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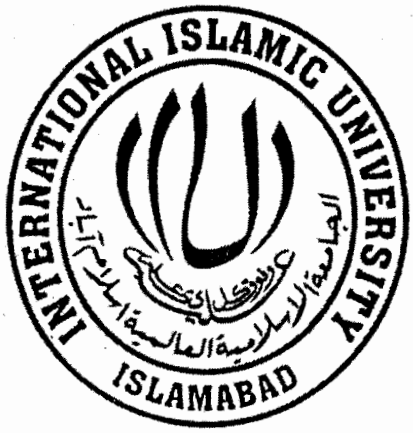
Shared understanding of requirements within GSD using Knowledge Management Repository: A Field Experiment



MS-SE Thesis

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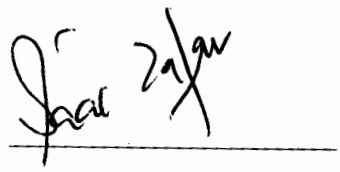

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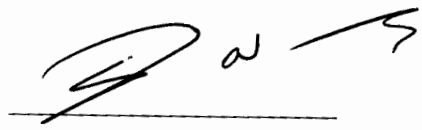

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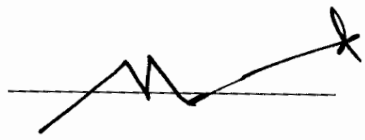

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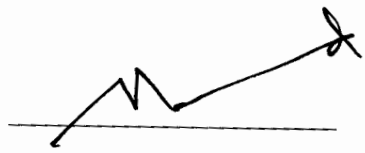

In
The
Name
Of
Allah
The most Merciful
The Most Beneficial

To
Prophet (Peace Be Upon Him)
&
My Dear Husband
Who is an embodiment of diligence and honesty?
Without his prayers and support
This dream could has never come true

A

Dissertation

Submitted as Partial Fulfillment

of Requirements for the Award of the Degree of

MS in Software Engineering

Declaration

I hereby declare that this thesis "**Shared understanding of requirements within GSD using Knowledge Management Repository: A field experiment**" neither as a whole nor as a part has been copied out from any source. It is further declared that I have done this research with the accompanied report entirely on the basis of my personal efforts, under the proficient guidance of my teachers especially my Supervisor Dr Naveed Ikram and my Co-Supervisor Mr Usman Nasir. If any part of this thesis is proved to be copied out from any source or found to be reproduction of any thesis from any of the training institute or educational institutions, I shall stand for the consequences.

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Thesis in Brief

Thesis Title: Shared understanding of requirements within GSD using Knowledge Management Repository: A field experiment

Objective: The basic aim of this research was to provide a solution of lack os shared understanding of requirements issue in global software development organizations

Undertaken By: Mamoona Bibi

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ABSTRACT

Developing requirements for software projects require shared understanding of requirements among all the team members. But in Global Software Development (GSD) this shared understanding becomes harder to achieve because of the challenges inherited in GSD; these challenges include cultural diversity, inadequate communication, Time Zone difference and improper knowledge management. By its very nature, software development consists of many knowledge management practices. One of the important needs is to study the impact of these practices on shared understanding of requirements in GSD. During a field experiment in a GSD organization we selected two GSD projects and applied a commonly used practice of knowledge management on one of these projects. We observed the understanding patterns of both development project teams by conducting multiple concept mapping exercises. This paper presents a comparison of the results obtained from the concept mapping exercises of both development teams. These results demonstrate how the selected knowledge management practice helps to improve shared understanding of requirements among GSD team members.

Acknowledgement

In the name of Allah; the most gracious, merciful and creator of this universe. I am beholden to Him who blessed me with the abilities and conferred upon me the courage and the resilience to successfully accomplish this thesis work.

I am highly indebted and extremely thankful to my supervisor, Dr. Naveed Ikram, who was the real source of encouragement and motivation during the whole work of thesis. His useful suggestions, advice and ideas to bottleneck problems encountered during this thesis work were just immensurable. His expertise, devotion and constant encouragement was very helpful and made this effort an enjoyable one.

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I am thankful to the project manager and development team of both projects. They were very cooperative in sparing their precious time for conducting concept mapping exercises and gave me useful suggestions and feedbacks.

In the end, I would like to extend my deepest gratitude to my family especially my husband for his kind support and encouragement. Indeed, without his prayers and emotional & financial support it would not be possible for me to accomplish this work.

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CHAPTER 1

Introduction

Global Software Development (GSD) refers to "software development that is geographically, remotely or globally distributed with the aim of rationalizing the development process and products" (Sarker, 2003). In GSD the software development activities are distributed across multiple sites. These multiple sites are scattered in different countries and communicate in a coordinated fashion involving real time (synchronous) and asynchronous interaction. With the advent of modern technologies the world is shifting from traditional form of in-house development to global software development because of different benefits achieved from GSD including global resource pool, attractive cost structures, the possibility of developing around the clock, technologies, availability of resources and methodologies etc (Damian & Moitra, 2006)

Requirement Engineering (RE) plays a very important role in software development. For some years now, it has been realized that problem associated with requirement engineering are a major cause of project failures because RE is the most communication rich activity of software development and the overall functionalities and boundaries of the software system are identified at this stage. Errors in requirement stage can have a major impact on software cost; errors detection and correction at RE stage alleviate many major issues in the later stages of design and testing.

In the context of GSD Requirement Engineering (RE) become even more challenging as stakeholders are from diverse background and interest and huge physical and cultural distance exists between them. Many researchers consider lack of shared understanding of requirements as a main barrier in the success of RE in GSD organizations. Therefore, it becomes very necessary for global software development teams to have a shared understanding of requirements, which means that individual communicating on a particular topic must have the same understanding of that topic. This lack of shared understanding of requirements among team members is normally due to the factors of cultural diversity, time zone difference, inadequate communication, physical distance and improper knowledge management (Damian, 2007).

Many practices and techniques are adopted by global software development organizations to improve shared understanding of requirements; still there is a need to identify such practices that helps in improving shared understanding of requirements among global software development team. The focus of this thesis is to identify the common challenges in achieving shared understanding of requirements in GSD, analyze the impact of these challenges on shared understanding of requirements and suggest some practice for the improvement of shared understanding of requirements in global software development by applying that practice on a GSD project.

1.1 Research motivation

As Requirement Engineering is very important in the development of software, In GSD based organizations lack of shared understanding of requirement is the main reason for the failure of RE activity. Further, researchers and practitioners are facing this problem of shared understanding from few decades and are trying to search a possible solution for it. Therefore, there is a need to adopt such practices and tools that may help the GSD organizations to overcome the problem of lack of shared understanding of requirements.

Software organizations are now realizing the usefulness and importance of implementing knowledge management (KM) practices in their organizations because KM is really helpful to solve communication problem, overcoming cultural issue, and helps in developing mutual trust. KM is considered absolutely essential to cope with the communication and coordination problems of GSD and the problem of improper KM in GSD based organization need to be solved to cope with the remaining issues of GSD (Avram, 2007).

Keeping in view the importance of KM and shared understanding for GSD based organizations, in this thesis work a commonly used practice of KM that is helpful in achieving shared understanding of requirements in GSD was selected from the literature. The impact of selected KM practice on shared understanding of requirements in GSD was studied by applying it on a field experiment, which will help and guide practitioners and researchers to solve requirements understanding problems of GSD.

1.2 Research Question

As shared understanding of requirements ensures that team members working on a project have the same understanding of the requirement and this understanding is a key towards success of software development project. The aim of this research is to understand the problems that cause lack of shared understanding of requirements in GSD and suggest a possible solution. In order to select the solution of this problem KM practices were studied and the practice that was used by many GSD based organization was selected as a topic of this research.

Following question was addressed in this research

RQ: What is the impact of Creating and maintaining Knowledge Management Repository of a project on shared understanding of requirements in GSD?

1.3 Research methodology

It was an empirical study which was done by field experiment. For conducting this field experiment two software development projects were taken as a treatment from a well known global software development company. It was a Microsoft certified company that was established five years ago and had a very well known name among global software development organizations. Our intervention that was applying knowledge management practice was

involved in one of the two selected projects and the other project was just observed without any intervention. Both projects were similar in the sense that:

- Both projects were web development projects
- The duration of both projects was 60 days each
- Both projects consist of seven team members each
- The development team of both the project was dispersed in two countries

In order to check the impact of selected knowledge management practice on shared understanding of requirements in GSD the shared understanding of both the projects was measured in parallel; raw data and results obtained from this data were analyzed in order to draw the conclusion.

1.4 Thesis Outline

This thesis is divided into six main chapters as per following details:

The **first chapter** was mere introduction.

The **second chapter** identifies the challenges of RE in GSD and the impact of these challenges on shared understanding of requirements in GSD. Moreover knowledge management and its practices are studied in detail from the literature in order to select the most commonly used practice. Different methods of measuring shared understanding are discussed along with their pros and cons in order to select the most suitable method for the measurement of share understanding.

Chapter three discusses the study design, provides an introduction to the selected experiment, its relevance and the methods for data collection. Then chapter four provides us the results obtained from the field experiment, and the comparison and analysis of the obtained results.

Chapter six involves the detail analysis and discussions of the obtained results.

The **final chapter** i.e. chapter six of the thesis provides a conclusion by discussing the contribution of the thesis and how these contributions answer the research question posed in the first chapter. It also discusses the possible directions for future research.

CHAPTER 2

2. Literature review

This chapter gives an introduction of the problem domain, which is global software development. It discusses the motivations behind the practice of developing software by geographically distributed teams. It reports the various challenges faced by GSD organization in requirement engineering with special focus on shared understanding issue of requirements in GSD.

2.1 Global software development

Global software development is becoming a common practice in software industry and organizations are now shifting from traditional form of collocated development to global software development rapidly (Herbsleb, 2007 ; Conchuir, Holmstrom, Agerfalk & Fitzgerland , 2006). GSD is characterized by stakeholders from different locations having different culture and background, collaborating by means of information and communication technologies to develop software systems (Conchuir, Holmstrom, Agerfalk & Fitzgerland , 2006; Avram, 2007).

With the advent of modern technologies, specially the internet facility, the communication and coordination between remote sites have become a practical option and have aided much in promoting GSD (Sengupta, Chandra & Sinha, 2006). There are a number of benefits and business reasons that motivate companies to shift from in-house development to GSD, these reasons include latest technologies, availability of resources and methodologies, being closer to emerging markets, low cost etc (Damian & Moitra, 2006).

2.2 Requirement engineering

Software development has been problematic since 1960s, which causes delay, low quality, customer's dissatisfaction and over budget delivery of the system. (Kotonya & Sommerville, 1998) considers difficulties and misunderstanding of requirements as a main reason behind these problems.

Niazi & Shastry (2003) argues that the process of RE should be done in a very careful and efficient manner as the output of this stage serves as an input for the other development activities. Moreover if RE is done carefully and requirements are understandable and unambiguous the whole development process will run smoothly, but if requirements are ambiguous and has conflicts, the whole development will suffer and the end product will be late, over budgeted and of low quality, therefore the success of a software system depends on the successful compliance of its requirements (Kotonya & Sommerville, 1998).

Requirement engineering is an important and challenging stage of a software development and even becomes more challenging and critical in case of GSD because in GSD cross-functional

of thinking, beliefs, attitudes, commitments, way of response and ways of solving a problem and so on, which requires close coordination and cooperation (Herbsleb & Moitra, 2001) .

Many researchers have found culture as a challenging issue that impacts the understanding level of individuals, hence it should not be neglected otherwise it may cause serious misunderstanding that will lead to unexpected results of a project (Herbsleb & Moitra, 2001 ; Carmel, 1999; Smith & Blanck, 2002; Vanzin, Ribeiro, Prikladnicki, Ceccato & Antunes, 2005).

Culture creates misunderstanding and dissatisfaction within a project, Therefore it becomes necessary for a GSD organization to spread different dimensions of culture throughout the organization otherwise it will cause lack of shared understanding of requirements, that will affect the development phase and the software will not be developed within time and budget constraints (Sirvio & Tihinen, 2005).

To overcome the problem of cultural diversity GSD organization can develop their own functional and organizational culture according to their own custom and values. Hence, this type of culture can help in creating shared understanding of requirements in GSD (Damian & Zowghi, 2002). Further, if people from different cultures understand customs and values of each other then they will act and behave more cooperatively rather than obstinate (Smith & Blanck, 2002).

The issue of cultural diversity can also be resolved by taking some measures for example if a problem is not going to be solved through electronic communication then face to face meeting can be conducted, Besides training of the culture can be a good mean of overcoming this issue. Moreover, cultural difference can be alleviated by using some factors; such as thorough communication and coordination among different units of an organization, introducing and using predefined terms for improving language skills, and creation and sharing of knowledge regarding cultures issues and customs (Sirvio & Tihinen, 2005).

Hsieh (2006) Considers cultural diversity factors problematic in the development of shared understanding of requirements in GSD, and gives the idea of developing collective mind and knowing in order to overcome the problem of cultural difference.

It is argued that cultural difference give rise to the problem of lack of shared understanding and an integration framework for SDLC tools is needed to enable coordination across different software development activities (Sinha, Sengupta & Ghosal, 2007).

It can be concluded that cultural diversity is a barrier in achieving shared understanding of requirements (Damian & Zowghi, 2002; Damian & Zowghi, 2003) to resolve this problem enable better and more frequent interaction with field personnel and employ collaborative Internet technologies for communication (Damian & Zowghi, 2003).

2.3.1.2 Time zone difference

Temporal distance is a change in time experienced by two members wishing to interact. It is one of the critical issues of GSD. Many papers have highlighted this issue and provided suggestions regarding temporal distance we provide here only few papers.

In GSD organizations stakeholders are dispersed in a large distributed area and they find very few overlapping hours for communication that causes lack of shared understanding among team members, as informal and frequent communication is very necessary to build shared understanding of requirements. Hence there is a need to develop such RE processes that addresses the problem of shared understanding (Damian & Zowghi, 2003).

Time zone difference attributes to the problem of lack of shared understanding. To overcome this problem a framework for SDLC tools should be used to enable communication and coordination across different software development activities (Sinha et al., 2007).

Organizations working in large time difference face more problems as compared to those organizations who are working within fewer time zones like arranging meeting time across units because the selected time may be suitable for one unit and not for the other. Moreover decision making meeting are also affected by time zone difference as the entire decision making members can't participate in the meeting because of the large time zone differences. Additionally, some inconsistencies may arise when different processes and policies are used in different units and so on. Therefore, in this case more communication and coordination is required that becomes difficult because of the large time zone differences (Herbsleb, Paulish & Bass, 2005).

Follow-the-sun strategy can also be used to get benefit from time zone difference. Organization can organize their tasks between different units and hence unfinished tasks are transferred between units. Furthermore, by implementing this strategy a virtual 24-hours development environment can be created that helps in increasing the development time (Dingsoyr & Conradi , 2002).

Vanzin et al (2005) and Herbsleb et al (2005) argue that time zone difference can be reduced by using synchronous and asynchronous communication. Further, asynchronous communication is more suitable for those organizations which are facing large time zone difference as compared to synchronous communication.

2.3.1.3 *Inadequate communication*

Inability to communicate affectively across distance in GSD organizations give rise to the problem of lack of shared understanding, irregular information flow and ultimately weak coordination. There is a need for an integration framework for SDLC tools to improve coordination in GSD team members (Sinha et al, 2007).

Inadequate communication is a hurdle in the transfer of unambiguous information that causes lack of shared understanding of requirements in GSD (Setamanit, Wakeland & Raffo, 2007).

Damian & Zowghi (2002) presents a layered architecture for showing that how inadequate communication with some other challenges of GSD affects shared understanding of requirements in GSD. It is how on the basis of empirical evidence that inadequate communication negatively impact all the activities of requirement engineering (Damian & Zowghi, 2002).

RE is a human intensive activity which requires communication so that development team can interact with each other. Most of the RE problems can be solved by conducting face to face meeting or by having rich communication, but due to large geographical distance it is not easy in GSD organizations due to which requirement ambiguity problems occur that affects the development activities (Herbsleb, Mockus, Finholt & Grinter, 2001).

Absence of informal communication is a hurdle in the development of good relationship between stakeholders, lack of communication causes lack of trust among stakeholders, which results in lack of shared understanding of requirements in GSD (Damian & Zowghi, 2003).

2.3.1.4 *Knowledge management*

Knowledge management is the process of creating, sharing, distributing, organizing, and understanding of knowledge about organizational policies, processes and products (Dingsoyr & Conradi, 2002).

Relationship building and knowledge management are helpful for GSD organizations in building shared understanding of requirements. Knowledge acquisition and sharing process helps the stakeholders in achieving shared understanding of RE activities (Damian, 2007).Further; the problem of shared understanding can be solved by using diverse knowledge and market proximity (Lane, Michael, Agerfalk & Par, 2008).

Knowledge management in GSD projects is absolutely essential in order to cope with the problem of coordination (Avram, 2007). An organization's knowledge management system serves as an organization learning mechanism which improves the individuals learning and

allows the organization to achieve the desired outcome, moreover the spread of knowledge within organization improves shared understanding of requirements (Ahmad & Khan, 2008).

Knowledge is an important asset of an organization that can be reused in the future. In large GSD organizations it is hard for the people to know each other, share experiences and ideas; in this situation knowledge stored in an organization helps the development team a lot (Ahmad & Khan, 2008).

Knowledge facilitates communication, resolves the issue of cultural difference by clarifying the ambiguities, it also helps in tool selection and context understanding (Aranda1, Vizcaino, Cechich & Piattini, 2008).

Lack of knowledge about how to communicate changes harms the trust relationship between teams, it slow down the process of integrating a new member in to a development team. Exchange of knowledge is necessary to keep the people up-to-date and to develop the shared understanding of requirements among team (Damian, Izquierdo, Singer & Kwan, 2007).

2.4 Knowledge management: its impact on shared understanding

Software development is just one of the knowledge intensive industries expanding so quickly nowadays. Knowledge work has its own particularities, and the additional challenges brought in by global distribution require attention. After reviewing the literature regarding issues in GSD and their impact on shared understanding of requirements the most common issue found in the literature that causes lack of shared understanding is improper knowledge management, There exist many studies on the topic of knowledge management and its impact on requirement engineering activities however the issue of shared understanding need to be discussed in the light of knowledge management because resolving this issue will indirectly solve many other problems of GSD that affect shared understanding of requirement .In the text given below the impact of knowledge management challenge on other challenges of GSD is shown from current literature.

In organization what is communicated? How it is communicated? All this is knowledge that is acquired and shared. So if the organization applies appropriate knowledge management practices the problem of inadequate communication can be resolved. KM is considered absolutely essential to cope with the communication and coordination problems of GSD (Avram, 2007).

Cultural diversity problem comes in the form of ambiguities, language problems, unavailability of the context etc, if knowledge management practices are there in an organization this issue can be resolved through knowledge acquisition and sharing (Ahmad & Khan, 2008).

Development of collective mind and knowing helps in solving the problem of cultural diversity, this collective mind and knowing are possible only if the organization applies proper knowledge management strategies (Hsieh, 2006).

If knowledge is shared and managed properly the decision making meetings can be made effective, similarly the problem of distance can be resolved if the knowledge is available on time.

