

# Utilizing Virtual Software Teams for Inconsistency Management in Distributed Software Development

Dillip Kumar Mahapatra, Tanmaya Kumar Das, Gurudatta Lenka

**Abstract**—In the challenging field of software project development, the work is invariably performed by teams. In today's world of privatization and globalization, where the development costs are increasing at a breakneck speed, the focus is now on cost reduction and availability of highly motivated and suitably trained workforce. Keeping the above mentioned parameters in mind, Companies worldwide are relying on virtual software teams to do the work. This paper highlights the characteristics and throws light on the specifics of virtual software teams. It also illustrates some of the most common issues and challenges that virtual teams face while working on a project there by exposing some of the ground realities as de scribe the most.

**Key words** : Cohesion, Complexity Factor, CSCW, Cultural Difference, Face-to-Face Interaction, Satisfaction, Socio-Emotional Process, Virtual Team.

## I. INTRODUCTION

### A. Social Aspects of Software Development

The software development process would not be possible without human beings who handles the tasks of requirement specification, analysis, design, implementation, testing, and evaluation. Therefore, the success of software development depends on the human factor involved in it, specifically on the complex relationships that exist among the people that collaborate in order to deliver the product successfully.

It is also considered that software development is essentially a social discipline and give psychological views to programming and software development. The cross-scientific research settings should be created more to better understand the group and personal psychological factors that plays essential role in software development. The team-level social processes may be a better predictor for team performance than the production methods explains theories from group psychology to management science can provide insights into how software development teams can improve their work practices by not only considering technical choices.

Therefore, the importance of social factors in software development is enormous. Because of this, organizations need to investigate relationships between team members and give special notice to the development teams and the complexities and problems they face every day(Ref. 2).

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## II. VIRTUAL VS. TRADITIONAL SOFTWARE TEAMS

Software engineering is a technical as well as a social discipline. However an organization is implementing traditional, distributed, virtual, or global software development project, the crucial building block of the project are the developer teams. A team can be defined "a collection of individuals who are interdependent in their tasks, who share responsibility for outcomes, who see themselves and who are seen by others as an intact social entity embedded in one or more larger social systems (for example, business unit or the corporation), and who manage their relationship across organizational boundaries" (Ref. 2).

In the traditional, co-located software development, the work is performed by traditional or face-to-face teams. Therefore, a traditional team would be a collection of co-located individuals who perform tasks and have responsibilities.

Similarly, virtual software teams are the work units of distributed, virtual, or global software development. However, they operate across time, geographical locations and organizational boundaries and are linked by communication technologies. A virtual team may be defined as "a team whose members use the Intranet, Intranets, Extranets and other networks to communicate, coordinate and collaborate with each other on tasks and projects even though they may work in different geographical locations and for different organizations". However, the most important distinction between virtual and traditional teams is that the members of a virtual team are distributed across geographical locations. It is experienced that, in contrast to traditional teams, virtual teams are very dynamic because they are prevalently formed as the need arises and disassembled when the task is complete (Ref. 3).

## III. VIRTUAL TEAM CHARACTERSTICS

The virtual teams are assembled and disassembled very dynamically, there is very little prior team history and work culture and responsibilities of team members vary with each new virtual team they are appointed to. Savage points out that the structures of virtual teams are typically non-hierarchical and decentralized. Moreover, virtual team members are prevalently dependent on lateral and informal information exchange to perform the tasks. The virtual team has to manifest following characteristics (Ref. 1):

- It is a set of culturally and organizationally differentiated members.

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- The members are grouped temporarily.
- The members are physically dispersed.
- The members are connected by weak lateral ties.
- The members are engaged in performing non-routine tasks.

