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Knowledge Management: A Solution to Requirements Understanding in Global Software Engineering

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Abstract: The aim of the study is to identify useful Knowledge Management (KM) practices/tools in order to overcome Requirements Understanding (RU) challenges in Global Software Engineering (GSE). As Requirements Engineering (RE) is considered one of the most crucial, human intensive and challenging phase of software engineering. A paradigm shift from traditional co-located to offshore development has introduced additional complications in RE specifically in RU. Issues in GSE like involvement of people from diverse culture, different inter-personal communication and coordination skills leads to RU problems. For this, the need of proper practices/tools to overcome RU challenges in global setting is obvious from literature. So, this study focuses on two things. Firstly, in this study authors have mentioned major RU challenges in GSE which were identified in author's pervious study. Secondly, authors have identified useful Knowledge Management (KM) practices/tools that can aid globally dispersed software development teams in RU. For this purpose, industrial surveys were conducted in software companies involved in GSE. Thereby, useful KM practices such as Document Management, Competence Management and Knowledge sharing processes such as Socialization are identified to address RU issues faced in GSE. In addition, modern and advanced ICT tools such as video and audio conferencing, Forums, Intranets, have also been proposed for overcoming these challenges. Moreover, a detailed analysis is presented that how a specific KM practice/tool helps to cater a specific RU challenge.

Key words: Global software engineering, knowledge management, knowledge management practices/tools, requirements engineering, requirements understanding

INTRODUCTION

Global Software Engineering (GSE) has been adopted widespread and gaining fame with the passage of time. As in GSE development teams are dispersed geographically therefore its major advantage is closeness to market/customer. GSE main driving force is economical factor i.e. as the product is developed in less time and resources used (Damian and Moitra, 2006; Herbsleb and Moitra, 2001). Moreover, GSE offers many benefits like cost effectiveness, shorter development time, skilled people and less use of resources (Steinberga and Smite, 2011; Holmstrom *et al*., 2006; Deshpande *et al*., 2010; Noll *et al*., 2010). However, as in GSE teams are dispersed geographically so therefore several problems occurs like collaboration (Noll *et al*., 2010), culture issues (Casey, 2009), trust, communication and co-ordination (Steinberga and Smite, 2011), Requirements Engineering (RE) (Herbsleb and Moitra, 2001).

RE phase is not only considered to be crucial and tricky phase in in-house development but becomes even more challenging in GSE (Damian and Zowghi, 2003a). As in GSE, organizations are spread geographically so therefore communication and coordination becomes more difficult which also has impact on the requirements being gathered. Furthermore, Requirements Understanding (RU) is considered to be one of the biggest and challenging issues for academia and industries in GSE from last decade (Casey, 2009; Damian and Zowghi, 2003a; Damian and Zowghi, 2002). Therefore development team working offshore might misunderstood requirements due to some tacit knowledge present with it which needs to be made explicit. The reason being this knowledge is tacit is due to challenges like lack of communication, lack of co-ordination between offshore teams, different time zones and culture differences (Fricker *et al*., 2007; Damian and Zowghi, 2003a), faced during RU in GSE environment.

In GSE, all organizations are involved in knowledge intensive activities which may be tacit or explicit. Knowledge which is shared or transferred must be managed and understood by organizational members in order to get most benefits out of it. Knowledge Management (KM) helps companies to enrich and share this knowledge residing in products, processes and people

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by various tools and methods. This KM exercise is often helped by Information Technology (IT). Besides, KM becomes especially of interest due to the fact of culture diversity, communication gap and coordination problems across organizations (Desouza *et al*., 2006). Software organizations involved in GSE are now realizing the usefulness and effectiveness of embedding KM practices in their organizations. Likewise, the knowledge resided in culture; people mind in the form of experience and working environment is of utmost importance for organization success and should be managed and shared efficiently. Therefore, there is a need to cater RU challenges in GSE with the help of KM.

A lot of study has been done on RE in global context, where different challenges and solutions to these challenges have been identified. Further, all those research is specific to one or two activities of RE like requirements management (Prikladnicki *et al*., 2003; 2003b), requirements specification (Lopes *et al*., 2004) and so on. Furthermore, many solutions have been proposed by researchers like multimedia meeting systems, video channels and electronic workspace, but it is limited for example to requirements negotiation process as in (Damian and Zowghi, 2003b). Since, there is a lack to tackle RU issue in global context. However, researchers have highlighted RU is a big issue but no one have taken it in such a broad category and also no one have provided KM solutions specifically to tackle this issue.

Author's contribution in this research study is to resolve the challenges of RU faced in GSE environment with the help of KM practices/tools because authors have identified in this research study that many organizations have good infrastructure for communication and coordination but they are unaware of its affective usage. For this, KM is a paradigm which creates a culture of awareness, teamness, collaboration and knowledge sharing and so on, due to which organizations can utilize their resources (practices/tools) perfectly and accurately. Therefore, in this study author's main focus is to resolve RU challenges faced in GSE with the help of proper KM practices/tools. To achieve this, authors have supplemented Carmel (1999) solutions with the help of KM practices/tools and to specify those solutions for RU challenges in global setting. In addition, authors have also addressed the tacit knowledge present with requirements which needs to be made explicit before it get processed, because this tacit-ness is due to challenges faced during RU. For this, authors have identified several useful KM practices/tools like Document Management, Competence Management, four processes of knowledge creation and sharing (Socialization, Internalization, Externalization and Combination) and so on which is found helpful for overcoming RU challenges in GSE setting.