2.5 Knowledge management practices

Literature review considers improper knowledge management as a core factor that causes lack of shared understanding of requirements in GSD, so there is a need to adopt such knowledge management practices in GSD organizations that may help in increasing shared understanding of requirements. For this purpose the practices of knowledge management were studied from the literature in order to find the most commonly used practice of knowledge management that impact shared understanding of requirements in GSD, below is the list of commonly used practices of knowledge management that are used in literature

KMPs	Freq	References
Establish a repository of project	6	(Damian & Zowghi, 2002; Clerc,2008; Ebert & Neve, 2001; Clerc et al, 2009;Damian & Zowghi, 2003; Nguyen, Smyth & Gable)
Leadership	6	(Ebert & Neve, 2001 ; "Knowledge management Information paper", 2003; Sanghani, 2009; Guan, Ryan & Gururajan, 2006; Maponya, 2004; "Investigating Knowledge Management practices in software development organizations")
Face-to-Face Project Kick-Off Meetings	5	(Damian & Zowghi, 2002; Clerc, 2008; Ebert & Neve, 2001; Clerc et al,2009; Damian & Zowghi, 2003)
A Clear Organization Structure with Communicating Responsibilities	5	(Damian, 2007;Damian & Zowghi, 2002; Clerc, 2008; Ebert & Neve, 2001; Clerc et al, 2009)
artially synchronize inter-organizational processes and perform frequent iterations and deliveries	4	(Damian, 2007; Damian & Zowghi, 2002; Dingsoyr & Conradi, 2002; Damian & Chisan, 2006)
Rewards	4	(Tracey et al; Sanghani, 2009; Gerald et al, 2006; Bechinal & Bommen, 2006)
Frequent Interaction across Sites	3	(Damian & Zowghi, 2002; Clerc, 2008; Clerc et al, 2009)
Cross-site delegation	3	(Clerc, 2008; Clerc et al, 2009; Bass, Herbsleb & Lescher)

establish cultural liaisons	3	(Damian, 2007; Lane et al,2008; Desouza, Awazu & Baloh, 2006)
Technology	3	(Tracey et al; Sanghani, 2009; "Investigating Knowledge Management practices in software development organizations")
Collocated High-Level Architecture Phase	2	(Clerc, 2008; Bass et al)
Urgent Request	2	(Clerc, 2008; Bass et al)
establish peer-to-peer links at all management, project, and team levels across distributed sites	2	(Damian, 2007; Damian & Zowghi 2002)
Knowledge capture and acquisition	2	("Knowledge management Information Paper", 2003; Pearl & Maponya, 2004)
Training and mentoring	2	("Knowledge management Information Paper", 2003; Sanghani, 2009)
Headquarter commissioned and executed	2	(Desouza et al, 2006; Desouza & Evaristo, 2003)
Headquarter commissioned and regionally executed	2	(Desouza et al, 2006; Desouza & Evaristo, 2003)
Regionally commissioned and locally executed	2	(Desouza et al, 2006; Desouza & Evaristo, 2003)
Distributed pair programming	1	(Bass et al)
Set up mixed teams from different countries to integrate individual cultural background toward a corporate and project oriented spirit	1	(Ebert & Neve, 2001)
Make teams fully accountable and responsible for their results. extremely cooperative engineers and highly effective management	1	(Ebert & Neve, 2001)
Talking the developer through his assigned work	1	(Avram, 2007)
Surviving the Babel Tower	1	(Avram, 2007)
Inventing a new role: The integrator	1	(Avram, 2007)
"How to" – the situated learning aspect.	1	(Avram, 2007)
"Who knows what?" – The transactive memory aspect.	1	(Avram, 2007)
Awareness maintaining – the mutual knowledge aspect	1	(Avram, 2007)

Knowing who is who across the project (directory)	1	(Clerc et al, 2009)
Have a shared infrastructure for work products and source code (configuration management)	1	(Clerc et al, 2009)
Document management systems	1	(Preece, Flett & Sleeman, 2001)
Discussion forum systems	1	(Preece, Flett & Sleeman, 2001)
Capability management system	1	(Preece, Flett & Sleeman, 2001)
Lessons-learned knowledge base systems	1	(Preece, Flett & Sleeman, 2001)

Table 2.1 Knowledge management practices

As there are much knowledge management practices found after studying the literature and it is practically not possible to check the impact of all these practices on shared understanding of requirements in GSD in a single research, therefore one of the commonly used practices will be selected from the above mentioned list based on our research question. As for this research we need that practice which has positive impacts on shared understanding of requirements. Below we consider the importance of commonly used practices of knowledge management with respect to the shared understanding of requirements in GSD.

Following two KM practices were discussed in literature commonly

2.5.1 Establish a repository of project

Knowledge Management repository is an important source of promoting information among cross-cultural stakeholders timely and efficiently. KM repository is used to store information and decisions including the rationale of these decisions (Damian & Zowghi, 2002; Clerc,2008; Ebert & Neve, 2001; Clerc et al, 2009;Damian & Zowghi, 2003; Nguyen, Smyth & Gable).

When a shared repository is in place within a GSD organization, all the team member can query it anytime. This repository provides the awareness about local working context and helps to improve shared understanding of requirements (Clerc, 2008).

Ebert & Neve (2001) Emphasize on the use of repository which consists of all the information related to the project and team specific information, so that shared understanding of requirements may be developed among the GSD team.

Creation and maintenance of a knowledge management repository overcomes the problem of ineffective knowledge management, which will ultimately solve the lack of shared understanding problem in GSD organizations (Damian & Zowghi, 2002).

2.5.2 Leadership

There must be a project leader in a team who is fully responsible for achieving project targets, and assign him a global project management team. Managers and executives are responsible to implement the best practices within organization (Ebert & Neve, 2001 ; "Knowledge management Information paper", 2003; Sanghani, 2009; Guan, Ryan & Gururajan, 2006; Maponya, 2004; **"Investigating Knowledge Management practices in software development organizations").**

Leadership is discussed as a knowledge management practice in the above mentioned reference papers but its impact on shared understanding of requirements in GSD is not discussed in the literature. The questions addressed by this thesis require that KM practice which is commonly used by GSD organization and that impact shared understanding of requirement so that its impact may be analyzed by applying this practice on a GSD based project. Therefore the practice of creating a knowledge management repository is more useful for this thesis.

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"Creating a knowledge management repository" is a KM practice that is most often used by GSD based organization in order to store and maintain an organizational knowledge, However from the perspective of shared understanding the impact of this knowledge management repository on shared understanding of requirements is not discussed in detail in the literature, current thesis is a step towards this direction in which the impact of KM repository on shared understanding will be studied in detail by applying it on a field experiment.

2.6 Measuring shared understanding

As the purpose of this research is to study the impact of selected knowledge management practice on shared understanding of requirements in GSD therefore it is necessary to know the ways of measuring shared understanding because analysis is not possible without statistical results. Researchers use the term shared understanding, shared knowledge and shared mental model interchangeably hence we discuss here the methods of measuring mental models. Following methods are used in the literature for the representation and measurement of mental models or shared understanding.

2.6.1 Pairwise rating

In this method a pool of concept is presented to the participants. All the possible pairs of concepts from this pool are given to the participants one pair at a time, and the participant has to provide the similarity or relatedness rating for each pair. In this way a matrix of Pairwise rating is obtained and then with the help of some algorithm, networks are derived and these networks are compared with an expert network (Kurt, Salas, Eduardo, Bowers, & Janis, 1995).

2.6.2 Repertory grid technique

In this method the respondent is presented with three of the study objects or elements, typically written on cards. These three elements constitute a triad and in the language of repertory grid technique, we have to establish a construct –contrast pairs via the triad method. The members of these first and subsequent triads that are presented to the interviewee are determined by the researcher before administration of the grids to respondents. For recording purpose the member of each triad are represented by circles in each row of the grid. The respondent is now asked to consider the presented triad and to state one way in which any two of the triad elements are similar with each other and yet different from the third member. Similar pair of available triad is considered to be the respondent's choice. This process is repeated to establish construct-contrast pairs (Tomico, Karapanos, Levy, Mizutani & Yamanaka, 2009).

2.6.3 Causal mapping

In causal concept mapping list of concepts are identified from the initial project document and is given to the participants. The participants are then asked to map these concepts on the basis of causal relationships. This map generates a diagrammatic mental model; the maps drawn by different participants are compared in order to measure the level of shared understanding (Scozzi, Crowston, Eseryel & Li, 2008).

2.6.4 Concept mapping

A concept map is a diagram showing the relationship between concepts, in this method a list of concept is identified from the initial project document, this list of concept is given to the participants with paper and pen and they are asked to map these concepts according to the relation exist between concepts. After concept mapping exercise individual maps are combined in order to check the shared understanding of requirements (Johnson & Connor, 2008).

2.6.5 Pros and cons of shared understanding measurement techniques

Johnson & Connor (2008) discusses the following pros and cons of the above mentioned shared understanding measurement techniques:

Method	Pros	Cons
Pairwise rating	• Thorough method	• Time-consuming • Labor intensive • Fails to capture the uniqueness of mental models • Complex
Repertory grid technique	• Thorough method	• Time-consuming • Labor intensive • Not flexible • Complex
Causal mapping	• widely used method in organizational and management settings • Easy method	• The nature of the link is only causal • Not flexible
Concept mapping	• Most widely used technique • Flexible • Reduces miscommunication between individuals • Take less time • Easy to use	• Not discussed □ □ □ □

Table 2.2: pros and cons of shared understanding measurement techniques

2.7 Analysis of measurements techniques

Form the above mentioned discussion of shared understanding measurement methods with their respective pros and cons, it is evident from literature that the most commonly used and the most flexible method of capturing individual understanding is concept mapping.

2.8 Techniques of integrating individual mental models

All the above mentioned methods of measurement only capture the individuals understanding or the individual's mental model, in order to know the shared understanding of the whole GSD team it is necessary to combine the individually constructed mental models into a single map so that the overall understanding may be measured from this map. For the purpose of aggregating individual mental model following two techniques are used in the literature:

2.8.1 Team constructed shared mental model (Tmc-SMM)

In this method the participant involved in concept mapping exercise creates a single map, which represents the understanding of all the participants. The drawback of this technique is that the individual understanding or the individual map cannot be separated if required (Johnson & Connor, 2008).

2.8.2 Analysis constructed shared mental models (ACSMM)

In this method all the participants is given the list of concept and they have to map these concepts according to their understanding. This technique then translates the individuals map into a team sharedness map without losing the original perspective of the individual; thereby it represents a more accurate representation of team sharedness.

CHAPTER 3

3. Study design

This is an empirical study that was done by the field experiment. In order to conduct this experiment a well known global software development company was selected. Two projects were selected from this GSD Company. In one project our intervention that was creating a knowledge management repository was involved, while there was no intervention in the second project. In order to conduct the field experiment and to obtain the required data the study design comprised of the following steps:

3.1 Selection of knowledge management practice

As the topic of this thesis discussion was the problem of lack of shared understanding of requirements in GSD organizations. The topic was selected after literature review, and then different challenges were identified from the literature that affected the shared understanding of requirements in GSD organizations. From these challenges of RE in GSD the most commonly used challenge was knowledge management that was very helpful in achieving shared understanding of requirements and that ultimately lessened the impact of other mentioned challenges also. Hence with, as a first step of this study; knowledge management practices that are going to be used in different GSD organizations were studied from the literature, a list of knowledge management practices was obtained but it was not possible to study the impact of all these practices in a single research, therefore one of the commonly occurring practice that directly impacts the shared understanding of requirements in GSD team was selected and it was **"create a knowledge management repository (KMR)"**

3.2 Selection of shared understanding measurement method

After selecting the appropriate knowledge management practice the next step was to work out how to measure the shared understanding since the impact of selected practice can be checked only if there exist some measurement techniques which provides us the results. For this purpose, literature was studied and different techniques were discussed along with their pros and cons, and when these techniques were compared on the basis of their pros and cons, the most suitable technique that was helpful in measuring shared understanding was ACSMM (analysis constructed shared mental model).

3.3 Selection of the GSD organization

In order to check the impact of selected knowledge management practice it was necessary to apply it on a GSD organization project, a well known software company was selected for this purpose having following details:

Type	Global software development company
Specialization	Business process automation
	E-commerce solution and web development services
Establishment	5 years ago
Workforce	200 technical professionals
Certifications	Microsoft & ISO 9001:2008
Clients	More than hundred across four continents

Table 3.1: Detail of GSD organization

Introduction of the projects:

To implement the selected knowledge management practice, two software development projects were taken from the above mentioned company. Knowledge management repository was created for one of the two selected projects and the team members working on this project were given full access to this repository. Then the shared understanding of both the project development team members was measured in order to check the impact of this repository on shared understanding of requirements in GSD.

Both projects were of the similar nature and duration, following were the similarities of these projects:

- Both projects were web-based, the projects were given by the remote client from UK and were developed in Pakistan.
  - Both projects had same duration of 60 days each.
  - Both projects were undertaken by the similar team of seven team members, and the detail of the team members is as follows:-
    - Project manager (from Pakistan)
    - Team Leader (from Pakistan)
    - 2 Developers (from Pakistan)
    - Designer (from UK)
    - QA Engineer(from UK)
    - Client (from UK)

3.4 Selection of repository

In order to check the impact of knowledge management repository, a repository was selected that was already in use of selected GSD organization. The project manager was requested to withdraw the use of this repository for one of the two selected projects, so that the impact of knowledge repository on shared understanding of requirements may be studied.

This KM repository had the following main features:-

Project Management

Manage projects with basic and advanced PM features, such as task dependencies, project tracking, project portfolios, task management, Gantt charts, calendar, project templates etc.

Timesheet Management

Users can fill out their time sheet online using time tracking tool, with a time clock. They can send it for approval and generate time reports.

Collaboration

It provides the facility to Communicate, work together & execute the projects as a team. Get email notifications and task reminders, among others.

HR Management

Through this feature organization can gather all human resources and external collaborators in one central place, with advanced security and access rights.

Document Management

You can upload documents to projects/tasks and share them with other users. Documents can be locked and even made public.

Expense Management

This feature record expenses against projects and tasks and submit them for approval. Stay on budget by tracking every project's cost.

Reporting

You can track your users' day-to-day workload with several reports, be it calendars, statistics, Gantt charts and/or custom task reports.

And even more

You can Customize the system's look, import and export data, and access your database remotely.

3.5 Data collection

In order to collect data for the measurement of shared understanding of both the teams and to study the impact of knowledge management repository; following tasks were performed:

Concept identification

Prior to data collection, a list of concept was identified from the initial project requirements document. List of important concepts used in the initial project requirement documents were selected and then from this list ten most important and core concepts of that project were selected for concept mapping exercise.

Team training

Prior to the start of the team task, a training of 15-20 minutes was given to the development team so that they may understand the idea of concept mapping. This training contained multimedia presentation in which a complete map was constructed for their understanding although this map was different from that of the team task. This demonstration covered the use of concepts, links and types of links.

Construction of concept maps

To obtain measures for determining change in the level of shared understanding of the team working on the project, concept mapping exercise was done three times for each of the project, first exercise was done when team started working on the project, second exercise was conducted during the middle of the project and the third exercise was conducted after the completion of the project.

Following the concept mapping demonstration, participants of the first GSD project team members were asked to map these concepts according to their understanding, they were also reminded that they are not limited to the handpicked ten concepts rather they can add any concept which they feel is more important.

In the middle of the project the development team members working on software development project were asked again to map the list of concepts that was given to them in the previous

concept mapping exercise. These maps were collected from the team members before they continued working on their task.

After the completion of project a final concept mapping exercise was conducted from the team members working on that project with the same instructions as were exercised on the previous two exercises. These final concept maps were collected from the participants.

The same process of the concept map was revised for the second software development team the only difference was that the grant of access to the software knowledge management repository of their project.

3.6 Measurement of shared understanding

After data collection the final step was measuring team shared understanding for this purpose ACSMM (Analysis Constructed Shared Mental Model) method was selected as discussed above. The ACSMM method is structured in such a way that it provides an overall analysis of all the individually constructed mental models. This ACSMM method consist of the following steps:

Elicitation design and preparation

In order to generate the list of concepts initial requirement specification documents of both the projects were studied and the list of concepts were identified from both the selected projects.

Elicitation of individual team member mental models

Prior to the data collection process, a brief training was provided to individuals who were not familiar with concept mapping by demonstrating how to create a map. And then the entire individual created their concept maps

Coding of individual data

All the individual concepts maps were analyzed and coded in spreadsheet software. In order to compare and measure a degree of sharedness in ICMMs, factors such as concepts and links were used in analyzing individually constructed concept maps.

Analysis of data to determine what is shared among team members

The data tables resulting from ICMM coding were compared for similarity across team members. To do this, the criterion for sharedness was determined and on the basis of this criterion it was decided that whether a concept or a link is shared among the team or not. In this experiment the sharedness criteria was determined to be 50 %. Now the question was that is this sharedness

criteria qualifies with just 4/7 individual or 50 % of the team member?(Johnson & Connor, 2008) suggest to start with the shared criteria of 50% .Then determine the shared item for that level. Depending on the sensitivity level of sharedness this criteria can be moved up or down. e.g. if there are not enough shared concepts or links at 50 % level then this criteria can be moved down so that the required data may be gathered. Moreover 50 % criteria is enough for bringing transparency in the results as it is the middle value.

Likert writes that goals should be "high enough to stimulate each member to do his or her best, but not so high as to create anxieties or fear of failure" (Parker 26). Hersey and Blanchard write that goals are best if set at 50% probability of success for highest motivation. This is because if there is a low probability of success (at or near 0%) there will be no motivation. On the other hand, a high probability of success (at or near 100%) will also reduce motivation to reach the goal.

CHAPTER 4

4 RESULTS

In order to validate the proposed solution, a field experiment was performed in which the selected knowledge management practice was applied on one of the two selected global software development projects. The raw data and the results obtained from this field experiment are presented in the following section:

4.1 Outcome of the 1st Software development project (Project A)

From the initial project development document of the project A, a list of concepts was identified and this list was given to the team member with a paper and pencil to map these concepts, this was a fifteen to twenty minute exercise and the results obtained are as shown below:

4.1.1 Results of project A Exercise 1

List of ten concepts were identified and given to the development team of project A for mapping, The team was given the option to add any concept which they feel were necessary to represent the process of performing their task, concept K was added by few team members raising the tally of total concepts to 11. The team members were asked to link these concepts according to their understanding, the obtained links established by the team members are tabled below:

A --> B	Y	N	Y	N	Y	N	Y
B-->F	Y	N	N	N	N	N	N
E-->F	Y	N	N	Y	N	N	N
E-->J	Y	N	N	Y	N	N	N
E-->I	Y	N	N	N	N	N	N
H-->G	Y	Y	N	N	Y	Y	Y
G-->K	Y	N	N	N	N	N	N
H-->B	N	Y	N	N	Y	Y	Y
H-->D	N	Y	Y	N	Y	Y	N
B-->E	N	Y	N	N	N	N	N
H-->J	N	Y	N	Y	Y	N	Y
J-->F	N	Y	N	N	N	N	N
H-->I	Y	Y	N	N	Y	Y	N
H-->E	N	Y	N	N	Y	N	N
B-->E	N	N	Y	N	N	N	Y

E-->I	N	N	Y	N	N	N	N
I-->F	N	N	Y	N	N	N	N
I-->J	N	N	Y	N	N	N	N
J-->G	N	N	Y	N	N	N	N
A-->G	N	N	N	Y	Y	N	N
B-->H	N	N	N	Y	N	N	N
B-->C	N	N	N	Y	N	N	N
D-->I	N	N	N	Y	N	N	N
A-->C	N	N	N	N	Y	N	Y
A-->D	N	N	N	N	Y	N	Y
A-->E	N	N	N	N	Y	N	Y
A-->F	N	N	N	N	Y	N	Y
H-->C	N	N	N	N	Y	N	Y
K-->D	N	N	N	N	N	Y	N
K-->H	N	N	N	N	N	Y	N
H-->K	N	N	N	N	N	Y	N
A-->J	N	N	N	N	N	Y	Y
D-->J	N	N	N	N	N	N	Y
A-->I	N	N	N	N	N	N	Y

Table 4.1: showing the use of links by the project A team members in Exercise 1

In order to know the shared understanding between links, the number of links used by the team members along with their percentage of sharing was calculated according to the shared criteria of 50 percent (as justified in study design). The following results were obtained:-

Links			
A --> B	4	57.14	S
B-->F	1	14.29	N
E-->F	2	28.57	N
E-->J	2	28.57	N
E-->I	1	14.29	N
H-->G	5	71.43	S
G-->K	1	14.29	N
H-->B	4	57.14	S
H-->D	4	57.14	S
B-->E	1	14.29	N
H-->J	4	57.14	S
J-->F	1	14.29	N
H-->I	4	57.14	S

H-->E	2	28.57	N
B-->E	2	28.57	N
E-->I	1	14.29	N
I-->F	1	14.29	N
I-->J	1	14.29	N
J-->G	1	14.29	N
A-->G	2	28.57	N
B-->H	1	14.29	N
B-->C	1	14.29	N
D-->I	1	14.29	N
A-->C	2	28.57	N
A-->D	2	28.57	N
A-->E	2	28.57	N
A-->F	2	28.57	N
H-->C	2	28.57	N
K-->D	1	14.29	N
K-->H	1	14.29	N
H-->K	1	14.29	N
A-->J	2	28.57	N
D-->J	1	14.29	N
A-->I	1	14.29	N

Table 4.2 showing the shared understanding of links used by the project A team members in Exercise 1

The summarized results of the above link sharing table are:

Number of Links	34
Shared criteria	50%
Total link shared	6
Percentage of shared link	17.64%

Table 4.3 showing the summary results of project A Exercise 1

In order to know the shared understanding between local and remote members of the team working on project A, the results obtained from the concept mapping exercises of both local and remote team were compiled separately.