The above characteristics would be the characteristics of the ideal virtual team. In practice, however, there are few such teams. For example, there are teams where the members are geographically distributed, but are culturally and organizationally homogeneous. In other cases, team members may come from different cultures and organizations, but be physically co-located. The consequence of this fact is that the virtuality of a team is determined in degrees rather than in kind. This virtuality has three characteristics(Ref. 5):

**A. Virtual Team Context** – The virtual team context is characterized by *low team history, novel tasks, and physically distributed members*. It's reported that one of the biggest advantages of virtual teams over traditional teams is that its members can be assembled quickly in order to utilize emerging opportunities, and disassembled when the job is finished. So, lack of team unit is argued by the fact that virtual teams tend to have no history of collaboration. Also, different knowledge and capabilities of people have to be leveraged in order to exploit emerging market opportunities. Novel tasks are a side-effect of the nature of these opportunities. In order to utilize them, virtual teams must perform non-routine tasks and have non-routine responsibilities. They also have to perform them under time-pressured environments. Furthermore, the members of virtual teams are prevalently not co-located but dispersed around the world. They are connected only by various information technologies. (Ref. 4)

**B. Virtual Team Composition** – Virtual team members are characterized by the *heterogeneity in their cultural and organizational backgrounds*. Virtual teams are often composed of culturally and organizationally diverse members. Now-a-days, as a result of the globalization and improvements in information technology, organizations are enabled to form virtual teams that connect members from different countries and organizations. It's found that due to the unique cultural and organizational backgrounds of team members, the mix of their knowledge and talents maximizes the potential of the team to take advantage of market opportunities.

**C. Virtual Team Structure** –The structure of a group describes the nature and the strength of patterns of relationships among individuals in work groups. As for the relationships between members in virtual teams, they are often lateral but weak. Virtual team members tend to be connected by lateral communication ties because of the physical distance between the members and the nature of the work they are performing. The team members have an efficient flow of information and are able to coordinate their task activities, despite the physical distance between them. These ties tend to be weak because *“the lack of face-to-face interactions, the span across cultural and organizational boundaries, and the lack of prior history of cooperation prevent the time, the mutual confiding and the emotional support required for the formation of strong ties”*. Due to the weak ties among the members in a virtual team, the members are more likely to treat each other formally and less likely to reciprocate requests from one another. Hence, due to cultural

and organizational barriers and the shortage of prior work history, the relationships connecting virtual team members are likely to be lateral but weak.(Ref. 6)

The coordination dynamics within the team greatly depends on the levels of virtuality characteristics it possesses.

## IV. DISTANCE AS A COMPLEXITY FACTOR

The physical distance that is imposed on team members working in a distributed environment is found to have the greatest influence on the collaboration issues in virtual software teams. To distributed project management, distance itself introduces barriers and complexities. For virtual teams however, the distance has negative influence on other factors such as coordination, visibility, communication, and cooperation. If the issues that rise in these areas are neglected, they can cause additional barriers and complexities to the project (see figure 1).

It has been known that physical proximity of co-workers has a great influence on collaboration. It is observed collaboration is more effective and probable if people in the building are located closer to each other. The frequency of communication among team members decreased with distance. Furthermore, he stated that in cases where the engineers' offices were about 30 meters or more apart, the frequency of communication dropped to almost the same low level as in cases where the offices are separated by many miles. (Ref. 4)

In order to combat the complexities introduced by the distance between members and aid virtual collaboration, software industry has been developing a number of computer supported cooperative work (CSCW) tools. These tools are far from perfect but research that is being conducted on virtual work helps developers improve their possibilities. (Ref. 4)

