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**KEY CHALLENGES OF VIRTUAL SOFTWARE  
DEVELOPMENT TEAMS**

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## **ABSTRACT**

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Many alleged benefits of virtual teams have motivated software companies to utilize virtual work in their projects. Building efficient virtual teams has, however, proven out to be a difficult task, and companies have found out that the alleged benefits may not always come true. To ease the efficient utilization of virtual teams in the future software development projects, this study researches virtual software development literature for key challenges that the teams face, as well as to find possible solutions to these challenges.

The study found several key challenges and solutions for virtual software development teams and organized them into six categories. The results of this study help virtual team managers and personnel to acknowledge the state of their team in relation to the key challenges, as well as to understand how to improve the team's chance for success and/or how to improve its performance. Additionally, the intuitive categorization presented makes it easier to understand and communicate the team's issues.

**KEYWORDS:** virtual, team, project, software development, challenges

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Kandidaatintutkielma

Virtuaalitiimien monet mahdolliset hyödyt ovat motivoineet ohjelmistoyrityksiä hyödyntämään virtuaalista työskentelyä projekteissaan. Toimivien virtuaalitiimien aikaan saaminen on kuitenkin osoittautunut yllättävän haastavaksi ja yritykset ovat joutuneet huomaamaan, että toivottuja hyötyjä ei olekaan aina saavutettu. Virtuaalitiimien tehokkaan hyödyntämisen helpottamiseksi tulevaisuuden ohjelmistokehitysprojekteissa tämä tutkielma etsii ohjelmistokehityskirjallisuudesta haasteita, joita virtuaaliset ohjelmistokehitystiimit kohtaavat, ja tapoja, joilla näitä haasteita voidaan ratkoa.

Tuloksena löytyi useita avainhaasteita ja -ratkaisuja, jotka tutkielmassa organisoidaan kuuteen eri kategoriaan. Tutkielman tulokset auttavat virtuaalitiimien päälliköitä ymmärtämään tiimensä tilan suhteessa löytyneisiin haasteisiin sekä parantamaan sen onnistumisen mahdollisuuksia ja/tai tehokkuutta. Lisäksi tutkielmassa esitetty intuitiivinen haasteiden kategorisointi helpottaa tiimin ongelmien ymmärtämistä ja niistä kommunikointia.

AVAINSANAT: virtuaali, tiimi, projekti, ohjelmistokehitys, haasteet

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## 1 INTRODUCTION

From the very advent of the modern internet, there have been projects on which software developers have worked on without ever, or only very seldom, meeting face-to-face. At first, the vast majority of such development was just for fun, as demonstrated by the blooming demoscene and a large amount of non-commercial open-source software projects. These kinds of physically separated teams are these days called *virtual teams* (VT) or *geographically dispersed teams* (Järvenpää & Leidner, 1999) (Hart & McLeod, 2003). In this particular, study the term virtual team will be used.

For a while already, the virtual way of working has been entering the software industry in forms of *global software development* (GSD) or *distributed development*. The motivation for implementing virtual teams is that the team can be formed without limitations of time, space, and the costs and disruptions of relocation (Schweitzer & Duxbury, 2010). Nowadays the global software development has become rather mainstream, but building efficient virtual teams has proven out to be a difficult task. Therefore companies have found out that the alleged benefits may not always come true (Paasivaara, Durasiewicz & Lassenius, 2009).

To ease the efficient utilization of virtual teams in the future software development projects, this study aims to research the virtual software development literature and find key challenges that virtual software development teams face, as well as to investigate possible solutions to these key challenges. To fulfil these goals primary and secondary research questions are presented. The primary research question is: *What are the key challenges of virtual*

*software development teams? And the secondary research question is: How could the key challenges of virtual software development teams be solved?*

The study includes three main parts. This introduction is the first one. The second section discusses virtual teams, team virtualness and introduces the definitions and views adapted in this study. The third section in the other hand presents the found key challenges in a newly formed grouping and discusses solutions for them. The last part, the summary and conclusion, draws everything together and presents a simplified table of the key findings, as well as discusses validity, practical implications, and topics for future research.