Following table shows the results obtained from the concept mapping exercise of local team members in first Exercise of project A for which there was no repository in place:

Link							
A --> B	Y	N	Y	N	2	50	S
B-->F	Y	N	N	N	1	25	N
E-->F	Y	N	N	Y	2	50	S
E-->J	Y	N	N	Y	2	50	S

E-->I	Y	N	N	N	1	25	N
H-->G	Y	Y	N	N	2	50	S
G-->K	Y	N	N	N	1	25	N
H-->B	N	Y	N	N	1	25	N
H-->D	N	Y	Y	N	2	50	S
B-->E	N	Y	N	N	1	25	N
H-->J	N	Y	N	Y	2	50	S
J-->F	N	Y	N	N	1	25	N
H-->I	Y	Y	N	N	2	50	S
H-->E	N	Y	N	N	1	25	N
B-->E	N	N	Y	N	1	25	N
E-->I	N	N	Y	N	1	25	N
I-->F	N	N	Y	N	1	25	N
I-->J	N	N	Y	N	1	25	N
J-->G	N	N	Y	N	1	25	N
A-->G	N	N	N	Y	1	25	N
B-->H	N	N	N	Y	1	25	N
B-->C	N	N	N	Y	1	25	N
D-->I	N	N	N	Y	1	25	N

Table 4.4 showing the shared understanding of local team members of project A in Exercise 1

Similarly the shared understanding of remote team members in first Exercise of project A is shown in the table below:

A --> B	Y	N	Y	2	66.67	S
H-->G	Y	Y	Y	3	100	S
H-->B	Y	Y	Y	3	100	S
H-->D	Y	Y	N	2	66.67	S
H-->J	Y	N	Y	2	66.67	S
H-->I	Y	Y	N	2	66.67	S
H-->E	Y	N	N	1	33.33	N
B-->E	N	N	Y	1	33.33	N
A-->G	Y	N	N	1	33.33	N
A-->C	Y	N	Y	2	66.67	S
A-->D	Y	N	Y	2	66.67	S
A-->E	Y	N	Y	2	66.67	S
A-->F	Y	N	Y	2	66.67	S
H-->C	Y	N	Y	2	66.67	S
K-->D	N	Y	N	1	33.33	N
K-->H	N	Y	N	1	33.33	N

H-->K	N	Y	N	1	33.33	N
A-->J	N	Y	Y	2	66.67	S
D-->J	N	N	Y	1	33.33	N
A-->I	N	N	Y	1	33.33	N

Table 4.5 showing the shared understanding of remote team members of project A in Exercise 1

The summary results of shared understanding of both local and remote team members in first Exercise of project A are as shown below:

Total link used	23	20
Link shared	7	12
Percentage of shared links	30%	60%

Table 4.6 summary results of both local and remote team members in Exercise 1 of project A

4.1.2 Results of project A Exercise 2

After twenty days the second concept mapping exercise of the project A was conducted by the same team by giving them the list of the same concepts as identified in exercise one. The results of this second concept mapping exercise are as under:

A --> B	Y	N	Y	N	Y	Y	Y
B-->J	Y	N	N	N	N	N	Y
J-->E	Y	N	N	N	N	N	N
E-->D	Y	N	N	N	N	Y	N
B-->C	Y	N	N	N	N	Y	Y
D-->C	Y	N	N	N	N	N	N
D-->I	Y	N	N	N	N	Y	N
D-->J	Y	N	N	N	N	Y	N
I-->J	Y	N	Y	N	N	N	N
D-->G	Y	N	N	N	N	Y	N
G-->K	Y	N	N	N	N	N	N
K-->J	Y	N	N	N	N	N	N
H-->E	N	Y	N	Y	N	N	N
H-->I	N	Y	Y	Y	Y	N	Y
H-->G	N	Y	N	Y	Y	N	Y
H-->J	N	Y	Y	Y	Y	N	Y
H-->D	N	Y	Y	Y	N	N	y
H-->B	N	Y	Y	Y	N	N	Y

A-->H	N	N	Y	N	N	N	N
J-->F	N	N	Y	Y	N	N	N
J-->G	N	N	Y	N	N	N	N
E-->I	N	N	Y	N	N	N	Y
A-->C	N	N	Y	N	Y	N	y
B-->E	N	N	Y	Y	N	Y	Y
A-->D	N	N	N	N	Y	N	N
A-->E	N	N	N	N	N	Y	Y
A-->F	N	N	N	N	N	Y	N
A-->J	N	N	N	N	N	Y	Y

Table 4.7: showing the use of links by the project A team members in Exercise 2

In order to know the shared understanding between the links, the number of links used by the team members along with their percentage of sharing was calculated according to the shared criteria of 50 percent and the obtained data is shown in the following table:

A --> B	5	71.43	S
B-->J	2	28.57	N
J-->E	1	14.29	N
E-->D	2	28.57	N
B-->C	3	42.86	N
D-->C	1	14.29	N
D-->I	2	28.57	N
D-->J	2	28.57	N
I-->J	2	28.57	N
D-->G	2	28.57	N
G-->K	1	14.29	N
K-->J	1	14.29	N
H-->E	2	28.57	N
H-->I	5	71.43	S
H-->G	4	57.14	S
H-->J	5	71.43	S
H-->D	4	57.14	S
H-->B	4	57.14	S
A-->H	1	14.29	N
J-->F	2	28.57	N
J-->G	1	14.29	N
E-->I	2	28.57	N
A-->C	3	42.86	N
B-->E	4	57.14	S

A-->D	1	14.29	N
A-->E	2	28.57	N
A-->F	1	14.29	N
A-->J	2	28.57	N

Table 4.8: showing the shared understanding of links by the project A team members in Exercise 2

The summarized results of the above link sharing table are:

number of Links	28
Shared criteria	50%
Total link shared	7
Percentage of shared link	25.00%

Table 4.9 showing the summary results of project AExercise 2

Similarly in order to know the shared understanding between local and remote member of the same team in second concept mapping exercise of project A, the results obtained from the concept mapping exercises of both local and remote team were compiled separately

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Following table shows the results obtained from the concept mapping exercise of local team members in second concept mapping exercise of project A:

A --> B	Y	N	Y	N	2	50	S
B-->J	Y	N	N	N	1	25	N
J-->E	Y	N	N	N	1	25	N
E-->D	Y	N	N	N	1	25	N
B-->C	Y	N	N	N	1	25	N
D-->C	Y	N	N	N	1	25	N
D-->I	Y	N	N	N	1	25	N
D-->J	Y	N	N	N	1	25	N
I-->J	Y	N	Y	N	2	50	S
D-->G	Y	N	N	N	1	25	N
G-->K	Y	N	N	N	1	25	N
K-->J	Y	N	N	N	1	25	N
H-->E	N	Y	N	Y	2	50	S
H-->I	N	Y	Y	Y	3	75	S
H-->G	N	Y	N	Y	2	50	S
H-->J	N	Y	Y	Y	3	75	S
H-->D	N	Y	Y	Y	3	75	S
H-->B	N	Y	Y	Y	3	75	S
A-->H	N	N	Y	N	1	25	N
J-->F	N	N	Y	Y	2	50	S

J-->G	N	N	Y	N	1	25	N
E-->I	N	N	Y	N	1	25	N
A-->C	N	N	Y	N	1	25	N
B-->E	N	N	Y	Y	2	50	S

Table 4.10 showing the shared understanding of local team members of project A in Exercise 2

And the shared understanding of remote team members in second concept mapping exercise of project A is shown in the following table:

A --> B	Y	Y	Y	3	100	S
B-->J	N	N	Y	1	33.33	N
E-->D	N	Y	N	1	33.33	N
B-->C	N	Y	Y	2	66.67	S
D-->I	N	Y	N	1	33.33	N
D-->J	N	Y	N	1	33.33	N
D-->G	N	Y	N	1	33.33	N
H-->I	Y	N	Y	2	66.67	S
H-->G	Y	N	Y	2	66.67	S
H-->J	Y	N	Y	2	66.67	S
H-->D	N	N	Y	1	33.33	N
H-->B	N	N	Y	1	33.33	N
E-->I	N	N	Y	1	33.33	N
A-->C	Y	N	Y	2	66.67	S
B-->E	N	Y	Y	2	66.67	S
A-->D	Y	N	N	1	33.33	N
A-->E	N	Y	Y	2	66.67	S
A-->F	N	Y	N	1	33.3	N
A-->J	N	Y	Y	2	66.67	S

Table 4.11 showing the shared understanding of remote team members of project A in Exercise 2

Following summary table shows the overall results of both local and remote team members in second concept mapping exercise of project A:

Total link used	24	19
Link shared	10	9
Percentage of shared links	42%	47%

Table 4.12 summary results of both local and remote team members in Exercise 2 of project A

4.1.4 Results of project A Exercise 3

Project A was of two months duration so after the completion of the project the same concept mapping exercise was conducted from the development team of project A in order to know the level of their shared understanding, the results of this final concept map exercise of project A are as follows:

Links							
A-->B	Y	N	N	N	N	N	Y
A-->C	Y	N	N	N	N	N	Y
D-->E	Y	N	N	N	N	N	N
E-->F	Y	N	N	N	N	N	N
E-->G	Y	N	N	N	N	Y	N
D-->H	Y	Y	Y	Y	Y	Y	Y
D-->I	N	Y	Y	Y	Y	Y	N
D-->C	N	Y	N	N	N	N	Y
F-->C	N	Y	Y	N	Y	Y	N
I-->J	N	Y	N	N	N	N	Y
F-->I	N	Y	Y	Y	N	N	N
F-->B	N	Y	Y	N	Y	Y	Y
F-->H	N	Y	N	Y	Y	N	N
H-->G	N	N	Y	N	N	N	N
D-->G	Y	Y	Y	Y	Y	Y	Y
F-->G	N	Y	N	Y	Y	Y	N
F-->K	N	N	N	Y	N	N	N
G-->K	N	N	N	Y	N	N	N
G-->E	N	N	N	N	N	Y	N
F-->D	N	N	N	N	N	Y	N
I--F	N	N	N	N	N	Y	N
C-->D	N	N	N	N	N	Y	N
F-->A	N	N	N	N	N	N	Y
D-->F	N	N	N	N	N	N	Y
D-->K	N	N	N	N	N	N	Y
A-->K	N	N	N	N	N	N	Y

Table 4.13: showing the use of links by the project A team members in Exercise 3

Shared understanding between the links used in the above table are as follows:

Links			
A-->B	2	28.57	N
A-->C	2	28.57	N
D-->E	1	14.29	N
E-->F	1	14.29	N
E-->G	2	28.57	N
D-->H	7	100	S
D-->I	5	71.43	S
D-->C	2	28.57	N
F-->C	4	57.14	S
I-->J	2	28.57	N
F-->I	3	42.86	N
F-->B	5	71.43	S
F-->H	3	42.86	N
H-->G	1	14.29	N
D-->G	7	100	S
F-->G	4	57.14	S
F-->K	1	14.29	N
G-->K	1	14.29	N
G-->E	1	14.29	N
F-->D	1	14.29	N
I--F	1	14.29	N
C-->D	1	14.29	N
F-->A	1	14.29	N
D-->F	1	14.29	N
D-->K	1	14.29	N
A-->K	1	14.29	N

Table 4.14: showing the shared understanding of links by the project A team members in Exercise 3

The summarized results of the above link sharing table are:

Number of Links	26
Shared criteria	50%
Total link shared	6
Percentage of shared link	23.00%

Table 4.15 showing the summary results of project AExercise 3

Similarly in order to know the shared understanding between local and remote members of the same team in final concept mapping exercise of project A, the results obtained from the concept mapping exercises of both local and remote team were compiled separately.

Following table shows the results obtained from the concept mapping exercise of local team members in final concept mapping exercise of project A;

Links							
A-->B	Y	N	N	N	1	25	N
A-->C	Y	N	N	N	1	25	N
D-->E	Y	N	N	N	1	25	N
E-->F	Y	N	N	N	1	25	N
E-->G	Y	N	N	N	1	25	N
D-->H	Y	Y	Y	Y	4	100	S
D-->I	N	Y	Y	Y	3	75	S
D-->C	N	Y	N	N	1	25	N
F-->C	N	Y	Y	N	2	50	S
I-->J	N	Y	N	N	1	25	N
F-->I	N	Y	Y	Y	3	75	S
F-->B	N	Y	Y	N	2	50	S
F-->H	N	Y	N	Y	2	50	S
H-->G	N	N	Y	N	1	25	N
D-->G	Y	Y	Y	Y	4	100	S
F-->G	N	Y	N	Y	2	50	S
F-->K	N	N	N	Y	1	25	N
G-->K	N	N	N	Y	1	25	N

Table 4.16 showing the shared understanding of local team members of project A in Exercise 3

And the shared understanding of remote team members in final concept mapping exercise of project A is shown in the following table:

Links						
A-->B	N	N	Y	1	33.33	N
A-->C	N	N	Y	1	33.33	N
E-->G	N	Y	N	1	33.33	N
D-->H	Y	Y	Y	3	100	S
D-->I	Y	Y	N	2	66.67	S
D-->C	N	N	Y	1	33.33	N
F-->C	Y	Y	N	2	66.67	S
I-->J	N	N	Y	1	33.33	N
F-->B	Y	Y	Y	3	100	S
F-->H	Y	N	N	1	33.33	N
D-->G	Y	Y	Y	3	100	S

F-->G	Y	Y	N	2	66.67	S
G-->E	N	Y	N	1	33.33	N
F-->D	N	Y	N	1	33.33	N
I—F	N	Y	N	1	33.33	N
C-->D	N	Y	N	1	33.33	N
F-->A	N	N	Y	1	33.33	N
D-->F	N	N	Y	1	33.33	N
D-->K	N	N	Y	1	33.33	N
A-->K	N	N	Y	1	33.33	N

Table 4.17 showing the shared understanding of remote team members in Exercise 3 of project A

Following summary table shows the overall results of both local and remote team members in third concept mapping exercise of project A:

Total link used	18	20
Link shared	8	6
Percentage of shared links	44%	30%

Table 4.18 summary results of both local and remote team members in Exercise 3 of project A

4.2 Outcomes of 2nd Software Development project (Project B)

From the initial project development document of the project B; a list of concepts was identified and this list was given to the team member of the project B development team for mapping, this team was using knowledge management repository which was created for project B. List of concepts with paper and pencil were given to the team member to map these concepts, this was a fifteen to twenty minute exercise. The results obtained are as follows:

4.2.1 Results of project B Exercise 1

List of ten concepts were identified from the initial project document of the software development project B; selected list of concepts was given to the development team of project B for mapping. Links established by the team members in the first concept mapping exercise of project B are as shown in the table below:

A-->G	Y	N	Y	Y	N	N	Y
G-->H	Y	N	N	N	N	N	N
G-->J	Y	N	N	N	N	N	N

B-->C	Y	Y	N	N	N	Y	Y
B-->F	Y	N	Y	Y	N	Y	Y
B-->D	Y	N	Y	N	N	Y	Y
D-->E	Y	N	N	N	N	N	N
F-->I	Y	N	N	N	N	N	N
I-->J	Y	N	N	N	N	N	N
A-->D	N	Y	N	N	Y	Y	Y
D-->F	N	Y	N	N	Y	N	N
D-->G	N	Y	N	N	N	N	N
D-->C	N	Y	N	Y	N	N	N
F-->D	N	Y	N	N	Y	N	N
H-->D	N	N	Y	Y	N	Y	Y
B-->G	Y	Y	N	Y	N	Y	Y
A-->F	N	N	N	N	N	N	Y
H-->J	N	N	N	N	N	Y	N
F-->G	N	N	N	N	Y	N	N
G-->B	N	N	N	N	Y	N	N
D-->B	N	N	N	N	Y	N	Y
B-->I	N	N	N	N	N	Y	N
H-->E	N	N	N	N	N	Y	N
H-->A	N	N	N	N	N	Y	N
A-->C	N	N	N	N	N	N	Y
H-->F	N	N	N	N	N	N	Y
H-->C	N	N	N	N	N	N	Y
H-->G	N	N	N	N	N	N	Y
H-->I	N	N	N	N	N	N	Y

Table 4.19: showing the use of concepts by the project B team members in Exercise 1

Shared understanding between the links used in the above table is as follows:

A-->G	4	57.14	S
G-->H	1	14.29	N
G-->J	1	14.29	N
B-->C	4	57.14	S
B-->F	5	71.43	S
B-->D	4	57.14	S
D-->E	1	14.29	N
F-->I	1	14.29	N
I-->J	1	14.29	N
A-->D	4	57.14	S
D-->F	2	28.57	N

D-->G	1	14.29	N
D-->C	2	28.57	N
F-->D	2	28.57	N
H-->D	4	57.14	S
B-->G	5	71.43	S
A-->F	1	14.29	N
H-->J	1	14.29	N
F-->G	1	14.29	N
G-->B	1	14.29	N
D-->B	2	28.57	N
B-->I	1	14.29	N
H-->E	1	14.29	N
H-->A	1	14.29	N
A-->C	1	14.29	N
H-->F	1	14.29	N
H-->C	1	14.29	N
H-->G	1	14.29	N
H-->I	1	14.29	N

Table 4.20: showing the shared understanding of links by the project B team members in Exercise 1

The summarized results of the above link sharing table are:

Number of links	29
Shared Criteria	50%
Total Link shared	7
Percentage of link shared	24.13%

Table 4.21 showing the summary results of project B Exercise 1

In order to know the shared understanding between local and remote team members of the software development project B, the results obtained from the concept mapping exercises of both local and remote team were compiled separately.