LITERATURE REVIEW

Requirements engineering: As RE is the first activity/phase of SDLC, therefore, it has great importance throughout all phases of software development i.e., design, development, testing and maintenance. According to (Niazi and Shastry, 2003), the process of RE should be defined in more detailed and organized way in order to get better quality software products. According to (Niazi and Shastry, 2003; Kotonya and Sommerville, 1998), despite the importance of RE process (phase), it has also brought problems (challenges) with itself which have destabilized the needs and expectations of organizations and stakeholders. Furthermore, different challenges have been identified in the literature faced during RE phase like inadequate requirements traceability, complexity of application and so on, for further details see (Niazi and Shastry, 2003; Kotonya and Sommerville, 1998; Siddiqi and Shekaran, 1996). According to (Niazi and Shastry, 2003; Kotonya and Sommerville, 1998; Damian and Zowghi, 2002), lack of requirements understanding is one of the biggest challenges which are due to the improper communication, organizational policies and political factors, culture diversity, lack of knowledge management implementation and so on.

Global software engineering: The steady and irreversible norm of globalization of businesses has been started from last decade and particularly in field of software outsourcing business (Herbsleb and Moitra, 2001). Further, software outsourcing companies tend towards globalization due to customers satisfaction, high quality software and due to rapid and cheaper development of software products to compete in the targeted market (Noll *et al*., 2010). Due to the advancement in communication media, especially with the emergence of internet systems, has increased the trend of team working across different sites. Furthermore, it has considerably helped organizations which are dispersed geographically despite of communication problems, coordination problems, language differences, culture differences and time-zone differences (Setamanit *et al*., 2007; Mockus and Herbsleb, 2001).

Knowledge management: Knowledge Management is considered to be the most important asset of an organization. Knowledge can be defined as "Knowledge, while made up of data and information, can be thought of as much greater understanding of a situation, relationships, causal phenomena and the theories and rules (both explicit and implicit) that underlie a given domain or problem" (Firestone, 2001). Knowledge is basically of two types namely tacit (implicit) and explicit. Tacit knowledge is the form of knowledge which is resided in people mind and which cannot be easily

transferred, shared and understood. Whereas explicit knowledge can be codified, shared, understood easily and is context independent (Hislop, 2005). Further, KM is a very broad field; it not only enables organizations to create and share knowledge but also helps in increasing co-ordination, understanding and resolving communication and culture issues (Hislop, 2005). With an increasing awareness and importance of the 'knowledge' residing in organizations, there has been a rise in awareness of methods and tools to retain and grow this knowledge. The most obvious and arguably most successful discipline to achieve this has been KM (Davenport and Prusak, 2000). Besides, software development is rapidly evolving day by day with many people involved in it. Furthermore, as there are lacks of resources but demands from market are increasing, due to which software organizations are facing problems in productivity growth. Software organizations has large amount of knowledge resided in their processes, methodologies, people, culture and working environment. So therefore, there is a need to share and transfer this knowledge in/across organizations in order to understand, manage, to identify customer and business needs, know-how of culture and co-ordinate throughout the software development life cycle effectively (Rus and Lindvall, 2002).

GSE puts new challenges on RU: As discussed earlier RE is the crucial and challenging phase of SDLC in co-located setting and GSE has brought new challenges like culture difference, geographical dispersion, time zone differences and so on which has made even more complicated the RE process (Damian and Zowghi, 2002, Damian and Zowghi, 2003b; Damian, 2007; Hsieh, 2006). Likewise, RE activities are becoming more challenging in GSE due to lack of interaction among teams across boundaries (Damian, 2007). Therefore, resolution of misunderstanding and conflicts of requirements become more difficult because it then requires effective communication, coordination among stakeholders to manage, negotiate and specify a specific requirement issue. However, different solutions have been proposed by researchers for working in GSE environment like multimedia meeting system, video channel and electronic workspace and so on to solve problems in requirements negotiation (Damian and Zowghi, 2003b). Further, problems of culture, communication and time zones in requirements specification can be reduced by close coordination and awareness of cultures and so on Lopes *et al*. (2004.). Moreover, focus of their studies is different from this research study in a sense that all these studies have focus on one or two RE activities as mentioned before. However, main focus of this research study is RU, which can arise at any stage of software development process. Further, in this research study we want to solve

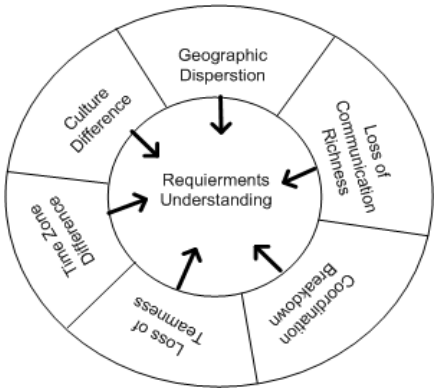

Fig. 1: RU challenges in GSE

major RU challenges faced by global software development teams with the help of useful KM practices/tools, because KM has been considered a very successful discipline from last decade by the software engineering researchers (Rus and Lindvall, 2002; Desouza *et al*., 2006). Likewise, a recent study of (Tang *et al*., 2011) shows the importance of KM perspectives when there are many stakeholders involved, as GSE is mesh of stakeholders. Therefore, we have adopted Carmel (1999) solutions in this research study and our contribution is to supplement it with KM practices/tools to solve challenges of RU in GSE, because RU is affected by GSE challenges (Khan *et al*., 2011) as shown in Fig. 1. Therefore, we have considered these challenges as RU challenges in GSE.

RESEARCH METHODOLOGY

The research question which motivated this study was RQ: "How KM practices helps to reduce requirements understanding challenges in GSE?"

The research approach of this study was only qualitative; therefore, interviewing technique was used for conducting survey in software industries involved in GSD. Semi-structured interviews were conducted in this research study because it gives free hands to interviewers therefore interviewers can ask different questions according to the interest of discussion (Seaman, 1999). For this purpose open-ended questionnaire was designed for conduction of interviews. Further, a grounded theory approach was used for data analysis because it is very helpful for researchers to analyze data in parallel with data collection (Corbin and Strauss, 2008).