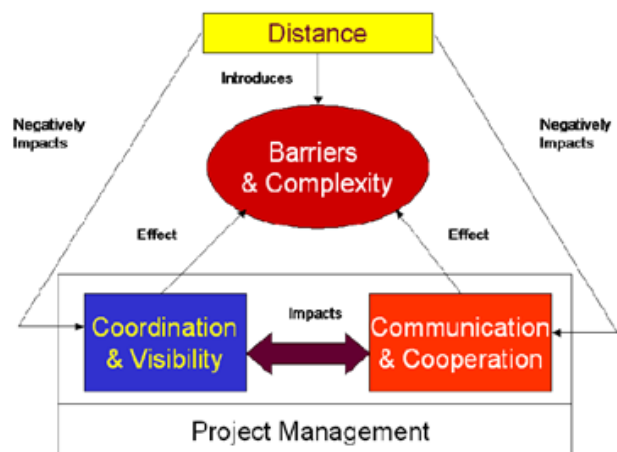


Figure 1: Virtual Software team environment

## V. ISSUES WITHIN VIRTUAL SOFTWARE TEAMS

The distance between the members in a virtual team, the lack of face-to-face contact and the cultural and organizational diversity complicate the work of virtual teams.

The results of current researches on virtual teams and present the issues that the virtual teams face and the following subsections are based on their work. The life cycle model includes four general categories of variables: inputs,

socio-emotional processes, task processes, and outputs (see figure 2).

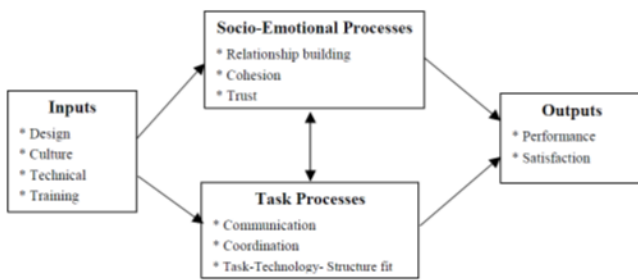


Figure 2: Categories of the life cycle model

### A. Inputs

Inputs stand for the design and composition characteristics of the virtual team and the benefits of resources, skills, and abilities with which the team begins its work.

The most commonly researched inputs are design, culture, technical expertise, and training.

#### (i) Design

The development of a shared language and shared understanding by team members depends greatly on the design of the virtual team and the structuring of its interactions. This is even more crucial early on in the team's life. There are a number of various designs of virtual teams. Some incorporate different levels of face-to-face interaction, planning of activities and the use of communication media, and the articulation of goals, structures, norms, and values.

The differences between traditional and virtual teams inform that traditional teams generally outperform virtual teams with respect to the ability to orderly and efficiently exchange information and to perform effective planning. The probability of the success of a virtual team can be greatly improved by team-building exercises, establishment of shared norms and the specification of a clear team structure. Some authors point out the need for periodic face-to-face meetings during project planning under the limitation of the use of electronic communication. This is due to the fact that discussion and team interaction in virtual environments can take longer and be confusing, thus leading to poorer comprehension and understanding. By organizing early face-to-face meetings during the team's launch phase, organizations can improve the team's project definition. This way they can also enhance the effectiveness and quality of subsequent electronic communication (Ref. 1).

By enabling knowledge sharing (either by face-to-face meetings or electronic communication), designs can establish a common understanding and language. The establishment of a common understanding and language helps the team members to solve ambiguous tasks communicating electronically. On the other hand, the absence of shared understanding and language bears with it a number of possible communication problems. Such problems are termed as: failure to communicate, unevenly distributed information, difficulty understanding the importance of information to various team members, and difficulty interpreting the meaning of silence or non-reply by others. A design of team interaction that employs the setting of goals and strategies leads to the establishment of shared mental models. Different goal and strategy decisions are found to improve the performance of virtual teams (Ref. 6).

#### (ii) Cultural Differences

As projects are being deployed around the world, they often include team members that come from different cultural backgrounds. The cultural differences and their effect on project success have been studied on numerous occasions. The most important issues that lead from these differences are the coordination difficulties and the creation of obstacles to effective communication. These negative effects are present not only in global virtual teams but also in teams where there are subtle differences among team members having from different regions of the same country. The negative effects of cultural differences can be surpassed by actively understanding and accepting the differences. However, cultural differences have a lesser impact than the distance between members when it comes to project management challenges such as setting goals, budgets, schedules, resources, and identifying needs (Ref. 6).