Following table shows the results obtained from the concept mapping exercise of local team members in first Exercise of project B for which there was repository in place:

A-->G	Y	N	Y	Y	3	75	S
G-->H	Y	N	N	N	1	25	N
G-->J	Y	N	N	N	1	25	N
B-->C	Y	Y	N	N	2	50	S
B-->F	Y	N	Y	Y	3	75	S
B-->D	Y	N	Y	N	2	50	S

D-->E	Y	N	N	N	1	25	N
F-->I	Y	N	N	N	1	25	N
I-->J	Y	N	N	N	1	25	N
A-->D	N	Y	N	N	1	25	N
D-->F	N	Y	N	N	1	25	N
D-->G	N	Y	N	N	1	25	N
D-->C	N	Y	N	Y	2	50	S
F-->D	N	Y	N	N	1	25	N
H-->D	N	N	Y	Y	2	50	S
B-->G	Y	Y	N	Y	3	75	S

Table 4.22 showing the shared understanding of local team members of project B in Exercise 1

Similarly the results obtained from the remote team of second project B's first concept mapping exercise are as follows:

A-->G	N	N	Y	1	33.33	N
B-->C	N	Y	Y	2	66.67	S
B-->F	N	Y	Y	2	66.67	S
B-->D	N	Y	Y	2	66.67	S
A-->D	Y	Y	Y	3	100	S
D-->F	Y	N	N	1	33.33	N
F-->D	Y	N	N	1	33.33	N
H-->D	N	Y	Y	2	66.67	S
B-->G	N	Y	Y	2	66.67	S
A-->F	N	N	Y	1	33.33	N
H-->J	N	Y	N	1	33.33	N
F-->G	Y	N	N	1	33.33	N
G-->B	Y	N	N	1	33.33	N
D-->B	Y	N	Y	2	66.67	S
B-->I	N	Y	N	1	33.33	N
H-->E	N	Y	N	1	33.33	N
H-->A	N	Y	N	1	33.33	N
A-->C	N	N	Y	1	33.33	N
H-->F	N	N	Y	1	33.33	N
H-->C	N	N	Y	1	33.33	N
H-->G	N	N	Y	1	33.33	N
H-->I	N	N	Y	1	33.33	N

Table 4.23 showing the shared understanding of remote team members of project B in Exercise 1

Following table shows the overall summary of the results obtained from first concept mapping exercise of both the local and remote team members of project B:

Total link used	16	22
Link shared	7	7
Percentage of shared links	44%	32%

Table 4.24 showing summary results of both local and remote team members in Exercise 1 of project B

4.2.2 Results of project B Exercise 2

After twenty days the second concept map exercise of project B was conducted by the same team by giving them the list of the same concepts as identified in exercise one and the result of this second concept mapping exercise of project B are as follows:

Links / Project B							
A-->G	Y	Y	Y	N	Y	Y	N
G-->H	Y	N	N	N	Y	N	Y
H-->D	Y	Y	N	N	Y	Y	N
G-->J	Y	N	N	Y	N	Y	N
B-->F	Y	N	N	Y	N	N	N
F-->I	Y	N	Y	N	N	Y	N
B-->C	Y	N	N	Y	N	Y	Y
B-->D	Y	Y	Y	Y	Y	Y	Y
D-->F	N	Y	Y	Y	Y	Y	Y
D-->G	N	Y	Y	N	Y	Y	N
G-->I	N	Y	N	N	N	Y	N
D-->C	N	Y	N	Y	N	N	N
A-->F	N	N	Y	N	N	Y	Y
B-->G	N	N	Y	Y	N	N	N
D-->E	Y	N	Y	Y	N	Y	N
G-->E	Y	N	Y	Y	Y	Y	Y
A-->D	Y	N	N	Y	Y	N	Y
J-->I	N	N	N	Y	N	N	Y
H-->G	N	N	N	Y	Y	Y	Y
F-->G	N	N	N	N	Y	N	N
H-->J	N	N	N	Y	N	Y	N
H-->I	N	N	N	N	N	Y	N

Table 4.25: showing the use of links by the project B team members in Exercise 2

In order to know the shared understanding between links, the number of links used by the team members along with their percentage of sharing was calculated according to the shared criteria of 50 percent and the data obtained is shown in the following table:

A-->G	5	71.43	S
G-->H	3	42.86	N
H-->D	4	57.14	S
G-->J	3	42.86	N
B-->F	2	28.57	N
F-->I	3	42.86	N
B-->C	4	57.14	S
B-->D	7	100	S
D-->F	6	85.71	S
D-->G	4	57.14	S
G-->I	2	28.57	N
D-->C	2	28.57	N
A-->F	3	42.86	N
B-->G	2	28.57	N
D-->E	4	57.14	S
G-->E	6	85.71	S
A-->D	4	57.14	S
J-->I	2	28.57	N
H-->G	4	57.14	S
F-->G	1	14.29	N
H-->J	2	28.57	N
H-->I	1	14.29	N

Table 4.26: showing the shared understanding of links by the project B team members in Exercise 2

The summarized results of above link sharing table are as follows

Number of Links	22
Shared criteria	50%
Total link shared	10
Percentage of shared link	45.00%

Table 4.27 showing the summary results of project B Exercise 2

Similarly the results obtained from local and remote team members in second concept mapping exercise of project B were compiled separately in order to know their level of shared understanding.

Following table shows the results obtained from local team members of project B in second concept mapping exercise:

A-->G	Y	Y	Y	N	3	75	S
G-->H	Y	N	N	N	1	25	N
H-->D	Y	Y	N	N	2	50	S
G-->J	Y	N	N	Y	2	50	S
B-->F	Y	N	N	Y	2	50	S
F-->I	Y	N	Y	N	2	50	S
B-->C	Y	N	N	Y	2	50	S
B-->D	Y	Y	Y	Y	4	100	S
D-->F	N	Y	Y	Y	3	75	S
D-->G	N	Y	Y	N	2	50	S
G-->I	N	Y	N	N	1	25	N
D-->C	N	Y	N	Y	2	50	S
A-->F	N	N	Y	N	1	25	N
B-->G	N	N	Y	Y	2	50	S
D-->E	Y	N	Y	Y	3	75	S
G-->E	Y	N	Y	Y	3	75	S
A-->D	Y	N	N	Y	2	50	S
J-->I	N	N	N	Y	1	25	N
H-->G	N	N	N	Y	1	25	N
H-->J	N	N	N	Y	1	25	N

Table 4.28 showing the shared understanding of local team members of project B in Exercise 2

And the results obtained from remote team members of the same projects are as follows:

A-->G	Y	Y	N	2	66.67	S
G-->H	Y	N	Y	2	66.67	S
H-->D	Y	Y	N	2	66.67	S
G-->J	N	Y	N	1	33.33	N
F-->I	N	Y	N	1	33.33	N
B-->C	N	Y	Y	2	66.67	S
B-->D	Y	Y	Y	3	100	S
D-->F	Y	Y	Y	3	100	S
D-->G	Y	Y	N	2	66.67	S
G-->I	N	Y	N	1	33.33	N
A-->F	N	Y	Y	2	66.67	S
D-->E	N	Y	N	1	33.33	N
G-->E	Y	Y	Y	3	100	S
A-->D	Y	N	Y	2	66.67	S
J-->I	N	N	Y	1	33.33	N

H-->G	Y	Y	Y	3	100	S
F-->G	Y	N	N	1	33.33	N
H-->J	N	Y	N	1	33.33	N
H-->I	N	Y	N	1	33.33	N

Table 4.29 showing the shared understanding of remote team members of project B in Exercise 2

The summary results of both the local and remote team members are shown in the following table:

Total link used	22	19
Link shared	14	11
Percentage of shared links	64%	58%

Table 4.30 summary results of both local and remote team members in Exercise 2 of project B

4.2.3 Results of project B Exercise 3

After the completion of project B, final concept mapping exercise of this project was performed in the same way as before by giving team members the list of concepts identified in the previous concept mapping exercises. This team had full access of the project repository as in the last two exercises of this project. The links used by the team members along with their percentage of sharing are shown in the following table:

Links							
A-->B	Y	N	Y	N	N	N	Y
B-->C	Y	Y	N	N	Y	Y	Y
B-->D	Y	Y	Y	Y	Y	N	Y
D-->E	Y	N	N	N	N	Y	Y
F-->G	Y	Y	Y	Y	Y	Y	Y
F-->E	Y	N	Y	N	Y	Y	N
F-->H	Y	N	N	N	N	N	Y
E-->I	Y	N	N	N	N	Y	Y
E-->H	Y	Y	Y	Y	Y	Y	N
J-->C	Y	Y	Y	Y	N	N	Y
D-->J	Y	Y	Y	Y	N	Y	N
J-->F	Y	Y	N	N	Y	Y	Y
E-->G	N	Y	Y	Y	Y	Y	N
F-->B	N	Y	Y	Y	Y	Y	Y
A-->E	N	N	Y	N	N	N	Y
B-->J	N	N	Y	N	Y	N	Y
H-->E	N	N	N	N	Y	N	N
D-->C	N	N	N	N	N	Y	Y

Table 4.31: showing the use of links by the project B team members in Exercise 3

In order to know the shared understanding between the links, the number of links used by the team members along with their percentage of sharing was calculated according to the shared criteria of 50 percent and the obtained data is shown in the following table:

A-->B	3	42.86	N
B-->C	5	71.43	S
B-->D	6	85.71	S
D-->E	3	42.86	N
F-->G	7	100	S
F-->E	4	57.14	S
F-->H	2	28.57	N
E-->I	3	42.86	N
E-->H	6	85.71	S
J-->C	5	71.43	S
D-->J	5	71.43	S
J-->F	5	71.43	S
E-->G	5	71.43	S
F-->B	6	85.71	S
A-->E	2	28.57	N
B-->J	3	42.86	N
H-->E	1	14.29	N
D-->C	2	28.57	N

Table 4.32: showing the shared understanding of links by the project B team members in Exercise 3

The summarized results for this link sharing table are as follows

Number of Links	18
Shared criteria	50%
Total link shared	10
Percentage of shared link	55.55%

Table 4.33 showing the summary results of project B Exercise 3

Similarly in order to know the shared understanding between local and remote member of the same team in final concept mapping exercise of project B, the results obtained from the concept mapping exercises of both local and remote team were compiled separately.

Following table shows the results obtained from the concept mapping exercise of local team members in final concept mapping exercise of project B:

A-->B	Y	N	Y	N	2	50	S
B-->C	Y	Y	N	N	2	50	S
B-->D	Y	Y	Y	Y	4	100	S
D-->E	Y	N	N	N	1	25	N
F-->G	Y	Y	Y	Y	4	100	S
F-->E	Y	N	Y	N	2	50	S
F-->H	Y	N	N	N	1	25	N
E-->I	Y	N	N	N	1	25	N
E-->H	Y	Y	Y	Y	4	100	S
J-->C	Y	Y	Y	Y	4	100	S
D-->J	Y	Y	Y	Y	4	100	S
J-->F	Y	Y	N	N	2	50	S
E-->G	N	Y	Y	Y	3	75	S
F-->B	N	Y	Y	Y	3	75	S
A-->E	N	N	Y	N	1	25	N
B-->J	N	N	Y	N	1	25	N

Table 4.34 showing the shared understanding of local team members of project B in Exercise 3

And the results obtained from remote team members of the same projects are as follows:

A-->B	N	N	Y	1	25	N
B-->C	Y	Y	Y	3	75	S
B-->D	Y	N	Y	2	50	S
D-->E	N	Y	Y	2	50	S
F-->G	Y	Y	Y	3	75	S
F-->E	Y	Y	N	2	50	S
F-->H	N	N	Y	1	25	N
E-->I	N	Y	Y	2	50	S
E-->H	Y	Y	N	2	50	S
J-->C	N	N	Y	1	25	N
D-->J	N	Y	N	1	25	N
J-->F	Y	Y	Y	3	75	S
E-->G	Y	Y	N	2	50	S
F-->B	Y	Y	Y	3	75	S
A-->E	N	N	Y	1	25	N
B-->J	Y	N	Y	2	50	S
H-->E	Y	N	N	1	25	N
D-->C	N	Y	Y	2	50	S

Table 4.35 showing the shared understanding of remote team members of project B in Exercise 3

The summary results of both the local and remote team members are shown in the following table:

Total link used	16	18
Link shared	11	12
Percentage of shared links	69%	67%

Table 4.36 summary results of both local and remote team members in Exercise 2 of project B

4.4 Shared understanding of both development teams

In order to check the impact of knowledge management repository on shared understanding of requirements, the results obtained from the concept mapping exercises of both the projects were compiled for analysis. The table below shows the shared understanding data of both the projects. In project A there was no shared repository while in the project B a knowledge management repository was created that was accessible by all the team members working on project B:

Ex # 1	17.64%	24.13%
Ex # 2	25%	45%
Ex # 3	23.1%	55.55%

Table 4.37: showing the shared understanding of both the projects team members

4.5 Shared understanding of local and remote clients in both projects

In order to compare the shared understanding level of both local and remote clients within different Exercises of both projects, the results obtained from both local and remote team members were compiled for comparison. The following table shows the overall results:

	Exercise 1	30%	60%	30%
Project A	Exercise 2	42%	47%	5%
	Exercise 3	44%	30%	14%
	Exercise 1	43.75%	31.80%	11.95%
Project B	Exercise 2	63.60%	57.89%	5.71%
	Exercise 3	68.75%	66.67%	2.08%

Table 4.38: showing the shared understanding of local and remote team members

CHAPTER 5

5. Discussion

This chapter discusses the results obtained from the field experiment. It discusses the major patterns that came in to the observation during field experiment. Moreover, it interprets results in terms of background laid out in the introduction session of this thesis.

The researcher came across multiple issues that caused lack of shared understanding of requirements in GSD. GSD challenges reported by studies done internationally were found to be similar in nature in Pakistani Software Company engaged in GSD. However, the method/ways and means of solving these problems vary from company to company.

The company selected for the field experiment of this thesis also faced the challenges of GSD like other global software companies, but it was seen during the field experiment that knowledge management repository helped a lot in the understanding of requirements, the results obtained from the field experiment also shows that knowledge management repository increases the level of shared understanding among GSD team members.

To check the impact of knowledge management repository on shared understanding of requirements the results obtained from the concept mapping exercises of both the projects were compiled for analysis. The table below shows the shared understanding data of both the projects. In project A there was no shared repository while in the project B a knowledge management repository was created that was accessible to all the team members working on project B:

Concept mapping exercises	Shared understanding of project A team members	Shared understanding of project B team members
Ex: 1	17.64%	24.13%
Ex: 2	25%	45%
Ex: 3	23.1%	55.55%

Table 5.1: Table showing quantitative measure of shared understanding of two GSD teams

If we compare the level of shared understanding in first concept mapping exercises of both the projects that was conducted after twenty days from the start of the project, the level of shared understanding in project B is 6% more as compared to project A. Similarly, if we look at the table above, the level of shared understanding in 2nd Exercise of project B is 20% more than project A and similarly 32 % in 3rd Exercise. It means that with the passage of time KM repository becomes more affective in increasing the level of shared understanding.

Following figure highlights the difference between shared understandings of both the projects

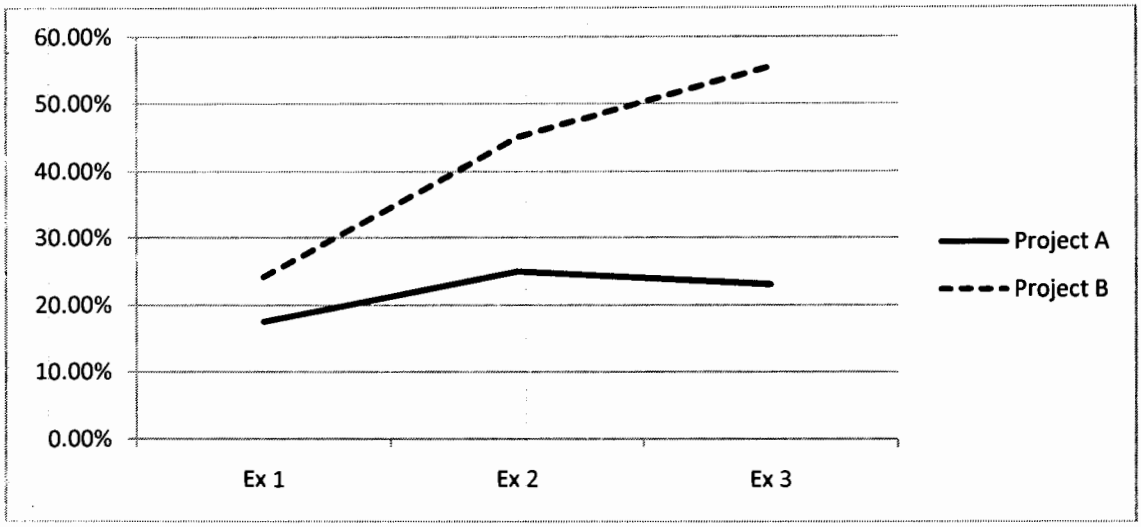

Figure 5.1: Showing the shared understanding of two global software development projects team

The above graph compares the shared understanding of two GSD projects team members for three concept mapping exercises from 1 to 3, that are labeled on X-axis and each was conducted with the gap of 20 days. Shared understanding was calculated in percentage from 100 that is labeled on Y-axis. It can be clearly seen that the level of shared understanding is increasing in 1st and 2nd concept mapping exercises of both the project A and project B but in exercise 3 that was conducted after the completion of the project, the level of shared understanding of project B team members increased while a declining/downward trend was observed in the shared understanding of project A team members.

In exercise 1 the level of shared understanding for project A team was 17.64%.This number increased gradually to 25% in exercise 2 and continued to decrease gradually to 23.1% by the end of 3rd concept mapping exercise. In contrast, the level of shared understanding in project B was 24.13% in 1st concept mapping exercise, by the end of 2nd exercise this level of shared understanding increased to 45% which was comparatively a high positive change as compared to project A. In exercise3 shared understanding level of project B increased to 55.55% which was a better change as compare to project A in which shared understanding decreased considerably.

It can be seen that shared understanding level in project B is high as compare to project A which shows the positive impact of KM repository in creating shared understanding of requirements in GSD teams.

The aim of the researcher was to check the impact of KM repository on shared understanding of requirements in GSD projects, but the major pitfall of GSD projects is the disbursement of development team in different geographical areas. Therefore to check the impact of KM repository on shared understanding of requirements in GSD, the overall change in the level of shared understanding of local and remote team was compared separately for each concept mapping exercises of both the projects. Following table highlights the major results:

Projects	Concept mapping Exercises	Shared understanding of local team members	Shared understanding of remote team members	Difference
1. Project A Without KMR	Ex 1	30%	60%	30%
	Ex 2	42%	47%	5%
	Ex 3	44%	30%	14%
2. Project B With KMR	Ex 1	43.75%	31.80%	11.95%
	Ex 2	63.60%	57.89%	5.71%
	Ex 3	68.75%	66.67%	2.08%

Table 5.2: Table showing the shared understanding of local and remote teams of both projects

This table gives us the following main points:

1. The level of shared understanding among local team members increased with the passage of time in both projects. Increase in GSD project B was more than the project A which shows that KM repository has a positive impact on shared understanding of requirements.

2. The level of shared understanding among remote team member decreased in project A while the level of shared understanding among remote team member increased with the passage of time. Which thus shows that KM repository should be used in order to develop shared understanding especially in remote members of the team.

Following figures shows the overall change in trend of local and remote team members in all three Exercises of project A

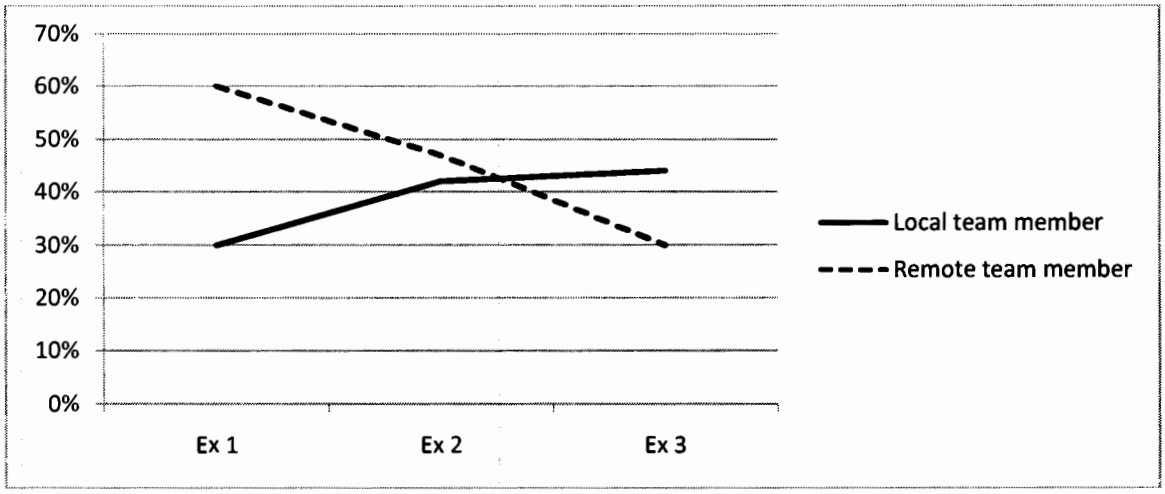

Figure 5.2: Shared understanding of local and remote team members in all three Exercises of project A

The above graph compares shared understanding of local and remote team members in all three concept mapping exercises of project A. Concept mapping exercises are labeled on X-axis from 1 to 3; shared understanding is measured in percentage from 100 that is labeled on Y-axis. It can be clearly seen that the level of shared understanding for remote team members was 60% in 1st

concept mapping exercise, this number deteriorated to 47% in 2nd exercise and declined steeply to 30% in 3rd concept mapping exercise.

In contrast, the shared understanding level of local team members was 30% in 1st concept mapping exercise of project A that was comparatively lower than the remote team members working on the same project. By the end of 2nd exercise this number increased to 42% as against the remote team members number whose shared understanding level slipped in 2nd excercise, and gradually raised again to 44% at the end of the 3rd concept mapping exercise.

It can be seen that there is no mutual understanding between the local and remote team members of the project A as both lines of the graph shows opposite behavior.

Moreover it was seen during the field experiment that the remote team member were fully dependent on KMR for communication and getting updates about the project; therefore the absence of KMR in project A decreased the level of shared understanding among team members with the passage of time.