## 2 TEAM VIRTUALNESS AND VIRTUAL TEAMS

Currently it is often viewed that teams are either virtual or not virtual. Based on the recent work of Schweitzer et al. (2010) this study takes a different view and looks into team virtualness as a degree.

Definitions for virtual team commonly include geographical, organizational, time and cultural dispersion between the team members, as well as temporality of the team and the usage of communication and collaboration technologies. Couple typical examples are the definitions by Powel, Piccoli and Ives (2004) and Lipnack and Stamps (2000). Powel et al. (2004, 2) define virtual team as: *“groups of geographically, organizationally and/or time dispersed workers brought together by information and telecommunication technologies to accomplish one or more organizational tasks”* and Lipnack et al. (2000, 18) as: *“a group of people who work interdependently with a shared purpose across space, time, and organization boundaries using technology”*.

The study conducted by Schweitzer et al. (2010) reviewed a broad range of literature to build up an exact definition of a virtual team. They found the six fore mentioned characteristics to be used most often as the criteria for virtual teams but argued against four of them. According to them, organizational and cultural dispersion, temporality, and the usage of technology are not valid virtual team criteria, as colocated teams are just as likely to meet them as is a virtual team. Their conclusion was that all virtual teams are first and foremost teams, which means that *“they are made up of individuals working together interdependently with mutual accountability for a common goal”* (Schweitzer et al. 2010, 274). According to them, the virtualness comes from the existence and extent of three virtualness dimensions and the usage of communication and



collaboration technologies is simply a consequence of it. The dimensions they found valid are: The proportions of work time spend working apart, the proportion of the team's members who work virtually, and the degree of separation between the team members.

According to Schweitzer et al. (2010), researchers have highlighted that some teams are more virtual than others and therefore the question is not "*whether a team is virtual*", but rather, "*how virtual is the team?*". They refer to the work of George (1996) when implying that team virtualness is not a condition, but a degree. Therefore, the greater the extent of each virtualness characteristic, the more virtual is the team. A fully colocated team whose members always work during the same hours and in the same office would have zero degree of virtualness, and therefore, be a fully proximate team. On the other hand, a team whose members never meet face-to-face is a fully virtual team. (Schweitzer et al., 2010)

Based on the findings of the previous paragraphs, any team with even the slightest degree of virtualness could be considered a virtual team. However, for this study the following definition of a virtual team is presented: *Virtual team is a group of individuals who work together interdependently with mutual accountability for a common goal and are mostly physically separated and/or work during different hours.* This kind of more strict definition is required because the study is based on literature about teams on which the participants were separated only most of the time. This way, this study tries to avoid drawing the questionable conclusion that being separated fifty percent of the time is simply five times as challenging as being separated ten percent of the time. Basing on pure common sense, one could think that being separated only a little does not bring up any considerable virtualness challenges. While on the other hand, being separated

all the time (100%) could bring up considerably more challenges than when being separated only most of the time (e.g. 90%). Therefore this study does not expect the degree of virtualness to affect the criticality of the challenges linearly. Without further research, it would be unreasonable to state that the findings of this study are valid for a team with a minor degree of virtualness.

Two very common environments for highly virtual teams appear to be (non-commercial) open-source communities and multiplayer gaming. On both of these, members are completely separated most of the time with just occasional get-togethers. In the business world, this kind of individual separation is still rare, but there are often multiple teams that never work on the same place at the same time working on the same project. While these teams would be colocated themselves, they are virtual in respect to each other. Therefore the findings of this study should be applicable to the relationships between those teams as well.

### 3 KEY CHALLENGES

This section describes the key challenges found in the literature study, but does so in no particular order. It also describes some possible solutions and to some extent the difficultness and relationships of the challenges in relation to each other. Additionally, categorization of six key challenge groups is presented. The goal is to form an as intuitive categorization as possible to make it easy to form an overall picture of the topic.

The literature used in the study is mostly from software development field, and as explained in the previous section, virtualness between two separated teams is considered equal to virtualness between separated team members. In addition, only challenges that are caused by the virtualness of a team were included rather than including challenges which are also true for fully colocated teams. For example requirement for skilled team members is not included for this reason.