#### (iii) Technical Expertise

The technical expertise of virtual team members has a great impact on team performance and individual satisfaction. The performance and individual satisfaction with the team experience are negatively impacted by a lack of technical expertise and the inability to cope with technical problems. It is observed that the novelty of the team affects the team members less than the novelty of the technology being used. The absence of technology related uncertainty and technological challenges foster the development of high trust among the team members.

#### (iv) Training

Various researches have shown that consistent training among all team members increases team performance. Moreover, team members require training not only in the usage of technology, but in effective communication using the virtual medium. However, virtual teams in which team members possess diverse technology skills may have difficulties if they cannot resolve differences and agree on one specific technology skill for the execution of a task. In order to foster cohesiveness, trust, team work, commitment to team goals, individual satisfaction, and higher perceived decision quality, organization can provide team members with early and uniform training. Organizations are also deploying formal mentoring programs. The goal of these programs is to cultivate relational development and help new members to feel connected to other team members (Ref. 6).

### B. Socio-Emotional Processes

Relationship building, cohesion, and trust are the most important processes within virtual teams. Their existence has positive effects on team performance. However, they are very hard to realize when the team members are separated by physical distance. Relationship building includes interaction processes designed to increase feelings of inclusiveness or belonging to the team that are hypothesized to foster cohesion and trust. Research has found that there is a positive link between socio-emotional processes and outcomes of the virtual team project. It has also shown that virtual teams are confronted with unique challenges when it comes to meeting socio-emotional needs of virtual team members.

#### (i) Relationship Building

Another difference between virtual and traditional teams is that virtual teams are often more task focused than social

focused. However, over time, the amount of the task focus usually lessens. Virtual team members also generally have weaker relational links to their co-workers. This problem rises from the fact that virtual teams rely significantly on electronic communication and from difficulties that are present with this kind of communication. Thus, many authors have found that face-to-face communication early in the project supports the formation of closer interpersonal relationships between team members. If the budget and deadlines allow it, the team members should physically meet early in the project. These meetings should focus only on relationship building. Such meetings strengthen the socio-emotional development of the team and support later success by enhancing learning and improving performance. If face-to-face meetings are not possible, the relationship building can be encouraged by other means. One way to foster relationship building is to focus on the exchange of social communication. Virtual teams that send more social communication achieve higher level of trust and better social and emotional relationships. Social conversations between team members can also foster relationship building and improve social bonds if they emphasize commonalities between members of different cultures. Effective team leaders can stimulate relationship building by scheduling regular chat sessions with all team members present (Ref. 6).

### (ii) Cohesion

Cohesion in a virtual team fosters better performance and greater satisfaction among team members. It has been identified as one of the differences between successful and unsuccessful virtual teams. Cohesion was the focus of several studies that compared virtual and traditional teams. However, the results have been mixed. It is found that the development of cohesion in virtual teams was obstructed by the use of collaborative technologies. Hence, traditional teams were found to have higher team cohesiveness. In contrast to this study, other studies have found that even though virtual teams start with lower cohesion, their members exchange enough social information over time and develop strong cohesion (Ref. 10).

### (iii) Trust

It is a big challenge to develop trust in virtual teams because team members can hardly assess teammates' trustworthiness if they never met them. Moreover, trust must develop quickly because the life of many virtual teams is relatively limited. The development of trust is essentially important because it is crucial for the successful completion of virtual team projects. Even though it is difficult to develop trust in virtual teams, early research has found that short-lived teams are in fact able to develop high trust. However, they do not develop trust by following the traditional model of trust development but by following a swift trust model. The swift trust model claims that, when they don't have sufficient amount of time to slowly build trust, team members assume that teammates are trustworthy and begin working as if the trust was already developed. During the project they seek for confirming or disconfirming evidence about this trustworthiness. Virtual teams that show high trusting behaviors experience significant social communication, predictable communication patterns, substantial feedback, positive leadership, enthusiasm, and are also able to deal with technical. The perceived integrity of other team members is especially important in the development of trust early in a team's life. On the other hand, the perception of other member's benevolence helps the

maintenance of trust over time. Face-to-face meetings with the focus on developing a strong foundation of trust between members can also be used to instantiate high trust virtual teams. Besides face-to-face meetings, communication training can also be used to develop high trust between virtual team members.