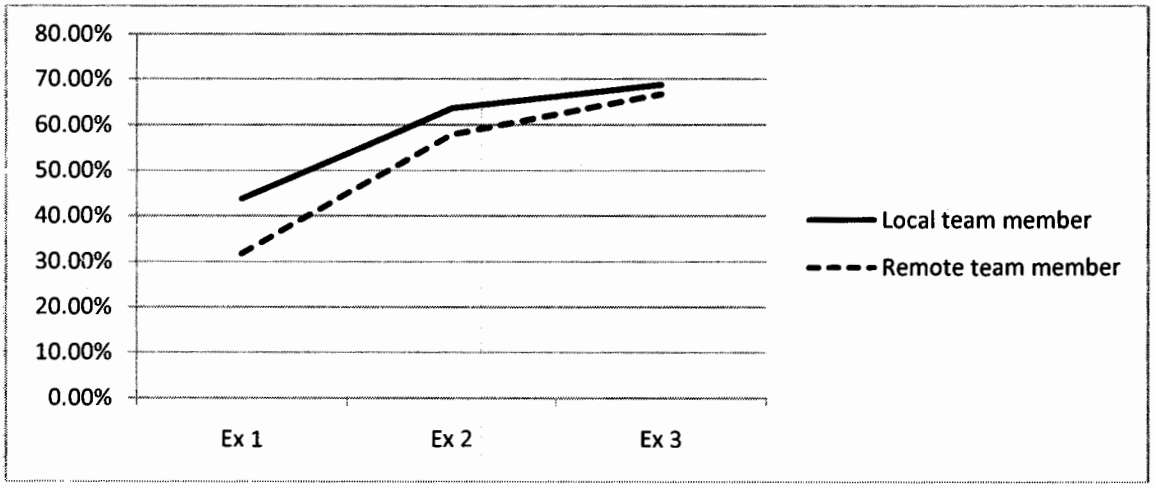

Figure 5.3: Shared understanding of local and remote team members in all three Exercises of project B

The above graph compares shared understanding of local and remote team members in all three concept mapping exercises of project B. Concept mapping exercises are labeled on X-axis from 1 to 3; shared understanding is measured in percentage from 100 that is labeled on Y-axis. It can be clearly seen that the level of shared understanding for remote team members was 31.80% in 1st concept mapping exercise, this number elevated to 57.89% in the 2nd exercise and again increased to 66.67% in 3rd concept mapping exercise. On the other hand the shared understanding level of local team members was 43.75% in 1st concept mapping exercise of project B that was comparatively high as compare to remote team members working on the same project. By the end of 2nd exercise this number increased to 63.60%, and increased again gradually to 68.75% at the end of the 3rd concept mapping exercise.

It can be seen from the graph that there is mutual understanding between the local and remote team members of the project B as both lines of the graph shows same behavior. It can also be concluded that KM repository helps in creating shared understanding between local and remote team members of the GSD team working on the same project.

The difference between understanding level of local and remote clients of project A team members in all Exercises was more than the difference between understanding level of local and remote clients in project B. This shows that GSD project B team that is using repository has more shared understanding as compared to GSD project A team. This is shown in the following figure

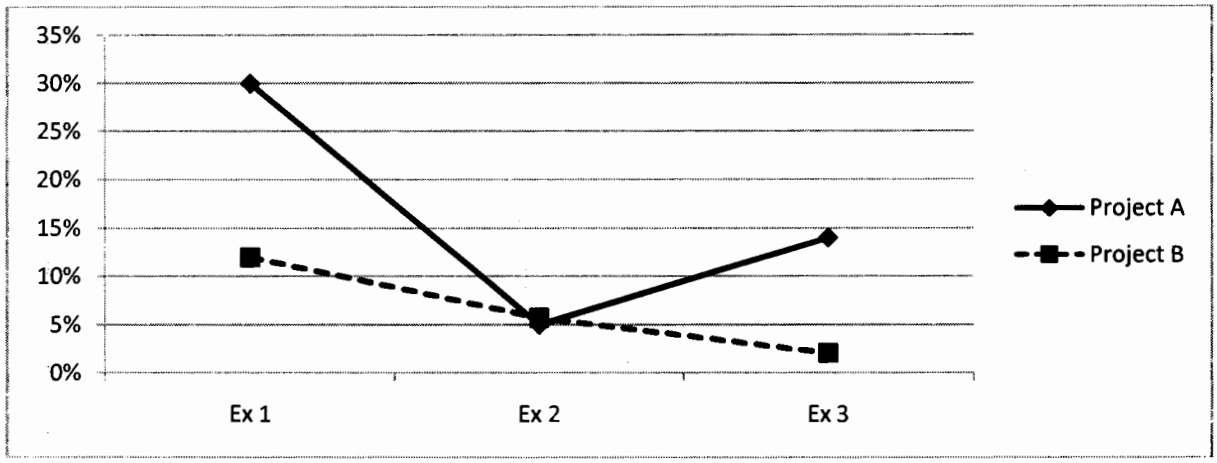

Figure 5.4: Shared understanding difference between local and remote team members in both projects

The above graph shows the difference between understanding level of local and remote team members of both project A and project B. Concept mapping exercises are labeled on X-axis from 1 to 3; shared understanding difference is measured in percentage from 100 that is labeled on Y-axis. It can be observed that the difference between level of shared understanding for local and remote team members in 1st concept mapping exercise of project A was 30% and was 11.95% for project B, this number decreased to 5% in 2nd exercise of project A and 5.7% in project B which is approximately same for both the projects. In 3rd concept mapping exercise the difference in level of shared understanding was 14% for project A team and was 2.08% for project B team members.

It can be seen that the difference between shared understanding levels of project B team members is low as compare to project A team members. Hence it can be concluded that the mutual understanding level between the local and remote team members of the project A is low as compare to project B.

As far as the behavior of the project A curve is concerned It is typical that initially understanding is better as compared to middle because of few concepts and issues as people dig deeper in to the work confusion starts which are clarified towards the end. Moreover literature use the term forming, storming and norming for the same scenario, in the **first stages** of team building, the *forming* of the team takes place. The individual's behavior is driven by a desire to be accepted by

the others, and avoid controversy or conflict. Serious issues and feelings are avoided, and people focus on being busy with routines, such as team organization, who does what, when to meet, etc Every group will next enter the *storming* stage in which different ideas compete for consideration. The team addresses issues such as what problems they are really supposed to solve, how they will function independently and together and what leadership model they will accept. Team members open up to each other and confront each other's ideas and perspectives. In norming team manages to have one goal and come to a mutual plan for the team at this stage. Some may have to give up their own ideas and agree with others in order to make the team function. In this stage, all team members take the responsibility and have the ambition to work for the success of the team's goals.

The same scenario is discussed in economics cycle or business cycle of a country which normally passes the four stages hat are expansion, prosperity , contraction and recession and almost all development organization passes through all these stages.

It was observed during field experiment that KMR helps to improve shared understanding of requirements because of the following benefits achieved from it:-

1. Our Field experiment shows that Knowledge management repository helps the team member in finding information easily and quickly.

2. During this field experiment it was seen that on number of occasions a team member was unable to attend some important meeting because of his own commitments, this repository helped him as it contained meeting minutes, important decisions and the rationale behind these decisions.

3. The KM repository used for this particular field experiment have built in communication and collaboration feature. Team members working on project B used this feature of repository to share their ideas, send email or instant messages to each other, thus this default/built in communication and collaboration feature of the repository overcome the problem of inadequate communication.

CHAPTER 6

6. CONCLUSION

This chapter discusses an overview of the research reported in this thesis, the contributions of the thesis and possible directions for future research.

6.1 Overview

Requirement engineering plays a vital role in software development and the success of the project depends mostly on it, but one of the main hurdles that global software development organizations are facing is "lack of shared understanding of requirements" which causes many problems during and after development. It is highlighted in literature that requirement understanding issue is commonly caused by lack of knowledge sharing and communication, lack of interaction, culture diversity, and time zone difference and so on. Besides, today's Global software development organizations are commonly engaged in highly knowledge intensive efforts. The movement of knowledge within and across organization must be done in affective and cost efficient manner in order to get most benefit from it and for this purpose proper knowledge management is essential in global software development projects.

Carrying out proper knowledge management is a key challenge of GSD organizations. Various techniques and knowledge management practices are employed for this purpose in GSD based organizations. In the current thesis one of the commonly used practices of knowledge management named as "creating a knowledge management repository" was selected from literature to check its impact on shared understanding of requirements.

In order to know the impact of selected knowledge management practice on shared understanding of requirements, a field experiment was performed in a GSD based organization. In this field experiment two software development projects of the same nature were taken and knowledge management repository was created for one of the two selected projects, for measuring shared understanding of requirements the techniques of concept mapping was used. Both projects were of the duration of two months and shared understanding was measured at three points during the development of both the projects once after each month. The results obtained from both the projects were compared in order to check the impact of knowledge management repository on shared understanding of requirements in GSD, these results shows that knowledge management repository increase the level of shared understanding of requirements among the team members.

The following section highlights the major contributions of this research

6.2 Contributions of Research

The major contributions of this thesis include: firstly literature was studied and the barriers that causes lack of shared understanding of requirements in GSD were collected from the literature and the impact of these barriers on shared understanding of requirements was discussed from the

literature in little detail. Secondly one of the common problems in achieving shared understanding of requirements that is "improper knowledge management" was selected and its importance and priority was discussed in detail so that the organizations involved in GSD may overcome this issue.

Thirdly literature review was performed to know the knowledge management practices that are going to be used by different organizations for overcoming the problem of improper knowledge management. Fourthly from the list of these knowledge management practices one of the commonly occurring practice was selected and it was applied on a global software development organization so that its impact on shared understanding of requirements may be studied, the selected practice was "create a knowledge management repository" because it has highest frequency of occurrence in GSD literature.

Moreover the methods of measuring shared understanding were also discussed form the literature with their respective pros and cons that will help the researcher in the selection of appropriate method for measuring shared understanding.

6.3 Conclusion and Recommendations

Literature review tells us that requirements understanding issues in GSD occurs normally due to the factors of cultural diversity, time zone difference, inadequate communication, physical distance, and improper knowledge management and so on and so forth. Besides, it is considered that improper knowledge management is a challenge in shared understanding of requirements in GSD that must be solved to overcome the problem of shared understanding and to decrease the negative impact of other GSD challenges. The analysis of the results obtained from the field experiment shows that KMR helps to improve shared understanding of requirements among GSD team members.

Therefore, following recommendations are made on the basis of our study

The practice of Creating and maintaining a knowledge management repository should be adopted by the global software development teams as it helps to improve shared understanding of requirements among GSD team.

Field experiment conducted for this research tells us that this knowledge management repository must be up-to-dated, all the project related information must be uploaded in the repository timely and all the team members must access and use it timely in order to increase shared understanding and to get benefit from it

6.4 Limitations

Following were the few limitations of this experiment

The projects selected for this field experiment had a life of only two months each.

The size of the development team was not so large; both project development teams consist of seven members each.

There can be many other factors like team skills or experience, project type, team mutual relationship etc that have pivotal impact on the shared understanding of requirements the impact of these factors was eliminated in this field experiment to some extent by taking the similar teams working on two same types of projects, still there can be the possibility of these factors impact on shared understanding of requirements

6.5 Future work

This thesis only study's the impact of one of the knowledge management practice by applying it on a field experiment. For future, there is a need to study the other practices of knowledge management in order to check their impact on shared understanding of requirements.

The projects selected for the field experiment of this thesis had a life of only two months because the organization was not willing to withdraw their practice of using KM repository for a long time. Hence, in the future there is a need to apply the selected practice on a long duration project.

Another possible direction for the future research would be developing an approach for selection of a combination of knowledge management practices based on various situational factors. It is our belief that future research in this area will overcome the requirement understanding issues.

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APPENDIX

Appendix A: List of concepts identified from project A

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Tracking number

Appendix B: List of concepts identified from project B

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

RAW DATA

Project 1 Concept Mapping Exercise 1

Project Title: SGS project

Name A Designation Project Manager

Experience Five Years Location Pakistan

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 1

Project Title: SGS project

Name B Designation Software Engineer

Experience 1.5 year Location Pakistan

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 1

Project Title: SGS project

Name C Designation Developer

Experience 6 months Location Pakistan

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 1

Project Title: SGS project

Name D I Designation Developer

Experience 1.5 years Location Pakistan

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 1

Project Title: SGS project

Name E **Designation** Client

Experience 5 Years **Location** UK

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

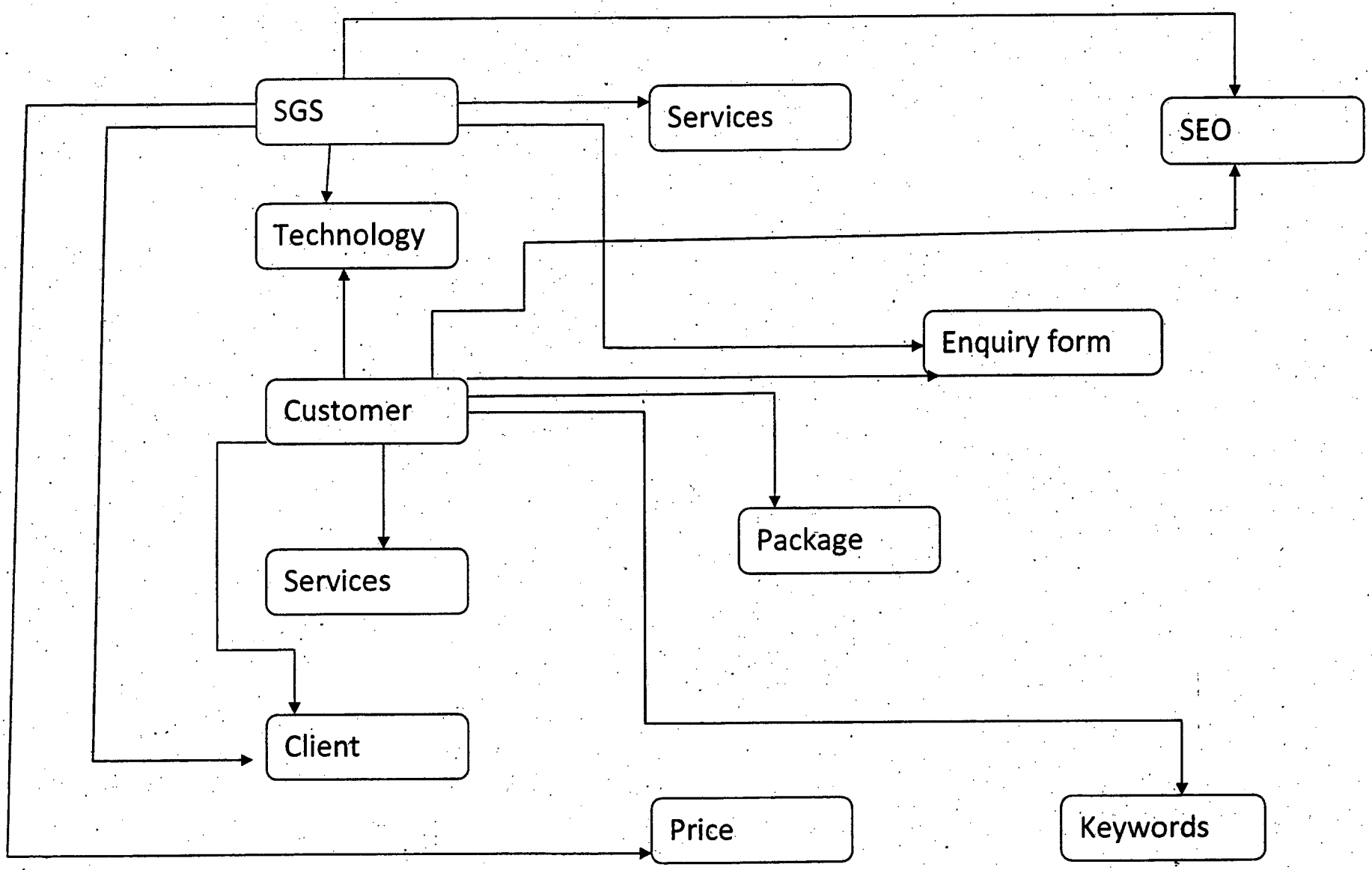
Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 1



Project 1 Concept Mapping Exercise 1

Project Title: SGS project

Name F **Designation** Designer

Experience 2 Years **Location** UK

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

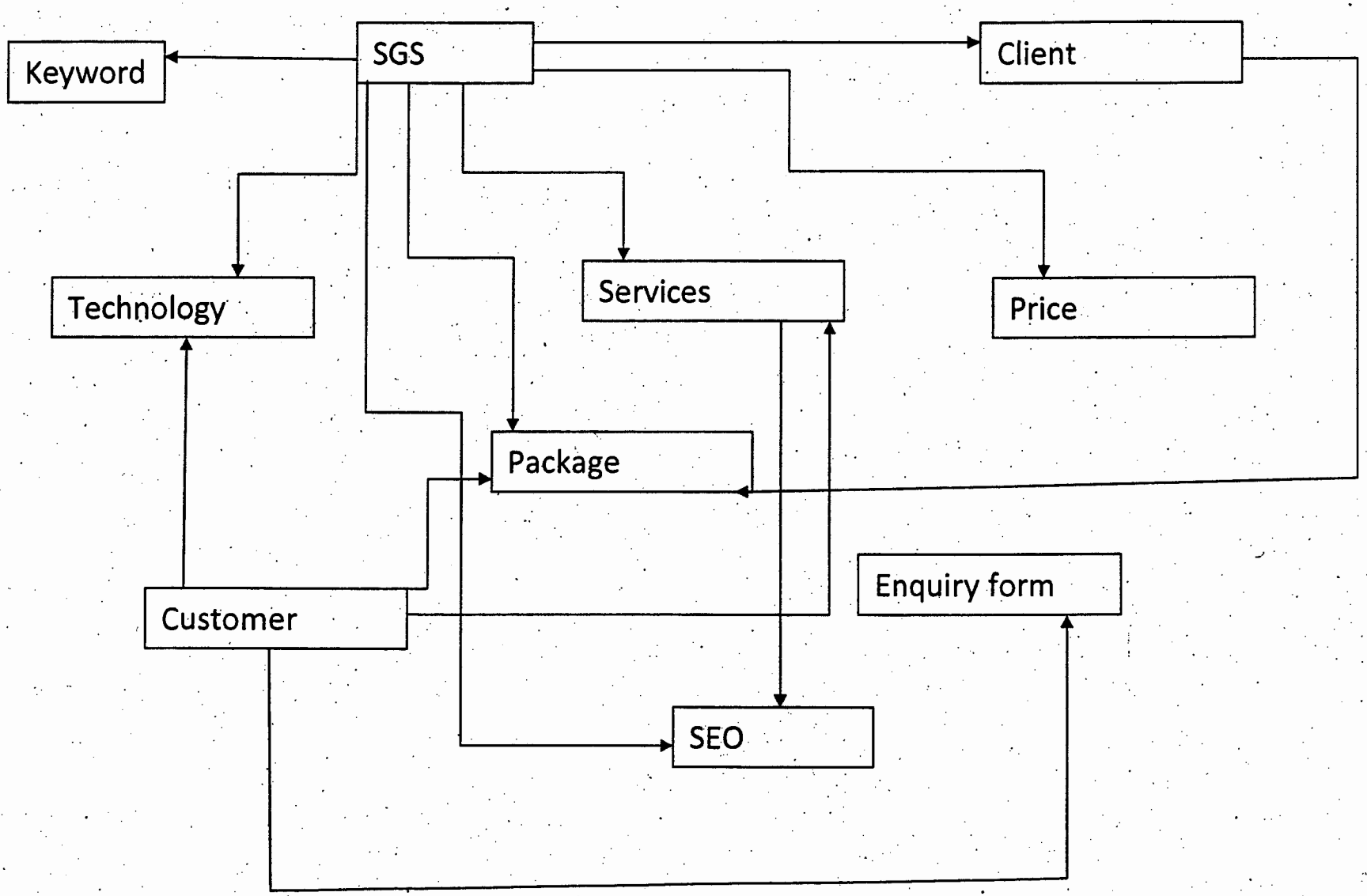
Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 1