For this research study three interviews were conducted in two companies working in Telecom Sector, we call them Company A and Company B. Two interviews were conducted in Company A with two different persons and both of the interviewees were specifically working in field of RE. The first interviewee was person X working as a Technical Product Manager

(TPM) in company A and had thirteen years experience. Person X was directly involved in RE activities and his main responsibilities were included initiating requirements, negotiating, involved in decision making, checking requirements fulfillment and requirements conflicts resolution. The second interviewee was person Y who also working as a TPM in Company A and had approximately eleven years of experience in Telecom companies. As Person Y was working in the same company as Person X with same position so therefore they had the same tasks and activities in RE. Third interview was conducted with Person Z and was working as a Supplier Manager and had three years experience at Company B. Before this position Person Z was working as a Software Quality Engineer. Although, Person Z was not involved directly in RE activities but he was quite competent and had a blend flavor of experience of both academia and industry. Moreover, he had deeper insight and knowhow of RE activities carried out in his Company B.

The interviews sessions were allotted by the interviewees according to their own suitable and flexible dates and time. According to Fowler (2002), interviewers should have flexible schedules so that interviewee (s) can make an appointment at any time suitable to them. In this research study all the interviews sessions were given by the interviewees which were quite flexible and comfortable for both concerned parties. The interviews sessions given by interviewee X and interviewee Z were 2 h while interviewee Y given us 1 and half h.

RESEARCH FINDINGS

We have divided this section in two sub-sections, where in first section we have given some basic overview of interview results along with literature findings. On the other hand, in section two we have discussed and analyzed detailed findings of our research.

Basic findings: This section gives an overview to the readers regarding the brief findings from software industries. The main intent behind conducting industrial interviews were to get industrial perceptions and opinions regarding the challenges of RU in GSE and to identify KM practices and tools which can be used as solutions to overcome/reduce those RU challenges. Moreover, views of Company A and Company B have been given regarding each challenge along with views from literature. In addition, solutions from industries have also been regarding each challenge along with solutions identified from literature.

Culture difference:
Views in literature: Different ways of thinking, solving problems, attitudes, commitment, language and style of communication and so on (Herbsleb and Moitra, 2001; Carmel, 1999; Fenema, 2002).

Solutions in literature: Face-to-Face Meetings (Komi-Sirvio and Tihinen, 2005; Battin *et al*., 2001), Training and Common sense, Terminology, Language trainings and sharing culture issues and customs (Komi-Sirvio and Tihinen, 2005), Trust, Encourage social interaction (Motivation) (Smite and Blanck, 2002).

Views from companies (A & B): Culture is not the way of celebrating Christmas but rather it's a way of thinking and solving problems. It's hard to reach on consensus due to lack of understanding and commitment.

Solutions identified from companies (A & B): Intense knowledge sharing (people, culture and product), Introduction of team members (Kick-off meetings), meetings/visiting, Formal discussions, Trainings, Liaisons and Job rotation.

Geographic dispersion:
Views in literature: Geographic dispersion is like "out of sight out of mind" which has caused several problems like trust, motivation, less co-ordination, miscommunication and control (Carmel, 1999; Smite and Blanck, 2002; Carmel and Agarwal, 2001; Duarte and Snyder, 2001).

Solutions in literature: Face-to-Face (Kick-off) Meetings, Audio and Video conferencing, Email and Voicemail, Internet and Intranet (Smite and Blanck, 2002), Centralized Bug Reports, Know-how of rules and policies of countries (Battin *et al*., 2001).

Views from companies (A & B): Misunderstanding of organizational framework, misunderstanding requirements and increases rework.

Solutions identified from companies (A & B): Intense knowledge sharing (culture, people and product), frequent communication (Formal and Informal), Discussion forums, Increments (Modularization), Increase collaboration and co-ordination.

Loss of communication richness:
Views in literature: As distance increases communication becomes more problematic and challenging, availability of technology infrastructure, lack of closer interaction, mode of communication and lack of face-to-face interaction (Vanzin *et al*., 2005; Komi-Sirvio and Tihinen, 2005; Duarte and Snyder, 2001).

Solutions in literature: Informal communication via email, Net meeting and Tele (Battin *et al*., 2001) and video conferencing (Komi-Sirvio and Tihinen, 2005; Vanzin *et al*., 2005), Splitting the projects into smaller independent units (modularization), Face-to-face meetings, Kick-off meetings (Komi-Sirvio and Tihinen, 2005), Liaisons, Intranet, Travel (Battin *et al*., 2001).

Views from companies (A & B): Lack of face-to-face meetings, availability and use of appropriate media, less co-ordination, less informal communication and culture differences.

Solutions identified from companies (A & B): Visual representation of requirements (Visualization), Face-to-face meetings, Discussion forums, Informal communication (Email, Telephone and Chat) and visiting.

Coordination breakdown:
Views in literature: Views in literature: It's hard to meet personally everyone i.e., lack of interaction and lack of intense communication (Carmel, 1999; Carmel and Agarwal, 2001).

Solutions in literature: Frequent communication (Carmel and Agarwal, 2001), Low coupling (modularization), Task distribution, Incremental milestones and Repository of bugs (Battin *et al*., 2001).

Views from companies (A & B): Lack of close collaboration, different units dispersed far from each other, lack of frequent visiting.

Solutions identified from companies (A & B): Frequent communication (Formal and Informal), Intranets, Discussions forums and Competence Management (CM) systems.