#### 3.1 Technological Challenges

Undoubtedly teams with a degree of virtualness rely more or less on communication and collaboration technologies. Without the technology, the virtual way of working is not possible. More importantly, it can be argued that the technologies facilitate *communication*, *knowledge sharing*, and *work coordination*, all of which are considered key challenges for virtual teams in this study. These, in turn, as explained in the future sections, highly affect yet another key challenge: *trust building*. For these reasons it can be argued that the inability to set up the technological infrastructure required by the team virtualness will have a dramatic effect on the team's success. Technology is an

enabling factor for team virtualness, but also a way to overcome other challenges caused by virtual work. Therefore, getting it right is considered a key challenge for virtual teams in this study.

The most straightforward technical issues in virtual teams are usually about incompatible data formats, schemas or standards, and problems in ensuring electronic transmission confidentiality and privacy. Sutherland, Viktorov, Blount and Puntikov (2007) list all of these as the top issues found in their study. Cohen and Thias (2009), on the other hand, write about a project in which the offshore team had limited hardware access and therefore was not able to integrate and test with the capacity they were expected to. This led the offshore teams to check-in untested code expecting that the onshore team would validate and fix any errors. This is an example of a technological issue which causes problems of a higher complexity, in this case, on following the planned development process.

Prikladnicki, Audy and Evaristo (2003) write that theory suggests that some problems, many of which will also be discussed in the following chapters, can be solved with using specific communication and collaboration tools. And surely enough, the examples presented here and in the following sections should give us implications of technology's two dimensional role in virtual teams: on one hand, it has the role of enabling the virtual way of working in the first place, and on the other hand, technological innovations can be used as an alternative way to solve, or at least ease, other challenges which virtual teams might face.

It is important to acknowledge that capable technologies alone will not be sufficient. Duarte and Snyder (2006) and Kayworth and Leidner (2000) bring up

the importance of virtual team's members' technological knowledge in using the collaboration and communication technologies. When referring to the work of Townsend, DeMarie and Hendrickson (1998), Kayworth et al. (2000) consider it as a critical difference in team member's skill requirements when comparing virtual and colocated teams. Duarte et al. (2006) studied a project in which implementing a groupware did not fully succeed as the project invested only on technology, but not on training. As a conclusion Duarte et al. (2006) write that all team members should have immediate access to not only the technology, but also training and technical support for its utilization. It clearly is not enough that the used technologies are capable and reliable, but the team members will also need to be able to efficiently utilize them. If the required technical knowledge is not there from the beginning, special attention needs to be put on training the team members to use the technologies.

The decision of which communication and collaboration technologies are used is seen by Kayworth et al. (2000) and Duarte et al. (2006) as a responsibility of the virtual team's leader. They also remind that there is no silver bullet solution for the technology, but the decision must depend on the characteristics of the team. The selected electronic collaboration and communication technology needs to meet the requirements of the team, and the organization needs to be ready to support the usage (Duarte et al., 2006). Also the relative infrastructural strengths and weaknesses of the various geographic regions of the team's members should be taken into consideration to achieve high quality transmission capabilities while keeping the costs down (Kayworth et al. 2000).

Fortunately, today, in year 2010, the technology is able enough for virtual teamwork. Lurey and Raisinghani (2001, 533) wrote almost ten years ago already that:

*[virtual] teams could be more effective if more advanced technologies were available, however, the technologies are only a partial factor. Being equipped with even the most advanced technologies is not enough to make a virtual team effective, since the internal group dynamics and external support mechanisms must also be present for a team to succeed in the virtual world.*

Therefore we can conclude that while implementations and utilizations of communication and collaboration technologies are highly critical for a virtual team, the most difficult challenges lie elsewhere.

### **3.2 Communication Challenges**

In this study, *communication* is defined as *transmission of messages* (e.g. Fiske, 1990). The messages can include for example thoughts, opinions, or information and can be transferred verbally, via body language, or through text, pictures etc. Additionally, this study acknowledges two major types of communication: *informal* and *formal*.