### C. Task Processes

Task processes are defined as "*the processes that occur as team members work together to accomplish a task or goal*". In the task processes category there are major issues regarding communication, coordination, and task technology-structure fit.

#### (i) Communication

Communication is an essential part of any virtual team process. Moreover, it is said that "*if technology is the foundation of the virtual business relationship, communication is the cement*". Past research on traditional teams suggests that successful co-located teams can communicate effectively and share information crucial to project completion in a timely manner; However, the communication in a virtual setting is confronted with serious challenges that evolve from the nature of virtual environment. Such challenges include time delays in sending feedback, lack of a common frame of reference for all members, differences in salience and interpretation of written text, and assurance of participation from remote team members.

In contrast to traditional teams, virtual teams usually suffer from absence of an important component of team communication, namely, nonverbal communication. Due to the importance of communication to virtual teams, it has been the most studied aspect of virtual work. These work represents that traditional teams often communicate more effectively than their virtual equivalents. Due to the physical separation between them, virtual team members are heavily dependent on information and communication technologies.

However, technology is very likely to restrain the communication process. This happens because electronic media are intrinsically leaner than face-to-face communication and convey a limited set of communication cues. Hence, the teams that perform the work in the virtual setting a front greater difficulties to orderly and efficiently exchange information than their equivalents in the traditional setting. Even though technical challenges have the greatest influence, they are not the only cause of restricted communication. Information exchange runs into problems also when some team members are co-located and others are dispersed. In such settings dispersed members prevalently assume that co-located team members are talking and sharing information that is not communicated to them. Also, private exchanges have been found to cause friction between team members. Similarly, ineffective leadership and cultural differences have also been identified as the negative influence on communication effectiveness. In spite to all the difficulties of communicating in a virtual environment, virtual team members must effectively exchange information if they are to achieve their objectives and successfully complete their tasks.

That is why the mitigation of communication difficulties and the development of information-sharing culture were the focus of many studies. The results of these studies

inform that the frequency and predictability of communication, and the extent to which feedback is provided on a regular basis, improves communication effectiveness. This then leads to higher trust and improves team performance. Contrarily, unpredictable communication patterns are said to cripple the coordination and success of virtual teams. The most frequent unstable communication pattern includes team members leaving for an extended period of time and failing to communicate the absence to other members previously. In regard to the extent of communication, virtual team members communicate more frequently than their traditional counterparts. In addition, members of female-only virtual teams communicate more than members of male-only or mixed gender virtual teams. Also, studies have found that more effective communication improves cultural understanding and vice-versa (Ref. 7).

#### (ii) Coordination

Coordination can be defined as the degree of functional articulation and unity of effort between different organizational parts and the extent to which the work activities of team members are logically consistent and coherent. Even though coordination has a great influence on the performance of virtual teams there are significant challenges that virtual teams face as they try to coordinate their work across time zones, different cultures and divergent mental models. Furthermore, collaboration norms need to be developed for the team to be able to consistently and coherently bring together team member's contributions. In order to get leverage on challenges to effective coordination in the virtual setting, the research has focused on investigating interventions and approaches designed to improve virtual team coordination. Face-to-face meetings have been identified as a huge help in mitigating various issues in the virtual environment. If they are feasible, they can also have positive influence on coordination activities and drive a project forward. On the contrary, if periodic face-to-face meetings cannot be held, organizations can develop coordination protocols and communication trainings. Such activities support the improvement of coordination and collaboration. Another way that has shown itself useful when it comes to improving coordination between virtual team members is the minimization of cultural barriers (Ref. 5).