Loss of teamness:
Views in literature: Lack of face-to-face meetings and hence trust is lost, culture diversity, difference in organizational standards, policies and development processes and language barriers (Carmel, 1999; Battin *et al*., 2001).

Solutions in literature: Kick-off meetings, Trust building (Smite and Blanck, 2002; Battin *et al*., 2001), Define the product, video conferencing, Face-to-face meetings, Trainings (Smite and Blanck, 2002), Define the project (Smite and Blanck, 2002; Battin *et al*., 2001) and common study products (Terminologies) (Battin *et al*., 2001).

Views from companies (A & B): Trust is the major issue, motivation, awareness, culture differences and lack of frequent communication.

Solutions identified from companies (A & B): Task modularization, Close collaboration and interaction, Frequent formal and informal discussions, Frequent meetings, CM systems, Rewards, Separate technical expert for expert identification.

Time zone difference:
Views in literature: As distance increases time zone difference increases which in turn causes many problems like arranging meetings, loss of intense interaction and co-ordination and mode of communication (Vanzin *et al*., 2005; Carmel and Agarwal, 2001).

Solutions in literature: Asynchronous communication media like email or voice mail (Fenema, 2002; Vanzin *et al*., 2005), Awareness of time constraints of both sides (Fenama) and Synchronous communication (Vanzin *et al*., 2005).

Views from companies (A & B): Discussing urgent issues and problems when needed, delay in response and increases rework due to unresolved issues on time. Further, team work is necessary to negotiate issues between different units at the same time.

Solutions identified from companies (A & B): Email and Communities.

DISCUSSION

Knowledge management is considered to be the most important asset of an organization. It plays an important role in efficiently sharing, creating and storing knowledge for future reuse. Further, the importance of KM cannot be neglected for globally dispersed teams because it plays a vital role in coordination and communication for dispersed teams due to which RU issues can be solved. Moreover, as the author's study is to supplement Carmel solutions with KM, therefore in following sections a comprehensive discussion has been made on how KM practices/tools can help in overcoming/reduction of RU issues faced in GSE.

Collaborative technologies: According to Carmel (1999), collaborating technology can help to resolve problems faced in GSE due to culture differences, geographic dispersion, loss of communication (both formal and informal), co-ordination breakdown, loss of teamness and time zone difference. However, KM can supplement Carmel solution by providing useful practices/tools like proper Competence Management (CM), Document Management (DM) and socialization and so on. It is obvious from Fig. 2 that we have elaborated collaborative technologies (suggested by Carmel for GSD challenges) into more detailed KM practices and tools. Further, according to (Bornemann *et al*., 2003), the role of ICT support for KM activities/processes cannot be neglected in GSE environment. Therefore, we have identified different ICT tools as given in the middle of Fig. 2 i.e., DM, CM etc which support four processes of KM (Socialization, Internalization, Externalization and Combination). Furthermore, we have identified these tools/practices from the real environment of industries which can be found very helpful for overcoming or reduction of a specific GSE challenge as shown in Fig. 2. The discussions about several KM practices/tools are given below in details that

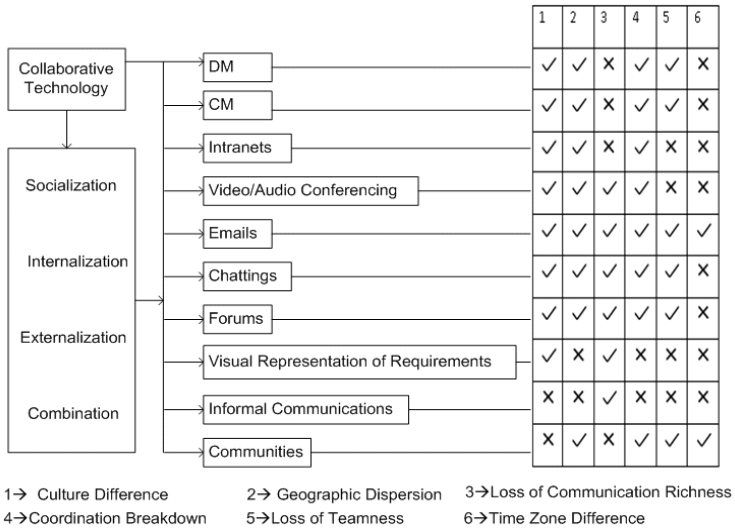

Fig. 2: KM practices/tools, elaborated from collaborative technology help in RU challenges in GSE (numbering identification is same for upcoming figures)

how a specific practice/tool can be used to overcome or reduce a specific GSE challenge.

In GSE when teams communicate requirements, they are actually transferring knowledge and this process is called socialization. In socialization (Bornemann *et al*., 2003; Lindvall *et al*., 2003) mostly tacit knowledge is transferred which is hard to understand. The interviewee Z at Company B claimed on tacit knowledge as "humans are afraid of snakes because of its poison and horribleness but if when you have not seen a snake into wild you can't say that you are afraid of it but when you see you are afraid of". Therefore, some visual representations of ideas are necessary to make the situation and issue more clear for better understanding of requirements. Further, tacit knowledge has impact on RU because requirements are always misunderstood by taking different assumptions, lack of culture knowledge, misinterpretations of words, richness level of communication and lack of collaboration. Therefore, we observed that socialization process should be adopted by organizations involved in GSE by using ICT tools like video conferencing, audio conferencing, emails etc, because it will help in reduction of culture difference issues as shown in Fig. 2 and hence RU will be improved. Moreover, all these issues of culture can be reduced by publishing and distributing culture, people and product knowledge on Intranets and codifying in Document Management (DM) system of organization. Some common examples of DM systems are Microsoft Share Point, Collaborative Document Management Solution (CDM), Documentum 5 and Lotus Discovery Server (Lindvall *et al*., 2003). Likewise, the process of socialization is not only useful to reduce culture differences issues but is also useful for reducing geographic dispersion, co-ordination breakdown, loss of teamness and time zone difference issues. As in socialization (Marwick, 2001) not only individuals share knowledge but also members in form of groups share knowledge i.e. communities. In communities all members share knowledge about same work and issues (requirements in this case) therefore it is very useful for reducing RU issues in GSE. For example, it can be helpful up to some extent to tackle time zone difference because if an issue arises to someone so therefore the person can not only search the solution in stored/codified knowledge of the community but can also contact the exact relevant experienced person. Besides, Company A also supported communities by commenting that our organization is now shifting towards communities because it solves problems easily.