According to Kraut, Fish, Root and Chalfonte (1990) informal communication is communication that is spontaneous, interactive, and rich. Formal communication on the other hand, is preplanned in schedule, participants, and agenda. Additionally, in this study, all asynchronous communication is considered to be formal communication. In opposite to the interactive communication on informal occasions, communication on formal occasions is often more or less one-way. Because of this more interactive nature of the informal communication, it can be more effective than formal, as the participants can immediately elaborate or modify their sayings to handle objections or misunderstandings. (Kraut et al. 1990)

Studies show that in a normal single-site project informal communication can take up around one third of a developer's day (Prikladnicki et al. 2004). According to Chisan and Damian (2004) and Sengupta, Sinha, Chandra, Sampath and Prasad (2004) an important aspect of informal communication is, that it is used to share knowledge on issues, like requirements changes, in which formal documentation is not updated quickly enough. Informal communication is also an important way of coordinating daily activities within the project team as well as building trust, a sense of unity, inclusion, or team cohesion (Prikladnicki et al. 2004; Kraut et al. 1990; Kayworth et al. 2000; Järvenpää et al. 1999). In the light of this information it is clear that communication, especially the informal one, is extremely critical to any project. It has also been found out that because of language barriers, time differences and the reliance on technology as the main tool of communication, virtual teams face considerable challenges in the field of the informal type (e.g. Kayworth et al. 2000). For these reasons, this study considers communication to be a key challenge for virtual teams.

As much as virtualness hinders informal communication, as much it fosters the formal counterpart. While single site projects may utilize informal communication to fill in the gaps in their formal type, many researchers agree that virtual projects should rely on formal communication and automate the information flow as much as possible (e.g. Chisan et al. 2004). This way the need for the problematic informal communication stays minimal. Multiple examples of these kinds of formal communication mechanisms are described in the following paragraphs.

Prikladnicki et al. (2003) refers to the work of Desouza and Evaristo (2003) when writing that projects (and teams) generate many type of beneficial

information. For the information to be of any use it has to be collected and then shared. In their study of awareness support models, Chisan et al. (2004) suggest a virtual workspace environment to serve this purpose. They write that when changes would be made, for example, to requirements, developers should be selectively notified about the change. The power of this kind of a system would not be limited to just information sharing though. The data about information movement and team member actions in the environment could possibly be used to automatically form speculations about the team's state and trend of development.

Another example of a formal mechanism for information spread is discussed by Sengupta et al. (2004). They write about a test-driven methodology as a mean to communicate for example requirements through test-suites. According to him the precision and the availability through a central repository of the test-suites should decrease the need for extensive cross-site communication. Bass and Paulish (2004), in turn, describe how the Uniform Resource Locator (URL) was made available to all team members in a project they studied. They write that in addition to greater information spread, this allowed everyone to be aware of the rapid progress being made and lead into a big morale boost, as well as a much greater sense of being a team. This is another example of a formal mechanism that facilitates information spreading. Bass et al. (2004) also write about other ways to overcome communication challenges in virtual teams. They propose that incremental release schedule with fairly short cycles would help to facilitate communication and highlight ambiguities and misunderstandings.

Communication in virtual teams is, just like technology, a two-edged sword. On one hand, informal communication, which is a powerful tool to build trust and fill the social needs of individuals (as discussed in section 3.4), is almost



nonexistent because of the virtualness. On the other hand, the fact that in an extreme case every single action in the team happens digitally, opens great opportunities for automated knowledge sharing. By the time of writing this thesis, there is already a great deal of research and even concrete work done on the subject. It is reasonable to expect that this is one aspect on which considerable development is going to happen in the near future, and on which virtual teams are going to surpass their non-virtual counterparts.

### **3.3 Work Coordination Challenges**

Kraut et al. (1990) refers to the work of Blau and Scott (1962) when writing that: *“Coordination is the activity of directing individuals’ efforts towards achieving common and explicitly recognized goals”*. They also write that even if the goals were identical, the *“input-output dependencies among individuals require that their efforts be sequenced and interrelated efficiently”*. Knowing this, we should be able to agree that explicit work coordination is critical for the success of any organization, including virtual teams.

