication needs for individual offshore software development activities. The purpose of this study is to provide guidance for offshore software development companies in order to know that how they can complete their projects successfully by utilizing different communication modes/mediums and how they can achieve the core objectives of offshoring the projects.

6.4. Benefits of the Study

In order to meet the challenges of offshore software development, to some extent our study suggests that how the impact of offshoring obstacles like geographical distances, time zone differences, cultural differences, and linguistic problems can be minimized. Our frame work (see fig. 4.1) for offshore software development has provided a base line to offshore software development community in order to improve their communication process. This framework helps companies to gain the fruitfulness of their offshoring decision. This helps them to minimize cost, meet the schedule, minimize time-to-market, and build a strong client-vendor trust relationship. If this framework is implemented carefully and effectively then most of software offshoring objectives can be achieved.

6.5. Limitations of the study

Along with benefits, our study may have some limitations. Our study may be criticized for conducting the survey in a single country that does not adequately represent the whole software offshoring market of the world. Since the offshore software development involve long geographical differences, multi culture, multi lingual, and long time zone differences. But in this study, results have been produced by investigating a single country's culture, geographical location, time zone differences, and language which is typically less than enough.

6.6. Future Work

This research study has provided a base line to improve the communication process in offshore software development that can be used as a basis for further research in the field of offshore software development.

In offshore software development, communication can be considered as the soul of offshore software development process. Therefore there is a need to improve communication process in order to improve the whole offshore software development process.

Our research findings show that through the effective and careful implementation of our framework, cost, schedule, time-to-market, customer and business satisfaction, and client vendor trust can be improved but it is interesting to note that despite utilizing communication

modes/mediums according to our framework many matching companies are falling into failure category and many mismatching companies which are not using our framework are successful. This is a potential research question that despite utilizing appropriate communication modes/mediums, why some matching companies are failing to achieves their objectives of cost, schedule, time-to-market, customer and business satisfaction, and client-vendor trust. Similarly why some mismatching companies are successful despite utilizing inappropriate communication modes/mediums?

Our study findings show that there is no impact of communication modes/mediums on time-to-market of offshore software development which goes beyond the common sense. The reason that why time-to-market is not significantly affected by the communication modes/mediums in offshore software development is further required to be investigated?

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Appendix

Survey Questionnaire and Survey Data

Impact of Communication Mode on Success or Failure of Offshore Software Development (OSD)

(Survey Questionnaire, February 2009)

Respectable Respondent!

Thanks for your participation in this study "Communication Issues in Offshore Software Development". This questionnaire should be completed by the individuals who are involved in offshore software development projects and working on most senior positions.

Your responses will be kept confidential, only aggregate results will be reported. Please complete this survey by February 8, 2009. Estimated time required to complete this questionnaire is 15 minutes. When our study will be completed, the key findings will be provided to all respondents by us. For any query, please feel free to contact with Mr. Farrukh Shahzad Ahmed (Student MS Software Engineering at International Islamic University Islamabad). fshahzad11@gmail.com

Respondent Profile		Company Profile	
Name		Company Name	
Designation		CMMI Level (if any)	
Email		Company established in	
Contact No.		No. of Employees	
No. of years in S/w projects		No. of years in S/W projects	
No. of years in OSD projects		No. of years in OSD projects	

Following is a list of offshore software development activities. Please select communication modes which you use against each activity. You may select multiple modes. To select a mode, write (Y) in the block.		Communication Modes										
		Face-to-face	Videoconferencing	Teleconferencing	Email	Discussion Board	Chatting	Web interactive TV	Web repository	Phone & fax	Net meeting	Any other
Q1	Contract negotiation											
Q2	Requirements elicitation											
Q3	Requirements verification & validation											
Q4	Requirements specification											
Q5	Resolving ambiguities from requirements document											
Q6	Requirements change											
Q7	Scope change											
Q8	Design communication											
Q9	Resolving design conflicts											
Q10	Client's acceptance testing											
Q11	Client-vendor artifacts review											
Q12	Code walkthroughs and inspections											
Q13	Initiating software maintenance											
Q14	Budget and schedule tracking											
Q15	User support											
Q16	Status review meetings											
Q17	Top management reviews											
Q18	Service level audits											