Project 1 Concept Mapping Exercise 1

Project Title: SGS project

Name G

Designation SQA Engineer

Experience 1 Year

Location UK

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

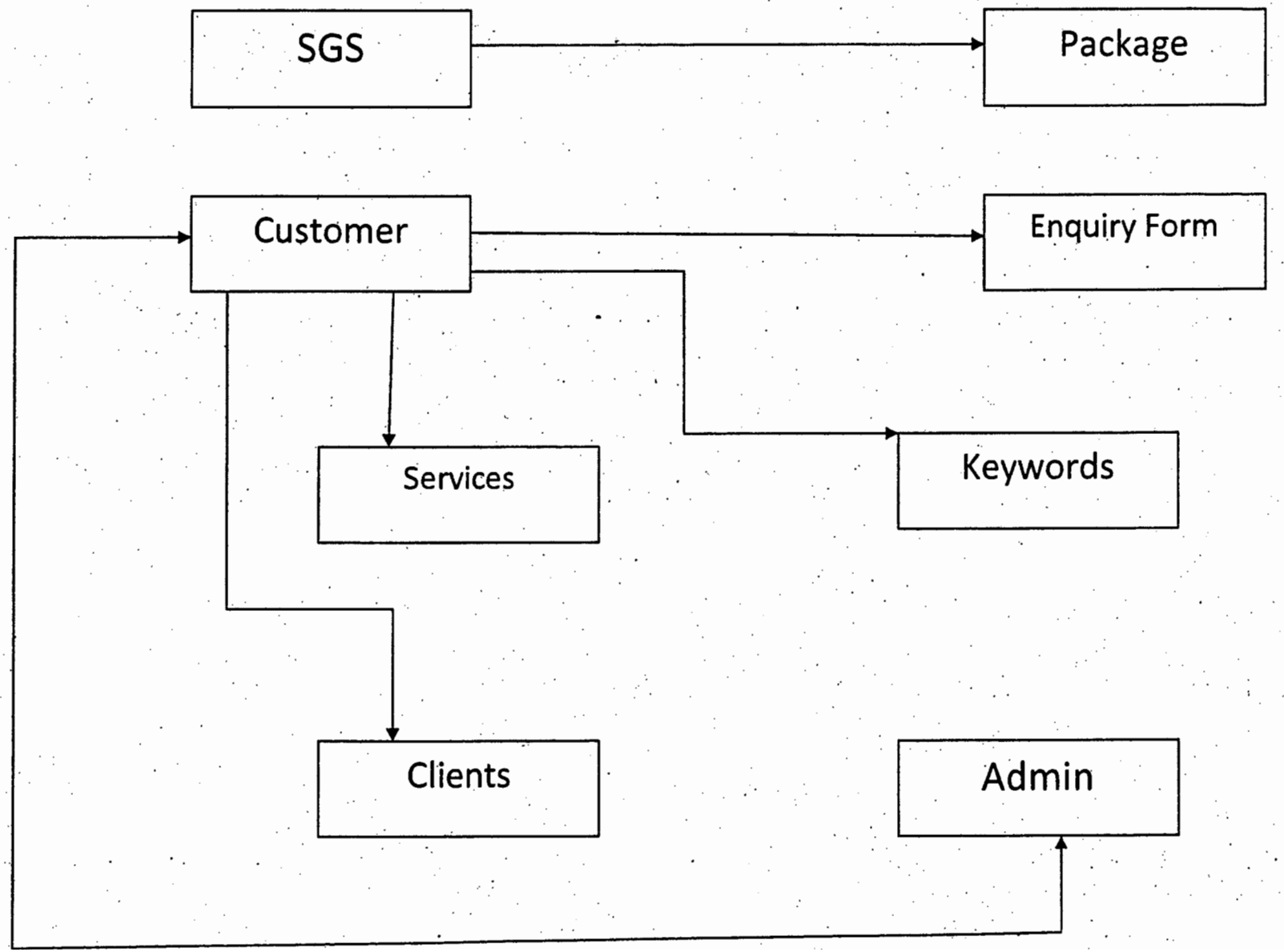
Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 1



Project 1 Concept Mapping Exercise 2

Project Title: SGS project

Name A Designation Project Manager

Experience Five Years Location Pakistan

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 2

Project Title: SGS project

Name B Designation SOFTWARE ENGINEER

Experience _____ Location PAKISTAN.

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 2

Project Title: SGS project

Name C Designation Developer

Experience 6 months Location Pakistan

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 2

Project Title: SGS project

Name D Designation Developer

Experience 1-5 years Location Pakistan

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 2

Project Title: SGS project

Name E

Designation SQA Engineer

Experience 1 Year

Location UK

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

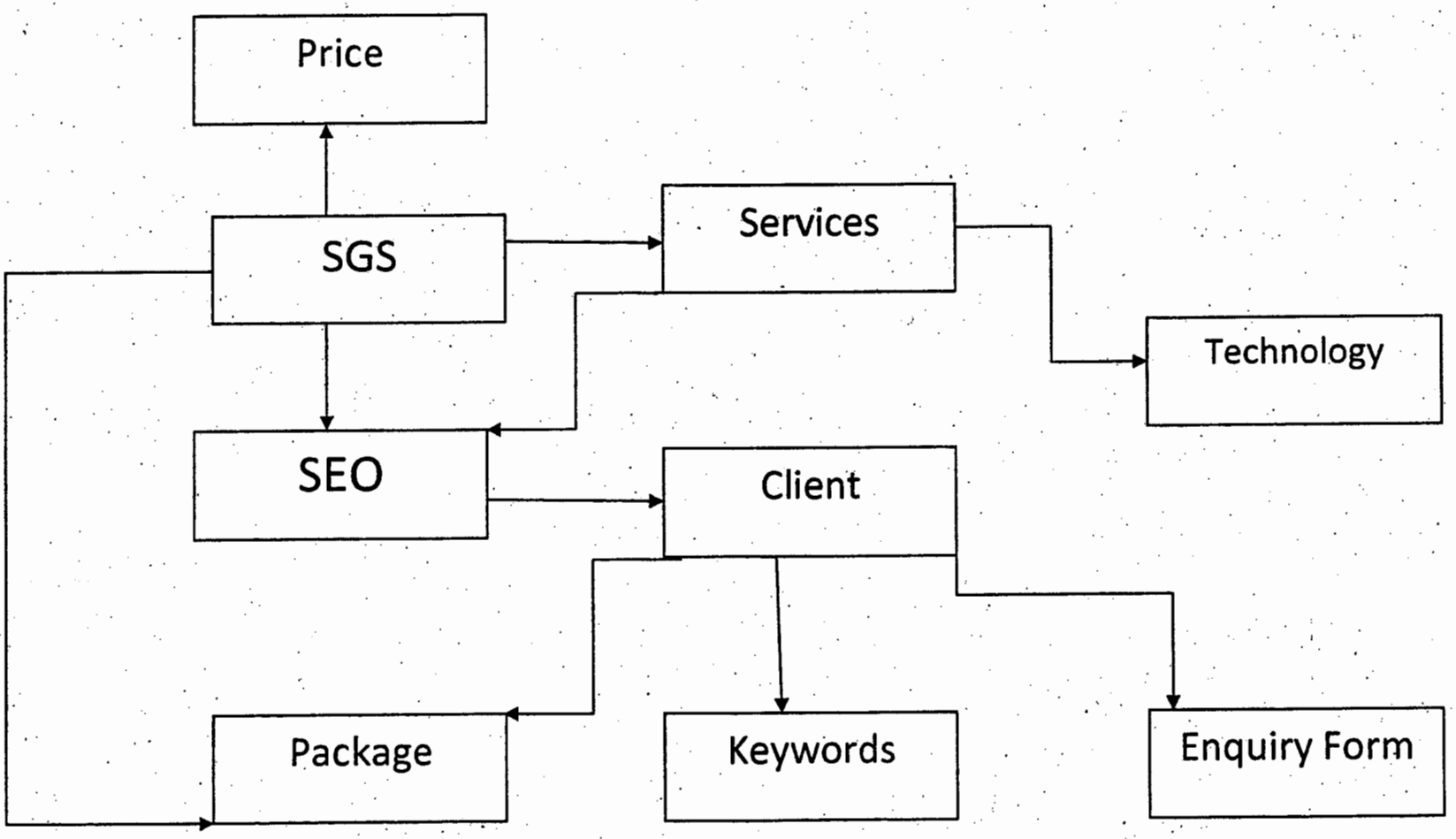
Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 2



Project 1 Concept Mapping Exercise 2

Project Title: SGS project

Name F **Designation** Designer

Experience 2 Years **Location** UK

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

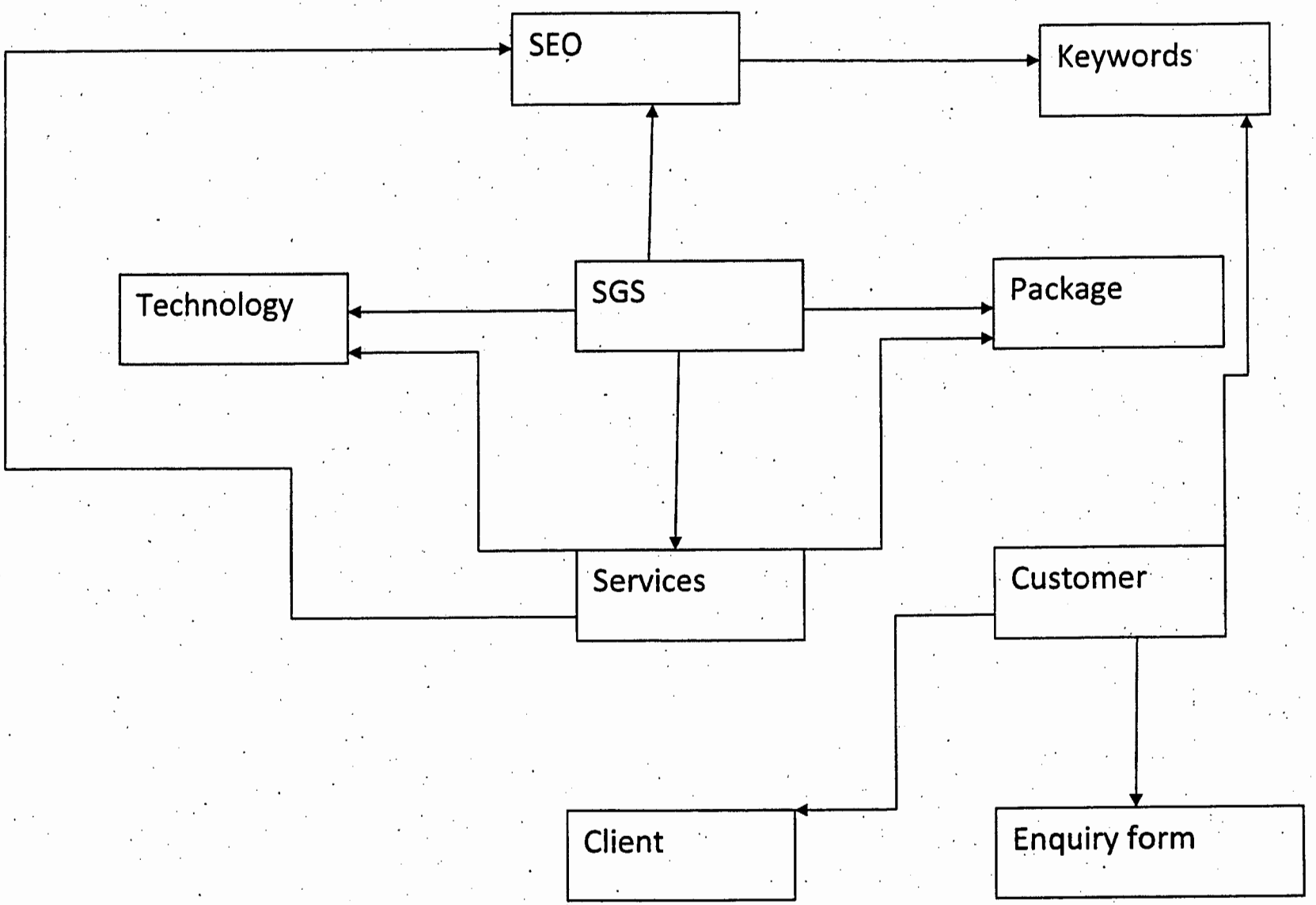
Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 2



Project 1 Concept Mapping Exercise 2

Project Title: SGS project

Name G1 **Designation** Client

Experience 5 Years **Location** UK

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

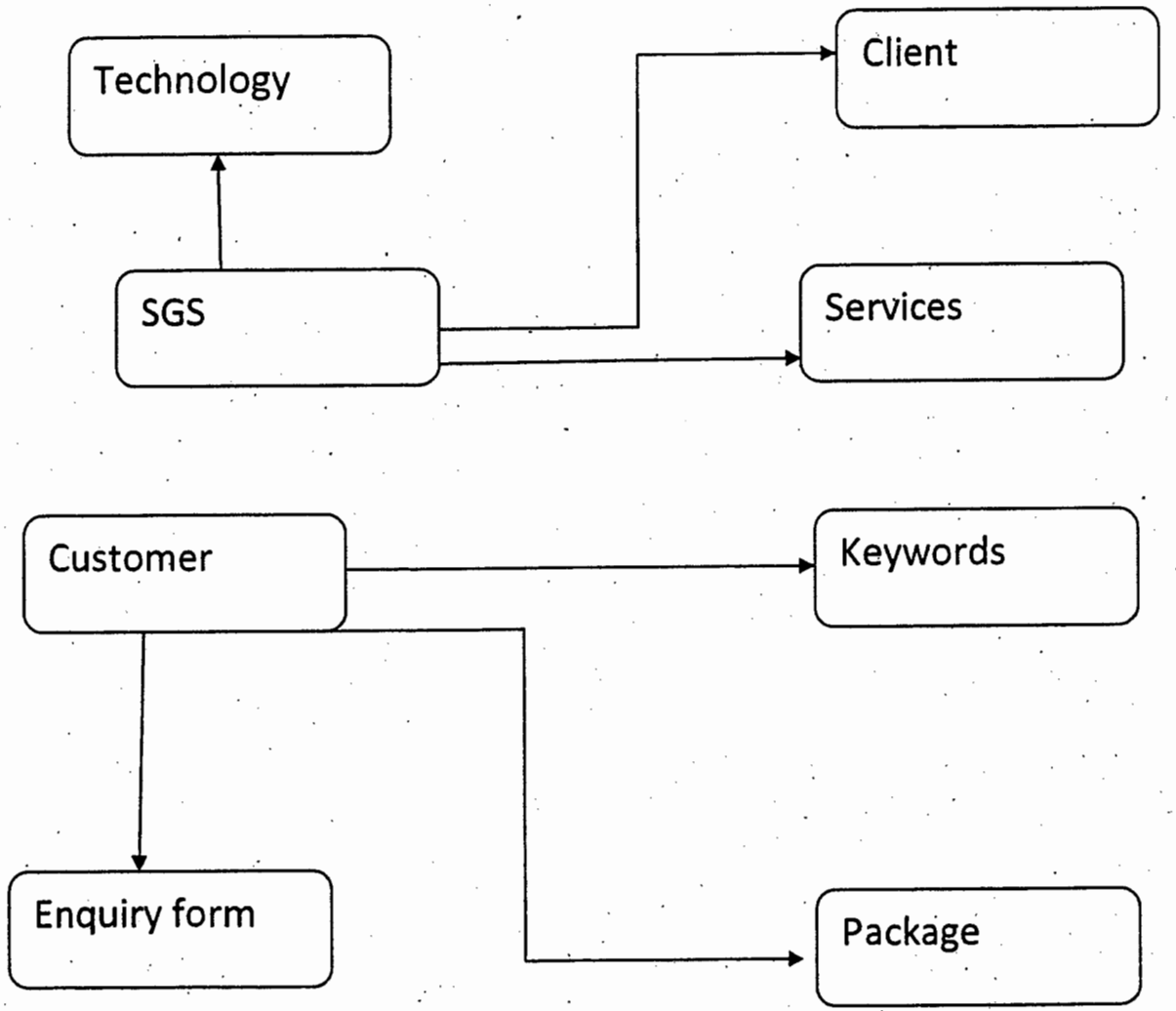
Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 2



Project 1 Concept Mapping Exercise 3

Project Title: SGS project

Name A Designation Project Manage

Experience Five years Location Pakistan

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 3

Project Title: SGS project

Name B Designation SOFTWARE ENGINEER

Experience _____ Location PAKISTAN

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 3

Project Title: SGS project

Name C Designation Developer

Experience 6 months Location Pakistan

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 3

Project Title: SGS project

Name D J Designation Developer

Experience 1.5 years Location Pakistan

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 3

Project Title: SGS project

Name E Designation SQA Engineer

Experience 1 Year Location UK

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

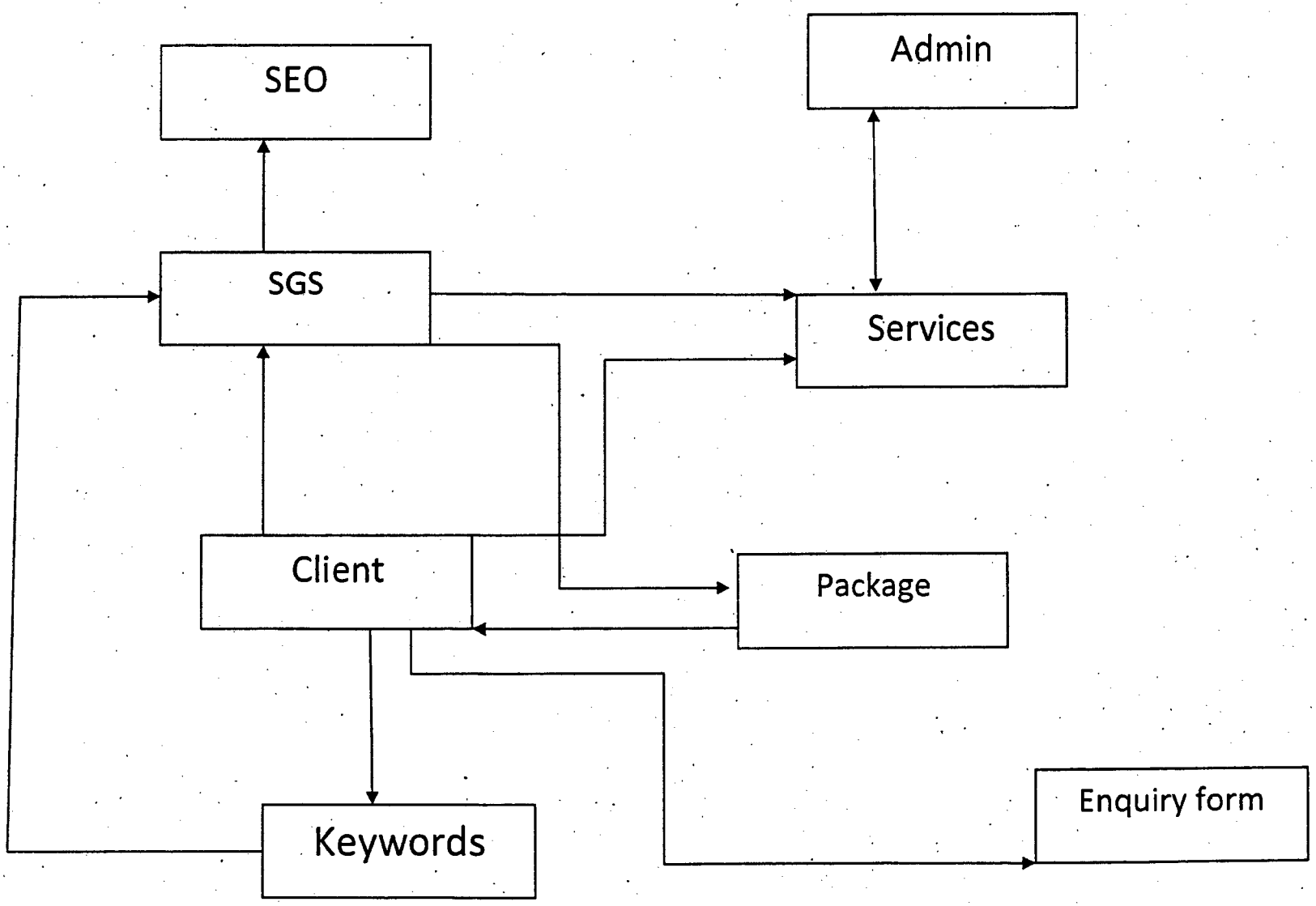
Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 3