In addition to the fact that work coordination is critical, studies show that virtual teams are having great problems with such functions. These issues might include some of the following: (1) Team members do not know who is in charge, who is doing what or who to collaborate with (Räsänen 2007; Lurey et al. 2001; Duarte et al. 2006), (2) team members are not aware or have not fully understood the objectives of the team or their task (Duarte et al. 2006; Bass et al. 2004; Lurey et al. 2001), (3) management is having difficulties in leveraging the available resources and forming a work break down across the whole team (Sutherland et al. 2007; Bass et al. 2004), and (4) management or team members

are having difficulties in synchronizing work between non-colocated team members (Sutherland et al. 2007; Prikladnicki et al. 2003).

Studies by Räsänen (2007) and Lurey et al. (2001) suggest that to solve the first issue in the preceding list, virtual teams should have clear explicit team structure. According to them, this would help team members to be aware of their 'surroundings' and of whom to contact in a particular matter. To solve the second issue of team members not being aware of the objectives, Bass et al. (2004) and Lurey et al. (2001) highlight the importance of having explicitly documented project goals in a virtual project (or for a virtual team). This, because it is possible that because of cultural and personal biases, one's decisions will not be in line with the project's (or the team's) goals when clear direction is absent (Bass et al. 2004). Additionally, Duarte et al. (2006) point out that in virtual teams special attention should be put into transferring the objectives of a task to the responsible team member.

To solve the issue of forming a good work break down in a virtual project, Bass et al. (2004) suggest that the architecture of the software being developed needs to be well partitioned and reflect the structure of the virtual team. In an ideal situation there would be well defined components or subsystems with well understood and documented dependencies for each site. Bass et al. (2004) also note that the components or subsystems need to take into account the technical skills of the responsible team members. Having this kind of architecture, which is partitioned by the team structure, should also help in lessening the need for non-colocated team members to work synchronously.

In addition, Prikladnicki et al. (2003), Lurey et al. (2001) and Duarte et al. (2006) point out the virtual team's greater need for a formal development process. In

some studies, the existence of a formal development process is in fact found out to be one of the most important success factors for virtual teams (Prikladnicki et al. 2003). Lurey et al. (2001) argued that this is because of the physical barriers involved with virtual work. The areas on which the lack of a well-defined development process has been found to cause problems include for example requirements engineering, configurations management and testing (Prikladnicki et al. 2003). Additionally, a suitable and well-defined process can be the solution for many other difficulties in virtual development. (Prikladnicki et al. 2003)

Such a conclusion can be drawn from the studies presented above, that in an efficient virtual project, the team is destined to be more structured and the software architecture more partitioned than in a completely colocated project. Additionally, as distributed development often relies on fixed upfront commitments on quality requirements, formal processes, and strict team structure, it seems hardly suitable for agile development (Ramesh, Cao, Mohan & Xu 2006). However, as agile methods have brought great advantages to software development, we can expect companies to have a keen interest in trying to combine the two. This mix, the Distributed Agile Development (DAD), will be a great additional challenge for work coordination in virtual teams.

### **3.4 Trust Challenges**

This study follows the trust definition by e.g. Mitchell and Zigurs (2009) when defining *trust* as *the team members' overall willingness to rely on one another*. Building trust is then taking implicit or explicit actions to plant this willingness into the team members.

Kirkman et al. (2002) point out the difficulty of trust building when writing that conventionally building trust is considered as the greatest challenge in creating successful virtual teams and organizations. In addition, Kanawattanachai and Yoo (2002) point out by referring to various sources that trust is also widely considered to be the key attribute for virtual team's success. They point out that trust leads to open communication, cooperation, a higher quality decision-making, and team members' satisfaction to the decision making process. Surely something that is both extremely difficult to handle and extremely critical for success deserves a lot of attention as a key challenge of virtual teams.

Mikawa, Cunnington and Gaskins (2009) refer to the work of Oshri, Kotlarsky and Willcocks (2007) when writing about the three stages of social ties lifecycle: introduction, build up, and renewal. They believe that due to the lack of face-to-face interactions and formality of the communication in geographically dispersed teams the build up and renewal phases are likely to be stunted or completely missing. According to the researchers, this might lead into dysfunctions such as low individual commitment, role overload, role ambiguity, absenteeism, and a phenomenon known as social loafing in which motivation declines due to team member's feeling that their contributions will not be recognized. These factors, in turn, are likely to vandalize any trust that is still left in the team.