Following are few questions about offshore software development. Please answer these questions in the light of your offshore software development experience. To select an option, write (Y) in only one block against each question.		Percentage				
		0 – 10 %	11 – 20 %	21 – 30 %	31 – 40 %	Above 40 %
Q19	As per your experience, how the initial estimated cost varies from the final actual cost of offshore software development projects?					
Q20	As per your experience, what is the lowest difference between the initial estimated cost and the final actual cost of any offshore software project?					
Q21	As per your experience, what is the highest difference between the initial estimated cost and the final actual cost of any offshore software project?					
Q22	How much in your experience, the initial estimated time varies from the final actual time consumed to complete offshore software development projects?					
Q23	In your experience, what are the lowest difference between initial estimated time and the final actual time consumed to complete any offshore project?					
Q24	In your experience, what are the highest difference between initial estimated time and the final actual time consumed to complete any offshore project?					
Q25	As per your experience, how much rework is done for offshore software projects?					
Q26	In your experience, what is the lowest rework percentage in any offshore software development project?					
Q27	In your experience, what is the highest rework percentage in any offshore software development project?					
Q28	How much in your experience, the functional and business issues encountered in offshore software development projects?					
Q29	In your experience, what is lowest percentage of functional and business issues in any offshore software development project?					
Q30	In your experience, what is highest percentage of functional and business issues in any offshore software development project?					
Q31	How much in your experience, contract non-conformance is encountered in offshore software development projects?					
Q32	In your experience, what is lowest contract non-conformance encountered in any offshore software development project?					
Q33	In your experience, what is highest contract non-conformance encountered in any offshore software development project?					

Following are few questions about offshore software development. Please answer these questions in the light of your offshore software development experience. To select an option, write (Y) in only one block against each question.		Frequency				
		Always	Frequently	Less frequently	Rare	Never
Q34	How often in your experience, cost overruns in offshore software development projects?					
Q35	How often in your experience, schedule slips in offshore software development projects?					
Q36	How often in your experience, an increase in time-to-market is encountered in offshore software development projects?					
Q37	How often in your experience, customer and business satisfaction issue is encountered in offshore software development projects?					
Q38	How often in your experience, a failure to fulfill client commitments is encountered in offshore software development projects happed?					

Following are few statements about offshore software development. Please give your opinion in the light of your offshore software development experience. To select an option, write (Y) in only one block against each statement.		Opinion				
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Q39	Cost of offshore software projects exceeds from estimated cost due to inappropriate selection of communication modes in offshore development.					
Q40	Deliverables become late due to inappropriate communication mode selection in offshore software development projects.					
Q41	Time-to-market for offshore software development projects increases due to inappropriate selection of communication modes.					
Q42	Customer and business dissatisfaction happens due to inappropriate selection of communication modes in offshore software development projects.					
Q43	Client-vendor trust loses due to inappropriate selection of communication modes in offshore software development projects.					

Company	CMMI Level	No. of employees	No. of years in S/W Develp	No. of years in OSD
C1	No	18	9	9
C2	No	18	9	9
C3	No	125	6	5
C4	No	80	11	8
C5	No	65	8	8
C6	No	350	12	12
C7	No	130	10	7
C8	No	23	9	9
C9	No	300	8	8
C10	No	500	13	13
C11	Level 2	50	10	2
C12	No	40	3	3
C13	No	500	10	10
C14	No	20	4	4
C15	Level 3	500	2	1
C16	No	250	10	10
C17	Level 3	280	12	10
C18	No	250	14	11
C19	No	25+	11	11
C20	No	54	8	8
C21	No	100	10	10
C22	No	35	9	6
C23	No	100	10	5
C24	No	160	10	8
C25	No	100	14	14
C26	No	120	14	14
C27	No	30	4	4
C28	No	110	11	8
C29	No	50	10	2
C30	No	45	2	2
C31	No	185	12	10
C32	Level 3	500	7	5
C33	No	53	14	11
C34	No	80	11	8
C35	No	25	25	20
C36	No	50	8	8
C37	No	500	2	1
C38	No	15	7	3
C39	Level 2	50	15	10
C40	No	15	8	5
C41	No	45	7	7
C42	No	40	5	5
Average	-	145.39	9.38	7.71