In GSE by making the process of socialization more easy and fluent will thereby help in reducing RU issues because, expert identification is a challenge which can be tackled through adopting KM practice of Competence Management (CM). CM helps in reducing culture difference, geographic dispersion, co-ordination breakdown and loss of teamness issues as shown in Fig. 2. For example, as in GSE teams are dispersed globally and requirements which are misunderstood due to challenges can be reduced through implementing and adopting an appropriate CM strategy. By doing so an appropriate CM strategy will let you know who can have relevant culture knowledge by visiting his/her profile i.e., previous experiences, previous trainings and previous visits and so on. Some common examples of CM tools are

Skill-Scape, Knowledge-Mail, Skill-View Enterprise 5.0 and Path-lore Skills Management System (Lindvall *et al*., 2003).

In GSE email is considered to be the most common way of transferring knowledge and discussing issues. It can reduce culture issues, co-ordination breakdown, geographic dispersion and time zone difference issues (Fig. 2) because it is easy to share and describe the knowledge in written text, visual representation like diagrams and figures. Moreover, email can lead to process externalization, internalization and combination because a team member share experiences (tacit/explicit), providing solutions (tacit/explicit), discussing issues (tacit/explicit) thereby the other team member will read and gain knowledge which helps in understanding requirements by minimizing challenges.

Forums are also considered to be useful for reducing RU issues. Company A has a separate requirements forum where they used to post every sort of knowledge regarding requirements and helped them a lot for solving and discussing issues. In addition, requirements forum also supports the three process of knowledge creation i.e., externalization, internalization and combination because team members post requirement issues and other team members provides solutions, comment, shares opinions and experiences which leads to creation of new knowledge. In addition, requirements forums also helps in reducing co-ordination breakdown, geographic dispersion, culture issues, loss of communication richness and loss of teamness because requirements forums acts like a one stop shop where one can find everything related to requirements and hence RU issues can be solved.

Moreover, ICT tools like video-conferencing, audio-conferencing also support the four process of knowledge creation. Further, ICT tools support cannot be neglected in GSE but the most important thing is to make use of the tools in order to increase the efficiency and productivity. Because, from interviews the authors' observed that Company A although had a proper infrastructure for video-conferencing but they did not use it at all for requirements communication and discussions. Furthermore, the interviewee X stated that it will be good for organization to make use of video-conferencing instead of only having telephonic calls or audio-conferencing because it makes a big difference when talking someone face to face. It also creates trust building, helps in knowing each other i.e., building relationship, understanding each other and especially for requirements discussions to pin point the issue. Hence, the most advanced ICT tools like video conferencing can help in the reduction of four RU challenges (Fig. 2) and thus RU will be improved.

Telecom infrastructure: According to Carmel (1999), telecommunication infrastructure is the need of every team involved in GSE. Further, it acts like a foundation for a building. So therefore, in order to go offshore every organization must have provided and installed a reliable and efficient telecommunication infrastructure in order to collaborate and communicate. Likewise, in KM there is emphasis on need for a good telecommunication infrastructure for globally dispersed teams. In author's opinion a good telecom infrastructure acts like a backbone for GSE teams, otherwise no such activity can be carried out between teams. In Fig. 3, we have elaborated telecom infrastructure (suggested by Carmel) into further two categories, which is used for functional practice of collaborative technologies.

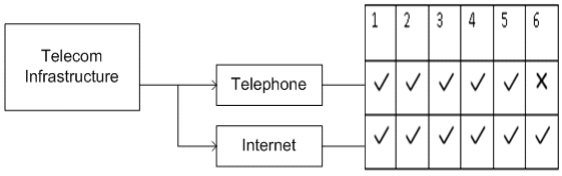

Fig. 3: KM practices/tools, elaborated from telecom infrastructure help in RU challenges in GSE

In KM a good telecommunication infrastructure includes telephone for making calls (formal and informal) and high speed internet (Fig. 3) to support email, online collaboration (video and audio), chatting, searching and so on. It is quite obvious that a poor and slow telecom infrastructure causes delay in work, increases rework, improper communication and co-ordination in GSE teams. As Smite *et al*. (2008), study shows that slow and poor communication channels caused delay in work because of extra hours taken in compilation of code per day.

In the context of RU in GSE, knowledge sharing and proper communication cannot takes place without good support of telecom infrastructure i.e., internet and telephone. Besides, both Company A and Company B have good support of telecom infrastructure. They claimed that RE is more human intensive activity which always requires sharing and communicating knowledge over and over which is only possible with full support of reliable telephone lines and high bandwidth internet. Moreover, by having efficient and reliable support of telecom infrastructure i.e., telephone and internet can help globally dispersed teams to reduce issues of RU by collaborating, communicating and sharing knowledge and co-ordinating easily. However, both Company A and B believe that telephone is not as helpful as internet infrastructure in time zone difference, because it causes delay to call and discuss requirements in large time zones.