Studies show that it is however possible to build trust in a fully computer mediated virtual team, but the type of the trust will be different from the trust developed in a face-to-face environment (Kirkman et al. 2002; Kanawattanachai et al. 2002). Kirkman et al. (2002) write that the trust developed in face-to-face interactions is called benevolent or interpersonal trust, while the trust in virtual teams is called ability- or task-based trust. Kanawattanachai et al. (2002) on the

other hand call the trust that dominates in virtual teams cognition-based and the opposing type affect-based trust. Although the terms are different, both research groups similarly point out that the trust in virtual teams is based on peer's competence, professionalism, and reliable behaviour. The 'normal' type of trust on the other hand is based on social factors like caring and emotional connection to each other.

As a solution to the trust building problem, Kanawattanachai et al. (2002) suggest that virtual managers provide task-relevant background information on team members. This should help the team to develop cognitive-based trust, which, in turn, enhances the generation of the affect-based type. They also refer to the work of Meyerson, Weick and Kramer (1996) when pointing out that, in virtual teams', resources should be put into developing trust swiftly on the project outset.

Mikawa et al. (2009) identified so called super connectors who were adept at building personal relationships by retaining knowledge about people's families, work history, and hobbies. They suggest that leveraging the abilities of these super connectors might be the solution for trust building in virtual teams. They write that to make this happen and to unlock the full potential of communication and collaboration technologies for trust building, the super connectors should be educated to efficiently utilize the tools. The super connectors' greater ability to have personal discussions could help them to change the normally so formal tune of computer mediated communication, and therefore, greatly help in forming interpersonal relationships within the team. In addition, Mikawa et al. (2009) suggest that the social networks of virtual teams should be proactively analyzed to identify the super connectors and to find out the best ways to shape the team for higher performance.

Some studies point out that shared experiences are a key catalyst in building social ties (and trust) (Mikawa et al. 2009). Shared experiences are developed over time when working on same features or on tasks that require collaboration with other team members. However, we can expect working virtually to greatly lessen the strength of such experiences. One emerging practice to virtually build up shared experiences (among many other team attributes) is to utilize online team building games or shared graphical virtual office environments (Tutton 2009; Ellis, Luther, Bessiere & Kellogg 2008). Axelsson and Schroeder (1999) found out that the social behaviour of humans in shared virtual environments is surprisingly similar to their behaviour in face-to-face interactions. They also found out that elements of trust are clearly present and that the relationships develop over time similarly to the development in real world. Therefore it does seem that avatar based shared virtual environments could have their uses in developing trust for virtual teams.

Cultural distance adds even more challenge to trust building, for example, in the form of communication difficulties. Misunderstandings or hindered ability to communicate due to differences in both verbal and non-verbal language could end up being a significant obstacle in building trust. Therefore members of a virtual team need to be well aware of the key differences in different forms of communication between their own culture and the cultures of the other team members'. In addition to communication challenges, cultural differences might also lead into enforced negative prejudices towards people with certain cultural background.

Maintaining trust is another difficult trust related challenge for virtual teams (Kanawattanachai et al. 2002). A single fault action or a misunderstanding and the mutual trust can be considerably reduced if not completely destroyed

(Kanawattanachai et al. 2002). Because of the communication difficulties in virtual teams, misunderstandings are more common than in colocated ones and therefore losing mutual trust more imminent. Crisp and Järvenpää (2000) also found out that without explicit trust maintenance activities, trust in virtual teams reduces over time. Therefore, it is not enough to only invest into trust building on the beginning of the project, but there must also be a keen interest to maintain the level of trust achieved.

Detecting the lack of trust among team members might not be straight forward even in colocated teams, let alone in a virtual one. After a while though, more visible problems start appearing because of the mistrust, making detecting it easier. As an example of a form of mistrust, Mikawa et al. (2009) mention team members holding back information from each other. This would not be an easy one to notice though, but it is easy to imagine straight disputes to start appearing. For example, objections to work on tasks highly based on someone else's work. Detecting lack of trust in a virtual team must come down to acquiring and listening the feedback from the team members. It is hard to imagine that solely 'looking' at the team's behaviour would bring up such an issue soon enough.