Company	Designation	No. of years in S/W Develp	No. of years in OSD
R1	Project Manager	7	7
R2	Software Designer/Architect	6	6
R3	Team lead	5	3
R4	QA Manager	3	3
R5	Software engineer	4	4
R6	Software Engineer	8	5
R7	QA Manager	5	5
R8	CEO	8	8
R9	Project Manager	3	3
R10	Database Administrator	15	15
R11	QA Manager	10	3
R12	Team Leader	3	3
R13	Team Lead	5	5
R14	SDM	13	13
R15	Project manager	6	6
R16	Project Manager	7	6
R17	Team lead	4	3
R18	Software Engineer	8	6
R19	Software Engineer	2	2
R20	QA manager	3	3
R21	Software engineer	3	1.5
R22	Director Technical	17	6
R23	QA Manager	8	4
R24	QA Manager	7	5
R25	Project Manager	13	5.5
R26	Manager Maintenance	8	8
R27	Project Manager	6	6
R28	Project Manager	7	5
R29	Software Engineer	10	2
R30	CTO	8	2
R31	Software Designer/Architect	9	9
R32	QA Manager	2	1
R33	Software Engineer	5	5
R34	QA Manager	3	3
R35	Software Engineer	4	4
R36	Team Lead	4	3
R37	PS Cosultant	3	2
R38	Software Engineer	2.5	1.5
R39	Software Engineer	2	2
R40	Software Engineer	4	4
R41	QA Manager	4	4
R42	Software Engineer	3	3
Average	-	6.13	4.65

Q1a	Q1b	Q2a	Q2b	Q3a	Q3b	Q4a	Q4b	Q5a	Q5b	Q6a	Q6b	Q7a	Q7b	Q8a	Q8b	Q9a	Q9b	Q10a	Q10b
459	.	456	.	456	.	456	.	4,569	.	456	.	456	.	456	.	4,569	1	456	.
459	.	456	.	56	.	456	.	45	.	456	.	46	.	456	.	4,569	.	56	.
149	.	148	.	58	.	28	.	36	.	46	.	489	.	17	.	26	.	349	.
14	.	148	.	14	0	1,468	.	48	.	49	.	69	1	28	.	4	.	69	.
14	.	148	.	14	0	1,468	.	48	.	38	.	58	0	27	.	3	.	58	.
14	.	1,347	.	1,348	0	48	.	4	0	8	.	249	.	47	.	.	10	136	0
14	.	14	.	45	.	46	0	2,469	.	48	0	4	.	278	.	3	10	136	0
4	.	4	.	489	.	49	.	49	.	489	.	489	.	489	.	49	.	489	0
1,345	.	134,569	.	45	.	145	.	134,569	.	15	.	15	.	14,569	.	15	.	145	.
1	.	134	.	34	.	34	.	.	1	34	.	34	.	134	.	1	.	1	.
124	.	14	.	4	.	14	.	4	.	4	.	4	.	4	.	4	.	14	.
4	.	4	.	46	.	4	.	46	.	4	.	4	.	46	.	4	.	4	.
1	.	149	.	149	.	149	.	1	.	149	.	149	.	149	.	1	.	14	.
34	.	346	.	4	.	23	.	34	.	23	.	34	.	34	.	34	.	56	.
1,349	.	1,349	.	1,349	.	1,349	.	1,349	.	1,349	.	1,349	.	14	.	14	.	1	.
123	0	129	.	2,467	.	2,469	.	23	.	15	.	57	0	15	0	157	.	236	.
14	0	148	.	4	.	46	.	24	0	24	.	4	.	8	.	3	10	13	0
4	.	4	.	6	.	46	.	6	.	5	.	5	.	5	.	6	.	8	.
1	.	129	0	249	0	1,459	0	23,469	0	12,349	0	1,259	0	12,459	0	12,469	0	1,238	0
9	.	3	.	34,689	.	134,689	.	3,469	.	34,689	.	34,689	.	39	.	369	.	469	.
34	.	34	.	349	.	234	.	34	.	34	.	349	.	349	.	349	.	8	1
1,469	0	469	0	46	0	468	0	46	0	468	0	468	0	468	0	46	0	46	0
1,345,689	.	14,569	.	1,458	.	34,589	.	345,789	.	345,789	.	14,579	.	34,789	.	34,789	.	1,789	.
14	.	158	.	4	0	46	.	24	0	8	.	4	.	8	.	9	0	4	.
15	.	146	.	4	.	14	.	14	.	14	.	14	.	1	.	1	.	4	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13,469	.	13,469	.	13,469	.	13,469	.	13,469	.	13,469	.	13,469	.	13,469	.	13,469	.	13,469	.
149	.	1,458	.	14	0	1,468	.	248	0	48	.	1,346	.	8	.	2	10	4	.
4	.	14	.	14	.	14	.	1,469	.	69	.	19	.	46	.	19	.	.	1
14	0	13,469	0	13,469	0	13,469	0	13,469	0	13,469	0	13,469	0	13,469	0	13,469	0	13,469	0
14	.	47	.	147	.	147	.	27	0	14	.	4	0	25	.	28	.	4	.
12	.	123	.	34	.	34	.	34	.	34	.	23	.	34	.	34	.	34	.
349	.	46	.	469	.	469	.	69	.	4	.	9	.	49	.	46	.	46	.
14	.	148	.	14	0	1,468	.	48	.	49	.	69	1	28	.	4	.	69	.
4	.	4,569	0	456	.	456	.	456	.	46	.	46	0	45	.	45	.	45	.
23	.	46	.	46	.	46	.	346	.	346	.	346	.	4	.	4	.	4	.