Managerial techniques: According to Carmel (1999), global software teams requires motivated and responsible project management committee for the management of different activities related to projects and also people

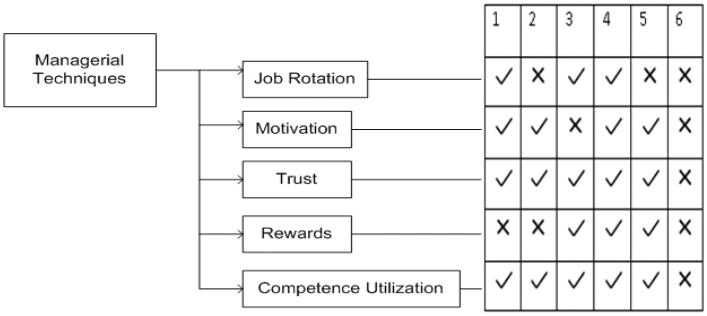

Fig. 4: KM practices, elaborated from managerial techniques help RU challenges in GSE

involved in these projects. To achieve this, global software managers use different techniques for successful completion of projects. However, in GSE global managers come across different challenges like culture difference, loss of teamness, co-ordination breakdown and so on along with the different activities of projects. Therefore, different solutions and techniques have been proposed by Carmel (1999). However, we have elaborated managerial techniques (suggested by Carmel) into main five KM practices as shown in Fig. 4.

RE phase is the crucial phase of SDLC because it is mostly human intensive activity. Further, requirements always need co-ordination, negotiation and discussion for resolving conflicts and ambiguities. In KM perspective this co-ordination and negotiation can be seen and leads to knowledge sharing. Therefore, different team members dispersed geographically requires knowledge sharing directly or indirectly related to requirements. Hence to share knowledge (related to requirements), the authors have proposed different KM practices like job rotation, motivation and trust building which can help global project managers for reducing RU challenges faced in GSE.

The first KM practice which should be adopted by global project managers is job rotation because it helps in the reduction of culture difference and due to which loss of communication richness and coordination breakdown will be reduced. We identified from both Company A and Company B that job rotation is a very good practice which can help in RU in GSE. Further, global project managers should create a culture of job rotation among different units dispersed geographically. By doing so, employee moved from one unit to another unit can easily understand the ways of working of other unit, culture of organization, culture of people, language and so on. On returning back to his/her own unit after serving for some specific period of time in another unit, he/she can easily understand the values, beliefs and words interpretations attached with the requirements as tacit knowledge as compared to other employees of an organization. Rus and Lindvall (2002) also suggest knowledge management practice i.e., job rotation which should be adopted by global managers because it helps team members to easily share their knowledge throughout the project and organization. Therefore, authors believe that job rotation is very good practice of KM which should be considered by managers involved in GSE projects.

As discussed earlier that knowledge sharing is important among different team members of GSE therefore, global project managers should motivate employees for sharing their knowledge. According to Hislop (2005), motivation is a managerial activity which is important for sharing knowledge. As most of the organizational knowledge is personal and tacit specifically in case of requirements, therefore motivation is important. Sharing of knowledge (requirements) can occur through close interaction and co-ordination which is totally based on motivation and willingness of people who have this knowledge. In addition, global project managers should offer different rewards like job security and promotions to employees for motivating them to share knowledge (Hislop, 2005) and making use of specific technologies like DM, CM, communication and collaboration tools and communities which helps in knowledge sharing. The study of Rus and Lindvall (2002) shows that the team members should not only be encouraged but should also be awarded for sharing, searching and reusing of knowledge by introducing the ‘reward systems’ throughout organization. Furthermore, rewards like job security and promotions also helps in loss of teamness because teams scattered geographically will always participate in sharing their experiences and knowledge for getting rewards and in this way communication and coordination challenges faced during RU will also be solved. As a result the people which are part of a team just dispersed geographically will be able to share knowledge and an environment of trust building will be created by sharing views and experiences with one another.

Moreover, organizational units dispersed geographically can work like people working in collocated if the global manager assign right people to the right task. This means that authors identified that proper competence utilization in proper place is also one of the useful practices which should be considered by global

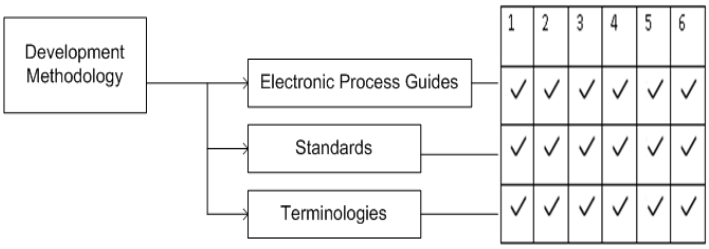

Fig. 5: KM practices/tools, elaborated from development methodology help in RU challenges in GSE

project managers. Interviewee X and Z stated that if an employee knows about some culture values and customs, he/she should be considered in requirements discussions whether he/she belongs to any department of the organization. By doing so the dispersed team could collaborate easily in resolving RU issues. At last but not least, motivation, trust building and competence utilization are the driving managerial techniques which can help a global project manager in reducing culture difference, co-ordination breakdown, geographic dispersion and loss of teamness faced during RU in global setting.

However we did not find any useful KM practice within managerial techniques which helps in reduction of time zone difference as shown in Fig. 4.

Development methodology: According to Carmel (1999), development methodology is a map which is used as a guide by software development teams throughout SDLC. It also acts like a bridge among different team members dispersed geographically to handle different issues and challenges faced during software development. As discussed earlier that GSE is difficult especially when teams are working in RE activities like understanding requirements in full due to culture difference, co-ordination breakdown and so on. Therefore, to overcome/reduce these challenges to minimal there is a need of common development methodologies along with collaborative technologies, telecom infrastructure and managerial techniques, among different units of an organization. We have supplemented development methodology (suggested my Carmel) with KM practices as shown in Fig. 5.