Project 1 Concept Mapping Exercise 3

Project Title: SGS project

Name F **Designation** Designer

Experience 2 Years **Location** UK

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

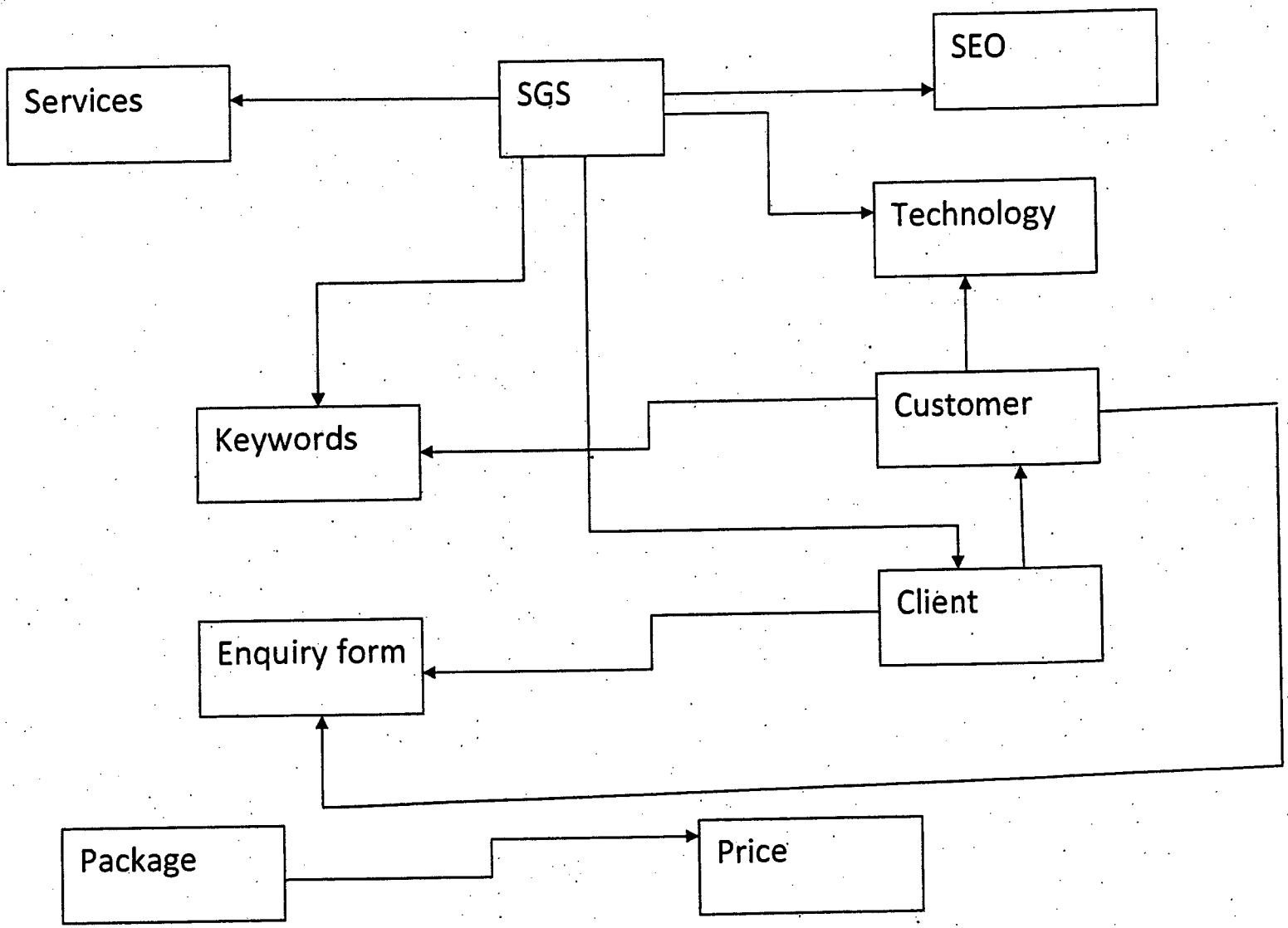
Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 3



Project 1 Concept Mapping Exercise 3

Project Title: SGS project

Name GT **Designation** Client

Experience 5 Years **Location** UK

List of Concepts

SGS

Services

Technology

Clients

SEO

Price

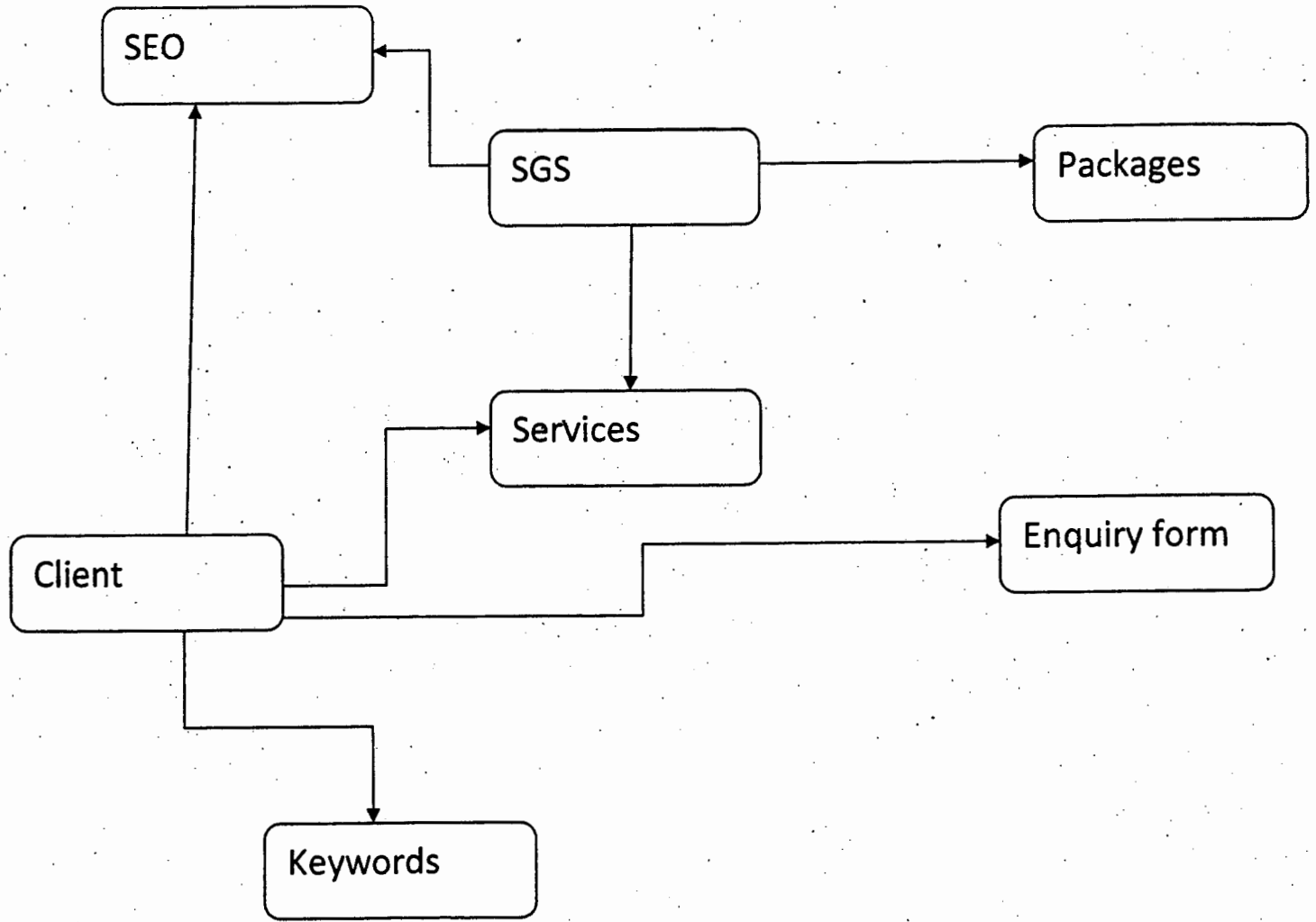
Enquiry form

Customer

Keywords

Packages

Project 1 Concept Mapping Exercise 3



Project 2 Concept Mapping Exercise 1

Project Title: Buy workwear Project

Name T Designation Project Manager

Experience Five years Location Pakistan

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 1

Project Title: Buy workwear Project

Name M Designation SOFTWARE ENGINEER

Experience _____ Location PAKISTAN.

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 1

Project Title: Buy workwear Project

Name V Designation Developer

Experience 6 months Location Pakistan

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 1

Project Title: Buy workwear Project

Name W Designation Developer

Experience 1.5 years Location Pakistan

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 1

Project Title: Buy workwear Project

Name X Designation SQA Engineer

Experience 1 Year Location UK

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

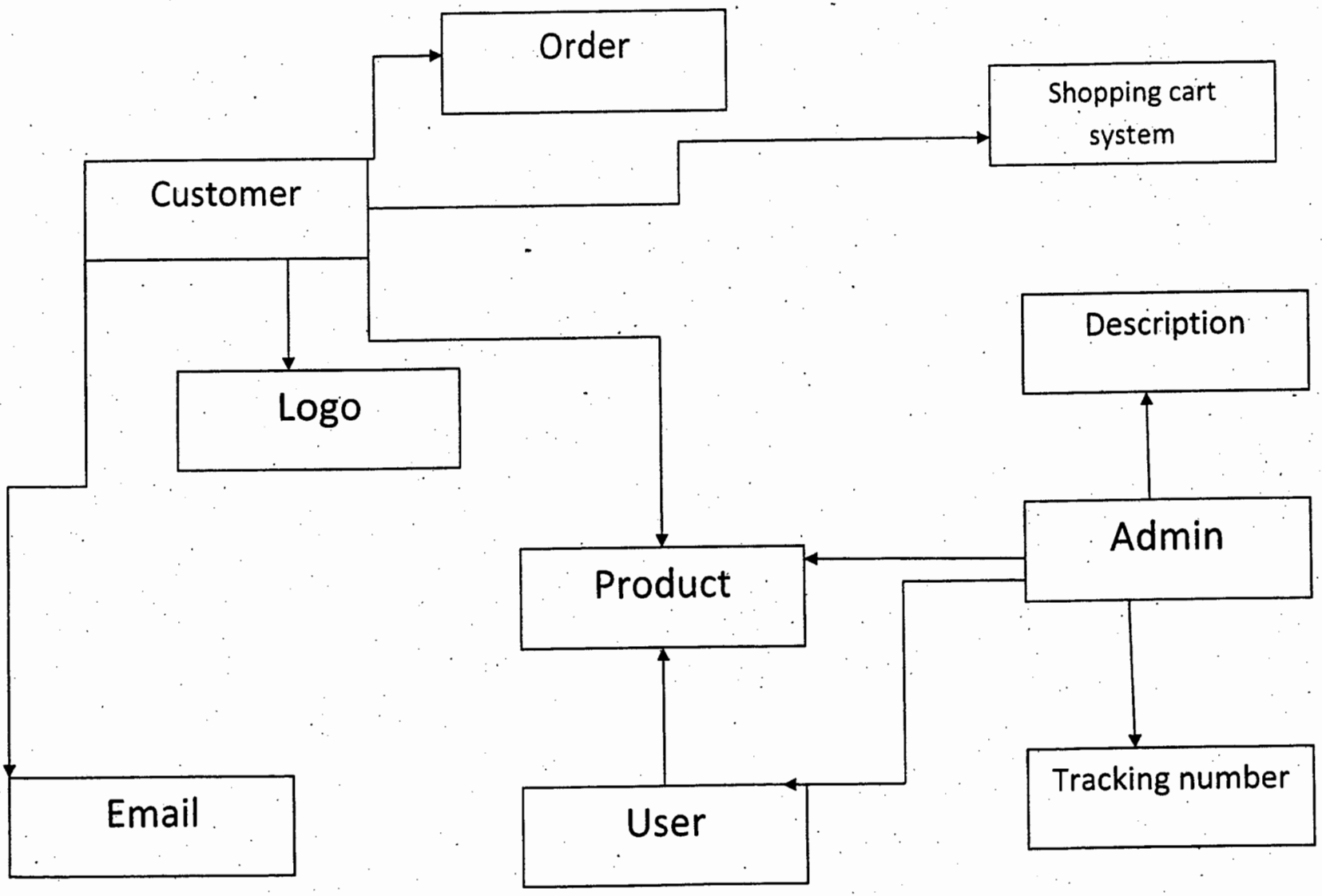
Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 1



Project 2 Concept Mapping Exercise 1

Project Title: Buy workwear Project

Name Y **Designation** Designer

Experience 2 Years **Location** UK

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

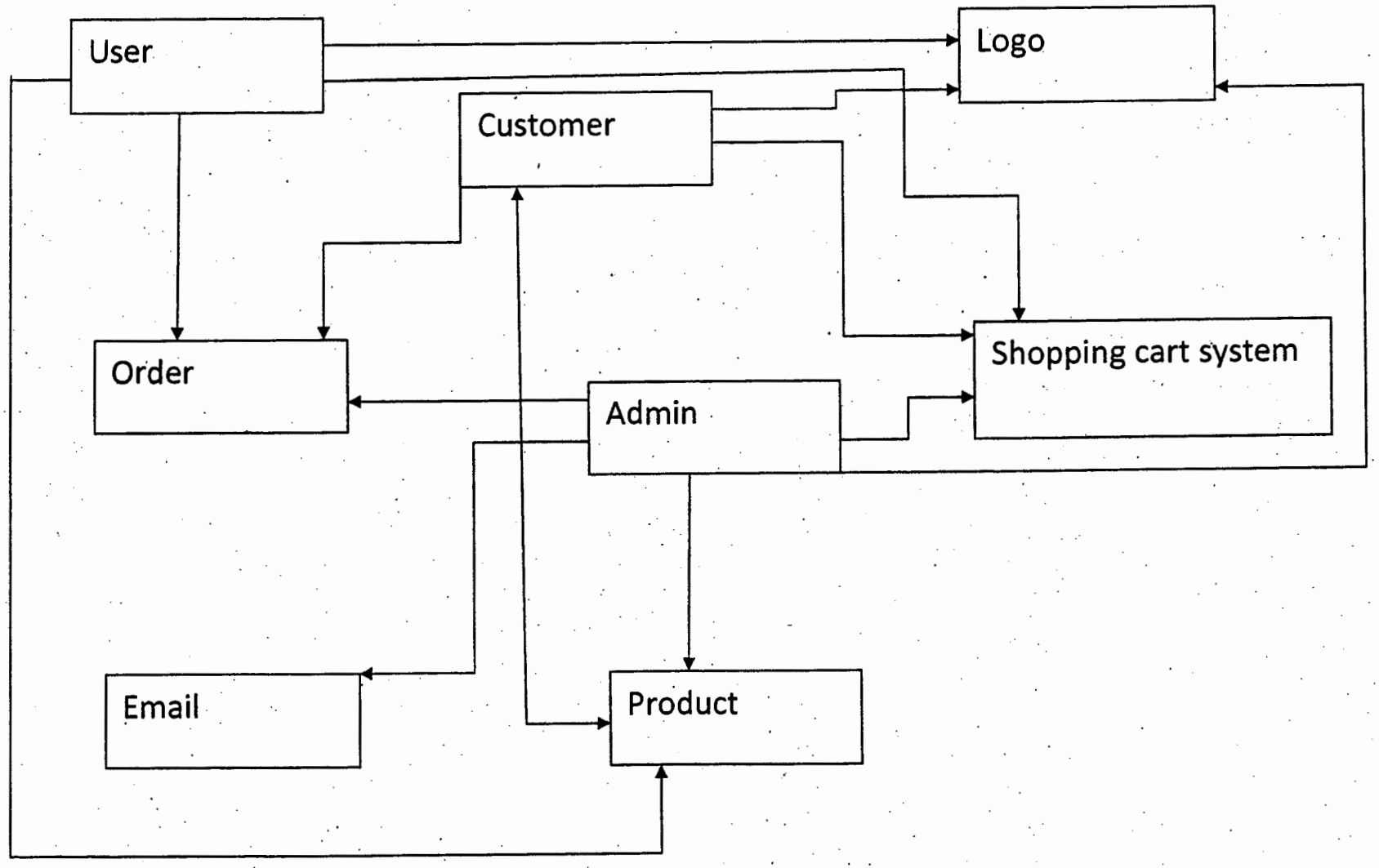
Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 1



Project 2 Concept Mapping Exercise 1

Project Title: Buy workwear Project

Name Z **Designation** Client

Experience 5 Years **Location** UK

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

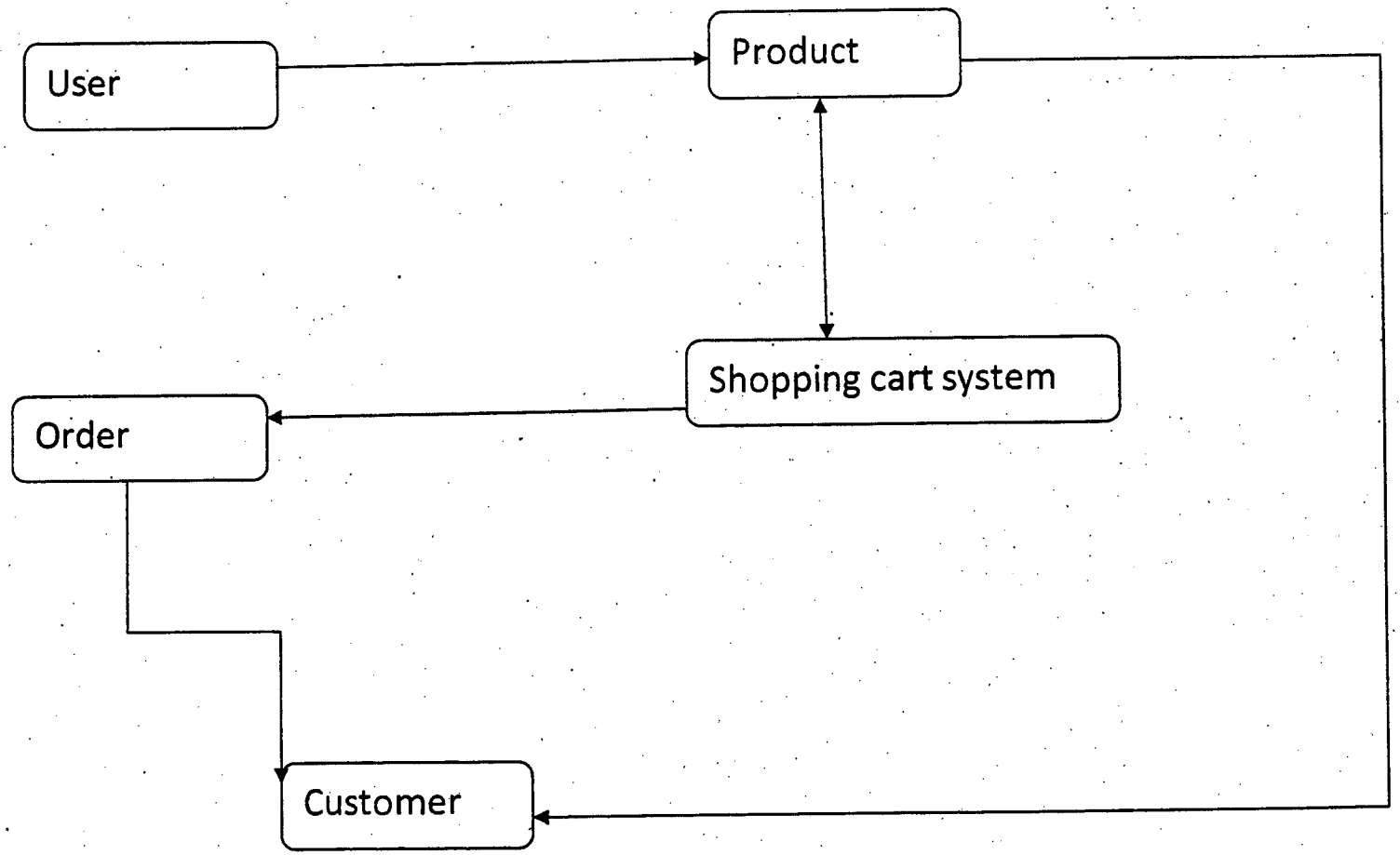
Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 1