138	.	138	.	138	.	138	.	1,348	.	1,348	.	1,348	.	1,348	.	138	.	138	.
3,469	.	469	.	49	.	49	.	49	.	49	.	49	.	4	.	49	.	4	.
5	.	5	.	9	.	45	.	459	.	459	.	459	.	45	.	45	.	45	.
34	.	34	0	34	0	34	0	34	.	34	0	34	.	34	0	34	.	34	.
12	.	1,234	.	124	.	12,349	.	149	.	1,249	.	12	.	1	.	149	.	1	.
469	.	469	.	469	.	469	.	469	.	469	.	.	.	5	1	49	.	4	.

Q11a	Q11b	Q12a	Q12b	Q13a	Q13b	Q14a	Q14b	Q15a	Q15b	Q16a	Q16b	Q17a	Q17b	Q18a	Q18b	Q19	Q20	Q21	Q22	Q23
4,569	.	4,569	.	456	.	456	.	469	.	46	.	49	.	46	.	3	1	4	2	1
4,569	.	456	.	456	.	456	.	469	.	46	.	49	.	46	.	2	1	4	2	2
148	.	148	.	47	.	259	.	37	.	347	.	2	.	15	1	1	2	3	2	2
469	.	46	.	7	.	5	.	5	.	348	.	146	.	268	.	3	1	3	4	3
358	.	36	.	7	.	6	.	6	.	349	.	147	.	279	.	2	1	1	3	2
48	.	14	.	469	.	469	.	147	.	14	.	159	.	49	.	2	2	1	1	2
58	0	157	.	4	.	9	.	47	.	19	.	159	.	469	.	3	3	2	2	1
489	0	489	0	489	0	489	0	489	0	489	0	489	0	489	0	4	3	3	3	3
15	.	1	.	145	.	1,359	.	1,234,679	0	45	.	45	.	5	.	2	2	3	3	2
34	.	34	.	13	.	1	.	34	.	34	.	1	.	23	.	4	3	5	4	3
23	.	56	.	4	.	4	.	4	.	23	.	4	.	34	.	4	3	4	4	3
36	.	4	.	4	.	4	.	45	.	6	.	4	.	4	.	2	1	3	2	2
14	.	14	.	14	.	1	.	149	.	149	.	1	.	1	.	5	3	5	5	2
34	.	1	.	4	.	23	.	346	.	3	.	14	.	1	.	3	1	5	3	1
14	.	8	.	1,349	.	4	.	46	.	3	.	3	.	3	.	2	1	3	2	1
249	.	145	.	78	.	5	.	238	.	459	0	458	.	16	0	3	1	2	2	4
5	.	57	.	4	.	4	.	4	.	19	.	159	.	169	.	3	2	1	1	3
8	.	1	.	456	.	4	.	46	.	4	.	9	.	468	.	3	2	1	4	2
1,248	0	2,458	.	1,489	.	12,359	0	49	0	125	.	12	.	15	.	2	2	3	3	1
4	.	1	.	4	.	19	.	4,679	.	13,469	.	469	.	469	.	1	2	4	3	1
8	1	8	1	4	.	4	.	4	1	34	.	348	.	348	1	2	1	2	2	1
468	0	46	0	46	0	468	0	468	0	468	0	46	0	46	0	3	1	5	3	2
1	.	148	.	469	.	134,567	0	13,456	.	45,678	.	126	.	15	.	1	1	1	1	1
58	.	1	.	47	.	9	.	247	.	59	.	149	.	49	.	2	2	2	3	2
4	.	14	.	45	.	4	.	3,456	.	14	.	4	.	2	.	3	2	5	3	2
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13,469	.	13,469	.	13,469	.	13,469	.	13,469	.	13,469	.	13,469	.	13,469	.	5	5	5	5	5
37	.	136	.	479	.	9	.	12,347	.	3,589	.	139	0	3,479	.	2	2	3	3	2
.	1	1	1	.	1	1,469	.	146	.	1	.	1	.	1	.	4	3	3	3	2
13,469	0	13,469	0	13,469	0	13,469	0	13,469	0	13,469	0	13,469	0	13,469	0	2	1	3	2	1
3	.	16	.	4	.	4	.	4	.	2,689	.	47	.	29	0	1	2	2	2	3
34	.	34	.	34	.	34	.	34	.	34	.	34	.	4	.	3	3	3	3	3
49	.	49	.	69	.	49	.	69	.	4	0	49	.	4	.	3	2	4	2	1
469	.	46	.	7	.	5	.	5	.	348	.	146	.	268	.	3	1	3	4	3
45	.	456	.	46	.	4	.	456	.	4	.	4	.	45	.	3	2	5	3	2
4	.	46	.	68	.	.	.	348	.	48	.	48	.	34	.	3	2	4	2	2