Hence, to deal with the RU challenges faced in GSE by using development methodologies, authors have identified Electronic Process Guide (EPG) as KM solution. According to (Dingsoyr and Moe, 2004), EPG is a structured, workflow-oriented and a reference document to help all the participants included in a project. Every organization produce their own EPG according to their needs but authors suggest that EPG should include terms and standards used in an organization for developing projects along with the elements suggested by Dingsoyr and Moe (2004). Terminologies and standards used in an organization can help in co-ordination breakdown along with culture difference, loss of teamness, communication richness and time zone differences among team members dispersed geographically and hence RU will be improved.

From interviews, we indentified that terminology helps in RU in a sense that requirements are always unclear due to terms used in one organization/unit and other unit even do not know what really that term means e.g. if we take the example of an SRS some call it as SRS, other call it as requirements document, others call it as functional specifications and so on. Besides, Company B using PReq for product requirements, if these types of terminologies are used and spread over the intranets in the form of EPG then the RU issues can easily be reduced up to some extent and understood by using same type of terminologies. Furthermore, terminologies also help in RU which is misinterpreted often due to culture difference like language peculiarities. Therefore Smite (2005) suggested terminology dictionary for coping with such types of issues and challenges, which will in turn reduce coordination breakdown, loss of communication richness, loss of teamness and time zone differences. According to authors' view time zone can be reduced by using terminologies because when a team member of every unit have knowledge about terms used, then the dependency on each other and communication will be reduced which in turn will increase RU.

Along with using different terminologies in software industries (in the form of EPG), standards should also be used in industries especially which are involved in GSE because it also helps in reduction of RU issues mentioned by Company A and B. Having multiple standards, tools and templates in different units of an organization can lead to rework or loss of requirements knowledge by converting one template or standard to another, which can in turn increase misunderstanding of requirements (Bhat *et al*., 2006). Therefore, authors have identified that software organizations dispersed geographically should use same standards and templates (can be in form of EPG) among all units, as a result it will reduce culture difference, loss of communication richness and so on. According to authors views, a good example could be

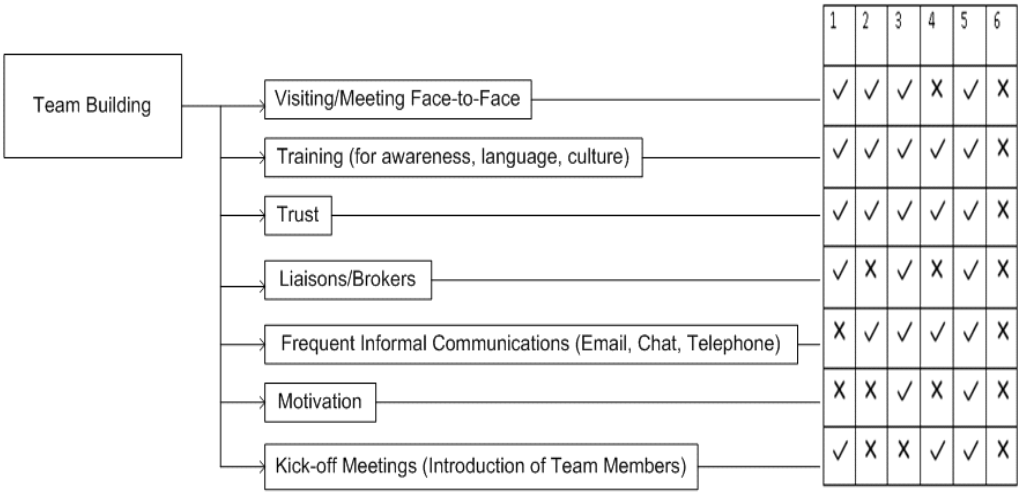

Fig. 6: KM practices/tools, elaborated from team building helps in RU challenges in GSE

using of standards like IEEE template for requirements documentation among different units of industries like Company A is using a standardized template throughout their units in managing and understanding requirements. Furthermore, if different units of an organization using different documents for requirements, like if one unit using IEEE template and other unit using simple MS Word document created internally by the unit, can create problems like misinterpretation, incompleteness and ambiguity in requirements. On the other hand if all units are following one standard document for requirements specification and documentation then most of the requirements problems can be reduced like misinterpretations and misunderstanding created due to culture difference, loss of communication richness, geographic dispersion and loss of teamness.

Team building: According to Carmel (1999), team work cannot be built up only by providing tools and installing advance technology across different sites in GSE but one of the major role is to build a culture of trust and relationship among employees so that they can easily collaborate and coordinate. Therefore, for RU in GSE team work is necessary because requirements are misinterpreted due to culture difference i.e. language and trust, lack of communication, co-ordination breakdown and lack of proper collaboration among teams. Therefore, we have identified several KM practices which have elaborated team building (suggested by Carmel) as shown in Fig. 6.

In author's opinion, for building a cohesive team work increase the socialization among different units. Besides, Smite *et al*. (2008) study shows that poor socialization affects coordination and collaboration among team members working in GSE. In addition, socialization can be achieved through visiting (meeting face to face), frequent sharing of knowledge, intense communication (formal and informal), kickoff meetings (introduction of team members) and trainings (culture and language). Besides, by ensuring socialization a culture of trust and motivation will be built among employees which are the pivot elements in team building. Thereby, all of the above KM practices help in reduction of RU challenges in GSE.