Project 2 Concept Mapping Exercise 2

Project Title: Buy workwear Project

Name T Designation Project Manager

Experience Five years Location Pakistan

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 2

Project Title: Buy workwear Project

Name U Designation Software Engineer

Experience _____ Location Pakistan

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 2

Project Title: Buy workwear Project

Name V Designation Developer

Experience 6 months Location Pakistan

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 2

Project Title: Buy workwear Project

Name r W Designation Developer

Experience 1.5 years Location Pakistan

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 2

Project Title: Buy workwear Project

Name X **Designation** SQA Engineer

Experience 1 Year **Location** UK

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

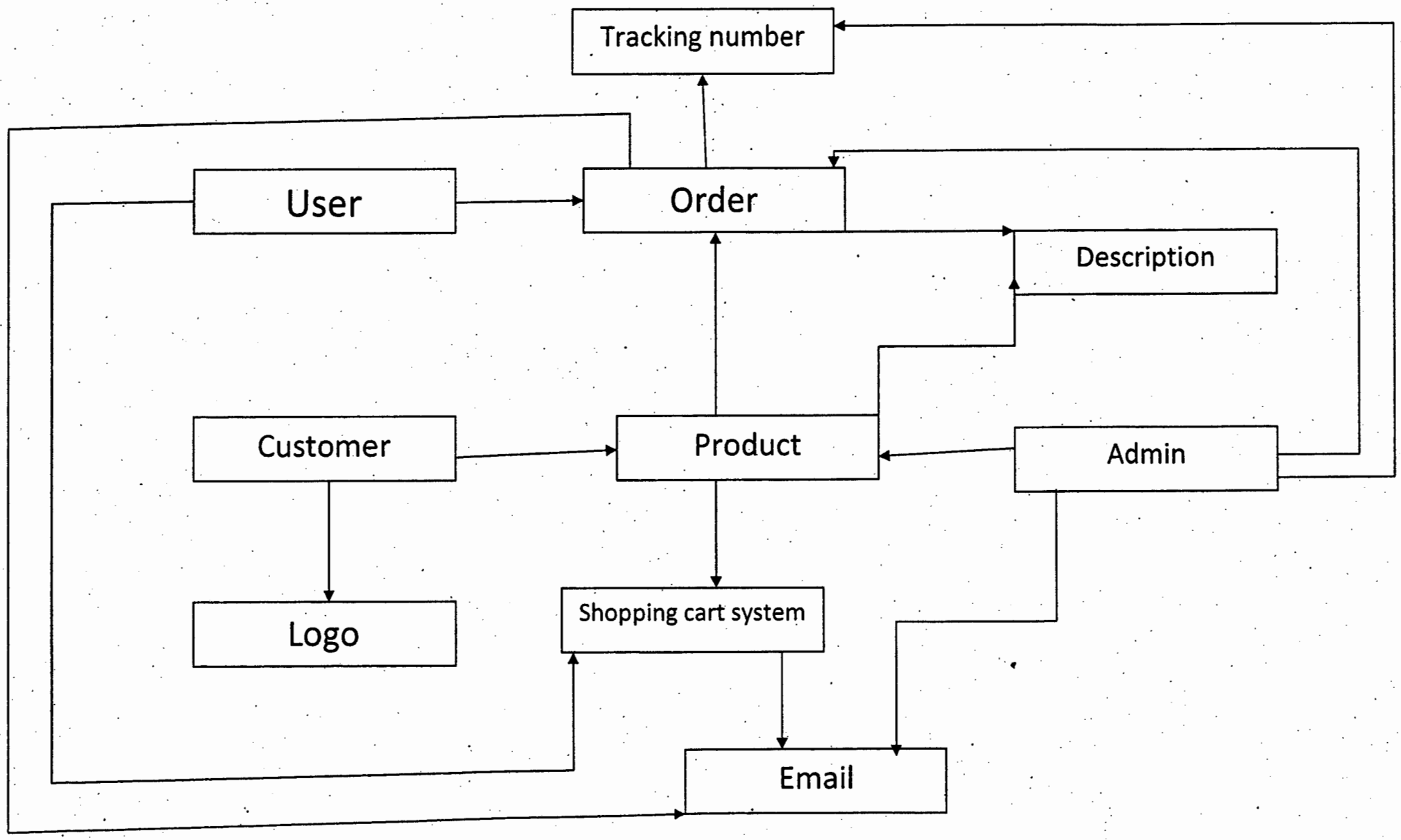
Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 2



Project 2 Concept Mapping Exercise 2

Project Title: Buy workwear Project

Name Y Designation Designer

Experience 2 Years Location UK

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

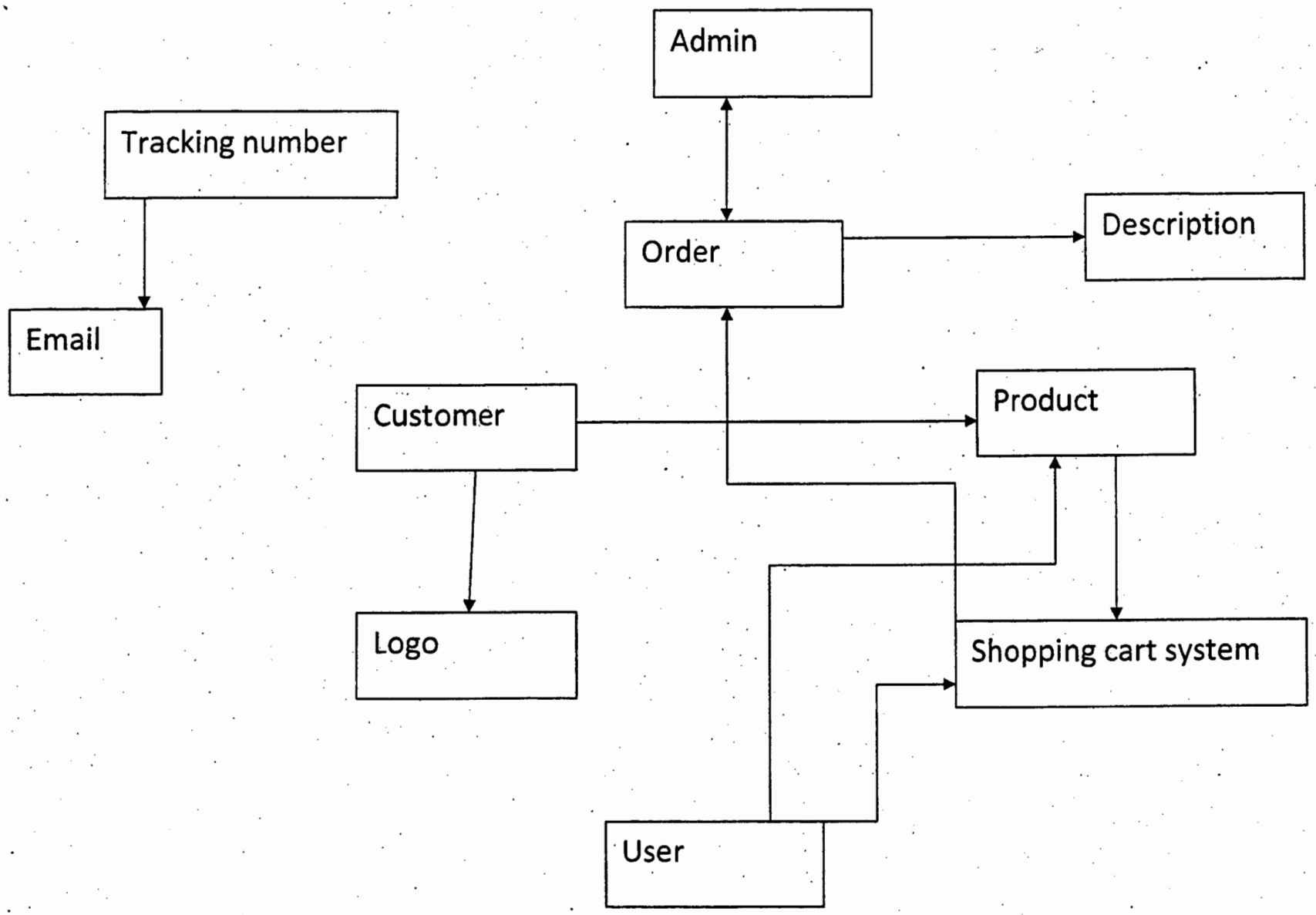
Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 2



Project 2 Concept Mapping Exercise 2

Project Title: Buy workwear Project

Name Z Designation Client

Experience 5 Years Location UK

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

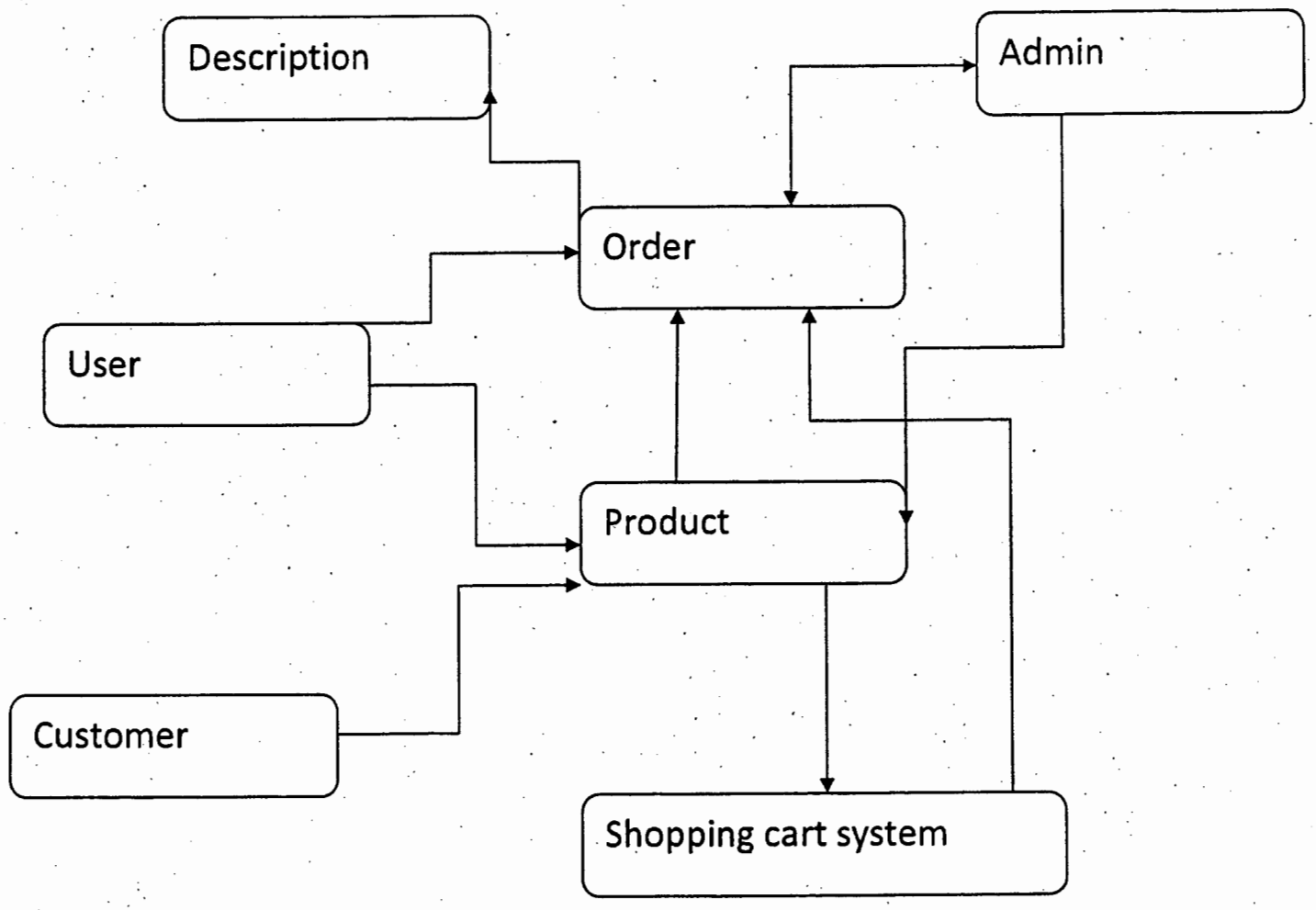
Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 2



Project 2 Concept Mapping Exercise 3

Project Title: Buy workwear Project

Name T Designation Project Manager

Experience 'Five years Location Pakistan

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 3

Project Title: Buy workwear Project

Name 11 Designation Software Engineer

Experience _____ Location Pakistan

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 3

Project Title: Buy workwear Project

Name V Designation Developer

Experience 6 months Location Pakistan

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 3

Project Title: Buy workwear Project

Name W Designation Developer

Experience 1.5 years Location Pakistan

List of Concepts

User

Customer

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Product

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Shopping cart system

Order

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Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 3

Project Title: Buy workwear Project

Name X Designation SQA Engineer

Experience 1 Year Location UK

List of Concepts

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Confirmation mail/E-mail

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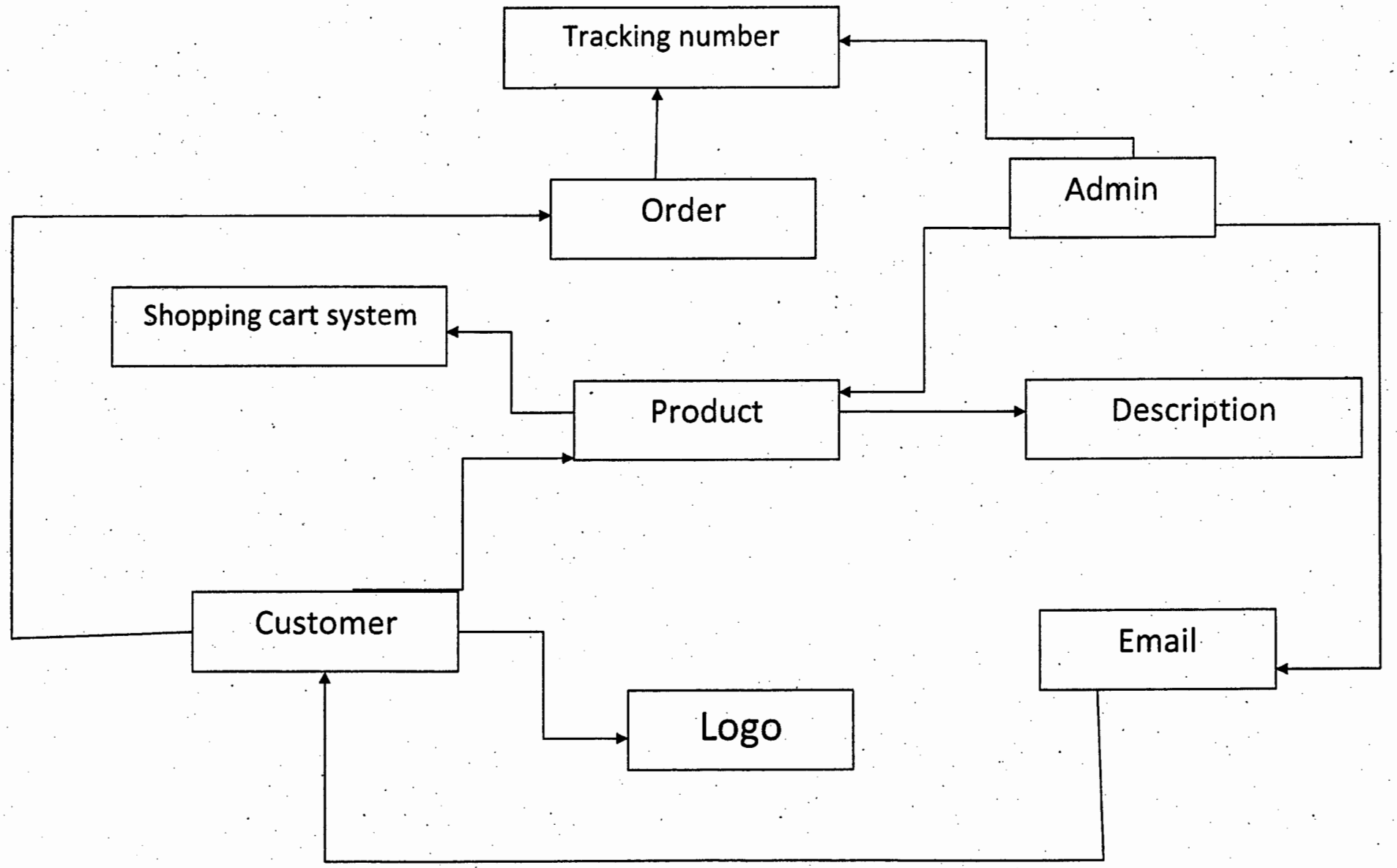
Project 2 Concept Mapping Exercise 3



Project 2 Concept Mapping Exercise 3

Project Title: Buy workwear Project

Name Y **Designation** Designer

Experience 2 Years **Location** UK

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

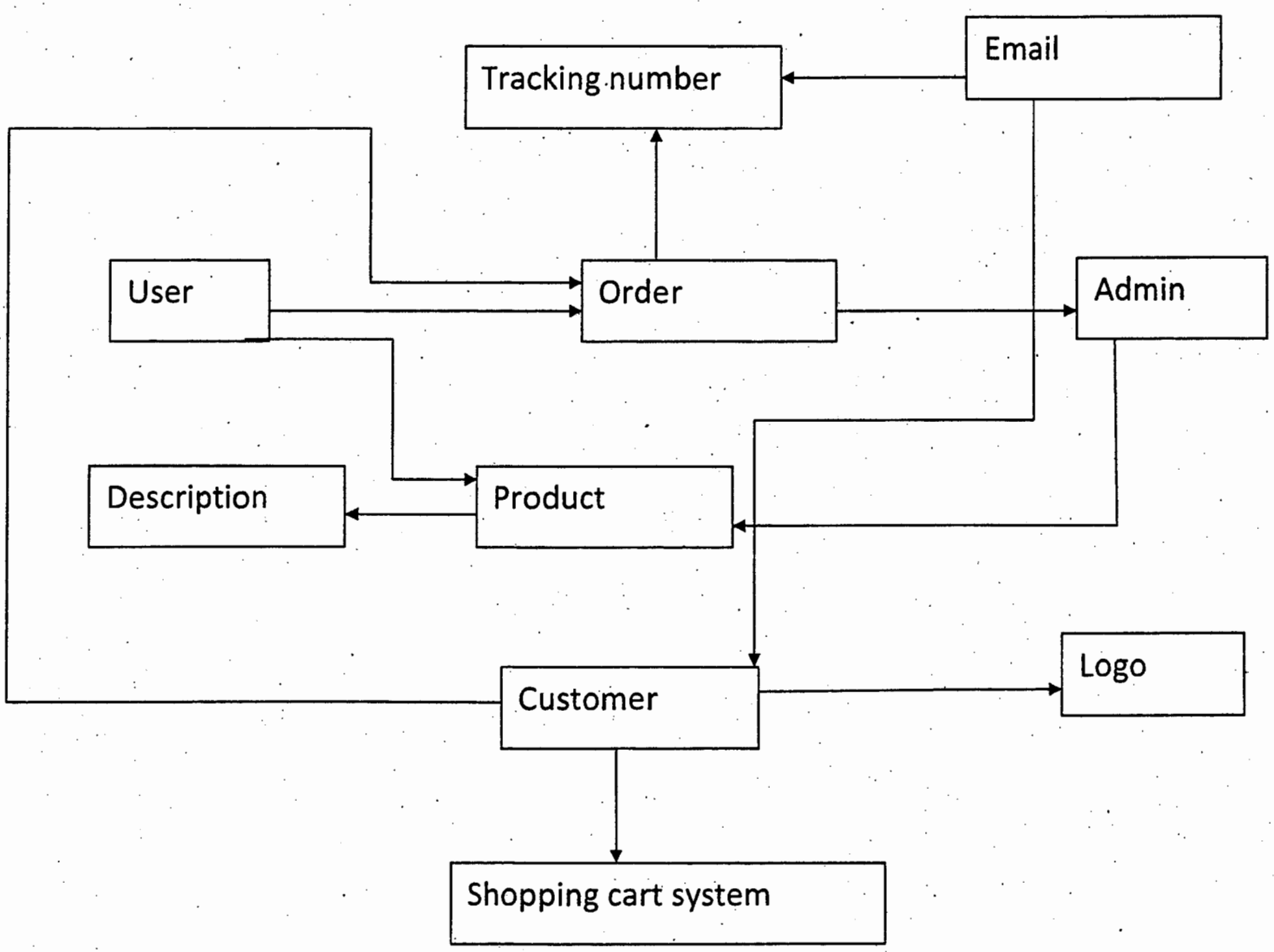
Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 3



Project 2 Concept Mapping Exercise 3

Project Title: Buy workwear Project

Name Z **Designation** Client

Experience 5 Years **Location** UK

List of Concepts

User

Customer

Logo

Product

Description

Shopping cart system

Order

Admin

Confirmation mail/E-mail

Tracking number

Project 2 Concept Mapping Exercise 3