38	.	348	.	348	.	13	.	1,348	.	1,348	.	138	.	138	.	2	2	3	2	2
4	.	4	.	49	.	469	.	45	.	39	.	4	.	5	.	4	1	4	1	4
.	0	.	1	4	.	5	.	9	.	4	.	45	.	4	.	3	3	4	3	1
34	.	1,349	0	4	0	34	.	13,469	0	34	.	1,236	.	34	.	2	1	1	3	2
148	.	8	.	14	.	49	.	12,469	.	1	.	1	.	1	.	2	2	3	2	2
4	.	1	.	56	.	46	.	1,469	1	1	.	1	.	1	.	3	2	4	3	5

Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43
4	3	2	4	4	2	5	1	1	3	3	3	2	2	2	4	2	3	3	4
3	2	2	3	4	3	4	1	2	2	4	3	2	3	2	4	1	2	2	3
3	2	3	2	1	2	2	2	1	3	2	2	2	2	1	1	2	2	2	3
1	3	3	3	1	1	1	1	2	2	2	4	2	3	2	1	3	1	2	2
1	2	2	2	1	2	2	2	2	2	1	3	1	2	1	2	2	2	3	3
3	2	3	3	2	3	2	2	1	1	2	1	2	2	1	2	1	1	2	1
2	1	2	2	1	3	2	4	3	3	3	2	3	3	1	3	2	2	2	2
3	3	3	3	3	3	3	3	4	4	2	2	3	3	3	2	2	2	2	2
3	2	1	2	5	5	5	1	1	2	3	3	3	2	3	2	3	3	3	1
5	3	2	4	4	3	4	2	2	3	1	2	2	3	4	2	3	3	2	2
4	2	1	2	3	2	3	5	4	5	1	1	1	2	4	3	3	3	3	24
4	2	1	3	1	1	2	2	1	2	2	3	2	2	3	2	3	4	3	3
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5	2	1	3	2	1	3	1	1	2	2	3	2	3	3	2	3	3	2	2
2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
3	3	3	4	5	5	4	4	2	5	3	2	5	4	4	2	3	3	1	5
2	2	2	3	1	3	2	2	3	2	2	2	2	3	2	3	2	2	3	1
4	5	3	1	4	4	4	3	2	2	2	2	2	1	3	2	2	2	1	1
3	2	1	4	5	3	5	2	1	5	3	3	3	2	3	2	3	3	2	3
2	2	1	5	1	2	4	3	2	2	3	3	2	2	4	3	1	2	4	4
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5	3	1	5	2	1	3	2	1	3	1	1	1	4	4	2	2	2	2	2
1	3	2	4	2	2	3	1	1	3	3	2	2	3	4	4	4	4	3	4
2	2	3	3	2	3	3	4	3	3	1	2	3	2	3	2	2	3	3	2
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.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	5	5	5	5	5	5	5	5	5	2	2	2	2	2	2	2	2	2	2
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3	2	1	3	2	1	3	2	1	3	3	2	4	4	5	2	4	5	1	1
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4	3	1	5	5	4	5	1	1	2	3	2	2	1	2	1	2	3	2	1
1	3	3	3	1	1	1	1	2	2	2	4	2	3	2	1	3	1	2	2
5	3	1	5	2	1	4	3	1	5	3	.	3	4	4	4	2	2	5	5
3	2	1	4	5	1	5	1	1	1	4	3	4	3	4	2	3	3	3	4

1	1	1	1	2	2	2	1	2	2	2	2	3	2	2	2	3	2	2	2
5	2	1	5	4	1	2	1	1	2	3	2	3	3	4	2	2	3	2	3
4	3	2	4	3	1	3	1	1	2	2	2	2	2	2	2	2	2	2	1
3	4	3	5	4	3	4	3	2	4	3	2	3	4	3	3	2	3	3	1
4	2	2	4	2	2	4	2	2	4	2	2	2	1	3	3	2	2	2	2
5	2	1	5	5	3	5	5	2	5	3	3	4	3	3	1	1	1	1	1