#### (iii) Task-Technology-Structure Fit

The possible combination between different technologies available to virtual teams and the tasks they need to perform plays a significant role in the life of a virtual team. Studies suggest that the technology for the completion of a task is chosen according to the individual preferences, individual experience with the technology and its ease of use, the need for documentation, and the urgency of the task. For instance, face-to-face meetings or phone calls have shown themselves as best adapted for ambiguous tasks, managing conflicts, managing external resources, brainstorming, and for setting strategic direction. On the other hand, electronic communication is the best choice when it comes to execution of more structured tasks or monitoring project status. In settings where virtual team members are not able to attend synchronous meetings (i.e. because of different time zones), a shared language can be successfully developed in order to help members overcome the limitations and adapt the technology to complete ambiguous tasks. Regardless of the availability of various technologies, effective virtual teams are often able to adapt the technology and accord it to the

communication requirements of the awaiting task. The availability of different technologies for the completion of tasks is said to foster more satisfaction and better performance from virtual team members'. The adaptability of virtual team members to the different team structure was also the focus of many studies. It is experienced that virtual teams experience distinct stages of team development just as traditional teams. In addition, in spite the fact that members of virtual teams need time to adapt to the technology and new team form, they are prevalently able to do so in a satisfying manner. It is also observed that virtual team members adapt themselves to the technology, organization/social environment, and/or team structures (Ref. 7).

#### D. Outcomes

The outcomes of virtual teams have also been the focus of many researches. They include the performance of virtual teams as well as the member's satisfaction with the virtual team experience.

##### (i) Performance

The researched on performance also compared traditional and virtual teams. It has been observed that virtual teams are more effective than traditional teams. The virtual teams cannot outperform traditional teams. In addition, the majority of studies conducted on this topic found no significant difference between the two types of teams. Other research conducted on the performance of virtual teams focused on more specific aspects such as decision quality, number of generated ideas, and time the members needed to reach a decision that virtual teams do not differ much from traditional teams when it comes to the number of generated ideas.. When it comes to time needed for decision making, virtual teams needed more time to make a decision because of the constraints in the virtual environment (Rf. 9).

##### (ii) Satisfaction

It has been observed that members of traditional teams were more satisfied with their experience than that of the members of virtual teams. There is no significant difference between two kinds of teams. The difference between satisfied and unsatisfied virtual team members was also studied. Training and the use of more communication methods are identified as possible prerequisites for a satisfied virtual team(Ref. 3).

## VI. CONCLUSION

As software development is both a social and a technical discipline, the aspect of team members is inherently important. Virtual software teams represent a group of software engineers who are involved in a distributed software project and collaborate toward its goal. Virtual team members have to use various communication technologies in order to collaborate and coordinate their work. The main reason of complexity in distributed projects and workflows of virtual team members is the geographical distance between various development sites. The distance has negative effects on coordination, communication, visibility, and cooperation. Neglecting negative effects can lead to various kinds of issues that hinder the success of virtual teams. The issues that face geographically distributed team members fall into four categories:

inputs, socio-emotional processes, task processes, and outputs. Every category includes several aspects of a virtual team. Inputs involve virtual team design, team culture, training, and technical expertise. Aspects of relationship building, cohesion, and trust fall into the category of socio-emotional processes. Task processes include communication, coordination, and task-technology-structure fit. Finally, performance and satisfaction of team members represent the outputs category. Research findings on issues of these aspects give a more clear view and insight on problems that distributed co-workers face as well as on reasons why these problems emerge. This can be highly useful for development and creation of new virtual collaboration tools that support virtual teams.. The activities that team members have to perform are presented afterwards. Finally, this paper presents the tools that support collaborative work in a virtual environment as well as the different modes of virtual collaboration.

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