In GSE visiting/face to face meetings and kickoff meetings can play a vital role in reducing culture issues, geographic dispersion and loss of teamness issues faced in RU in GSE. Besides, Moe and Smite (2007) study shows that organization needs to spend some money on arranging one or more face to face meetings because it helps in creating trust which helps in team building. Because, meeting with each other helps in knowing each other, culture, problems are solved easily by discussing face to face, helps in knowing the status of work and organization helps in increasing trust and motivation among team members. In addition, meeting face to face is also considered to be the pivot role in the process of socialization because it creates trust and increases motivation. Furthermore, the interviewee Z at Company B claimed the importance of visiting for team work and therefore they have some dinner parties to buildup relationships and to increase trust. Likewise, the interviewee Y at Company A stated that they used to have kickoff meetings about people, product and culture which in turn help in reduction of culture difference, coordination breakdown and loss of teamness. Hence by adopting KM practices i.e., visiting and kickoff meetings, RU can be improved.

As units are dispersed far flung from each other therefore training is necessary for team members. Besides, Smite (2006) shows that training is necessary for culture understanding, creating trust and awareness among team

Fig. 7: KM practices/tools, elaborated from product architecture helps in RU challenges in GSE

members. Further, as requirements are also misinterpreted due to differences in culture therefore training of culture and language is necessary for team members. It also helps in making good relationships, trust and awareness among team members which boosts team work. We identified that all the interviewers stated that training can play a vital role in reduction of all RU challenges in GSE except time zone as shown in Fig. 6. Furthermore, the role of liaison or brokers can also help in bridging culture issues, knowing each other, sharing knowledge, problem solving, helps in explaining the interpretations of words and culture values. Therefore, the team members will be more socialized and they will be able to transfer tacit knowledge of requirements. Moreover, the interviewee X at Company A claimed as "in order to overcome culture issues learn more about cultures, product and each other through some liaisons/guide who can help out in knowing about cultures and frequently sharing of knowledge". Likewise, the interviewee Z at Company B claimed that they have Single Point of Contact (SPOC) persons for helping in translation and communication and also have assigned a responsible technical person who helps in problem solving and if he cannot solve a problem then he contacts to other relevant person.

The interviewee Z at Company B claimed the importance of frequent informal communication i.e., telephonic call as "I used to stress to call at least once a week to other units even if it is not really important to build a culture so that talking with each other becomes easy. They should not think twice IS IT OK to call Mr. XYZ? They should just call because it solves problems much easily". Therefore, to increase socialization in GSE teams always share and transfer knowledge, discuss issues and ideas, make frequent telephonic calls, emails and chatting. Moreover, by increasing informal ways of sharing knowledge will increase socialization which will in turn help in building team and thereby improving RU affected by co-ordination breakdown and geographic dispersion in GSE.

Product architecture: According to Carmel (1999), product architecture should be designed in such a manner so that dispersed units can be less dependent on each other work. Besides, as in GSE teams are scattered therefore it is always hard to communicate, collaborate and coordinate due to distance and difference in time zones.

From industrial interviews the authors' found that both Company A and Company B have good approach of modularization in which they ensure to have little dependency on each other i.e. *component ownership*. Furthermore, they also have incremental approach for product development. Besides, the interviewee Z at Company B claimed that "*Don't wait for big-bang*" i.e., always frequently communicate, increase feedbacks and increments because it is an easy way to solve problems. In addition, Smite *et al*. (2008) study shows that complex task division makes the process of coordination and collaboration more complex. Therefore, we have supplemented product architecture (suggested by Carmel) into KM practice i.e. modularization as shown in Fig. 7.

As RU is not confined only to RE phase but is an ongoing process throughout SDLC therefore modularization helps in RU and especially in GSE where teams are dispersed geographically. Moreover, as in GSE modularization helps in reducing dependencies of units on each other therefore it helps in overcoming issues of geographic dispersion, coordination breakdown, loss of teamness and difference in time zones faced in RU within GSE.

CONCLUSION AND RECOMMENDATIONS

Based on the analysis of literature review and industrial interviews the authors have concluded that RU issues in GSE occurs due to lack of knowledge sharing and communication, lack of interaction, culture diversity, mutual discussions, lack of face-to-face meetings, co-ordination and communication breakdown due to time zone difference and loss of teamness. Therefore, following recommendations are made:

- It is very important that organizations should adopt culture of Knowledge Management, because it solves problems in a social way especially in case of human intensive activity like RE (RU).
- Always share knowledge and communicate even if it is not necessary because it helps in creating trust, mutual understanding, increases collaboration and co-ordination which in turn reduce RU issues.
- For RU, build communities because it helps in problem solving, knowing each other, better competence identification and utilization.
- Motivate team members to share and codify knowledge of requirements because it helps in reducing RU issues.
- Always arrange kick-off meetings and face-to-face meetings because it helps in knowing each other, creates trust and motivation among team members and requirements issues are better resolved in this fashion.

- Provide a good telecom infrastructure that can not only support efficient and reliable communication but can also support KM tools in order to enable team members to share and access knowledge easily from anywhere in the world.
- For requirements to be more clear, put them in some context, elaborate and discuss it with help of visualization i.e., diagrams and pictures.
- Global project managers should use KM practices like rewards, job rotations etc because it motivates team members for sharing knowledge about requirements and thus RU can be reduced in this way.
- The use of standardization throughout organization can also helps in reducing RU issues.
- Invest in hiring culture liaisons/brokers can help in reducing issues of RU by providing knowledge of culture, people and product.
- It will be good for organization to hire some technical experts who can help in problem solving and also help in referring to some other competent person.

Future work: In this research study authors performed only qualitatively research; therefore, in future a quantitative study is needed. In addition, as authors have only conducted interviews in two industries working in same domain i.e., Telecom, so therefore it would be a nice future work to see the results if the interviews are conducted in more than two industries working in different domains. It can also be a useful contribution to research for evaluating the effectiveness of KM practices for reducing impact on RU of each and every GSE challenge i.e., culture difference, loss of teamness, loss of communication richness and so on.

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