In the end, although there are obvious obstacles for building trust in fully computer mediated environment, the issue might not be as great as conventionally thought. Kirkman et al. (2002) are very clear in saying that trust can be build without face-to-face interaction. It also seems reasonable to expect that once the right practices are found the issues of building and maintaining trust will be very similar to the same issue in colocated teams. The area on which virtualness causes most headache could end up being detecting the lack of trust. While trust or the lack of it is apparent in all of our interactions, a

virtual manager cannot spot this as he is missing the change to watch the team members' informal day-to-day communication.

### **3.5 Challenges in Monitoring and Giving Feedback**

As no suitable definition for monitoring was found from the literature, a special definition is constructed for this study. *Monitoring* is therefore defined as the *act of observing something/someone and keeping explicit or implicit record of the findings for future use and to be able to acknowledge the trend of development for the monitored subject*. By this definition even looking at someone today and acknowledging his hair length, and then looking at the same person weeks from now and noticing that his hair has grown, is (implicit) monitoring. *Giving feedback* on the other hand would be to let the monitored participant know about your observations.

Räsänen (2007) states that keeping the team understanding the reasons for successes and failures is one of the jobs of a manager or a group leader. He refers to the work of Harris and Sherblom (1999) when pointing out that this is required as understanding the reasons for successes and failures is the key to improve the performance and to predict the future of the team. Keeping the team aware of its state includes both monitoring the actions and behaviours of the team to find out the reasons, and then passing the observations and development ideas to the team by giving feedback. Monitoring is a unique challenge to virtual teams as the traditional methods of walking around and so on are simply impossible. Similarly extreme virtualness introduces great challenges for giving feedback as the communication is restricted to electronic methods only. As proven above, monitoring and giving feedback are both



important and especially challenging for virtual teams, and are therefore included in this study as key challenges.

It is believed in this study that time zone difference between virtual team's members causes delay to the monitoring, and that this delay can cause problems in some cases. Even the data would be collected on time, the person to actually look into it might be sleeping and therefore is only able to access the data on the next morning. On most cases, a delay of few hours should not cause a problem, but the delay to actually give the feedback might be closer to a full day as the manager might only be able reach the person during his next workday. Let's say we'd have a system which the manager can use to spot a spur of angry emails (or other communication) between two team members. In a colocated environment this would correspond to an angry yelling episode in the hallway or tension in the break room, both on which the manager could be able to act instantly. In the case of extreme virtual team, the manager would only be able to act with a considerable delay, when it might already be irrelevant and the damage already inflicted.

Additionally, it is believed in this study that cultural distance introduces challenges into feedback giving. People with different cultural backgrounds might perceive feedback differently. What is positive and encouraging to one, might be completely intolerable to another. Therefore virtual managers should always be aware that the way the feedback is given has a major effect on how the participant perceives one's observations. In addition, a lot of the communication issues discussed previously in the section 3.2 apply to giving feedback too.

Virtual environment does however offer managers with unique opportunities to get real time data about the team's state and progress. The data does not get collected without an effort though. Kirkman et al. (2002) conducted a study in which a performance review system provided an excellent foundation for recognizing and rewarding team and individual performance as well as developing new training programs for both of them. The system monitored the electronic communications and systematically collected data from peers. Kirkman et al. (2002) state that with the help of this system, feedback could be given to individuals by referring to the gathered statistics, and that the team members could be judged more on what they have actually been doing, rather than on what they have been appearing to be doing. Basing feedback on actual collected data should help in giving feedback to different kind of personalities with different cultural backgrounds. Additionally, the manager's ability to do this and not just base the feedback on what he or others have been subjectively observing should make receiving even negative feedback a lot easier for many team members.

McCarthy (2008) writes about giving feedback in virtual teams, and his first advice is that one should not leave giving feedback to a chance. As the 'water cooler' moments, in which team members just run into each other, are missing from the virtual environment, giving feedback requires a more formal approach than just waiting for the right moment. McCarthy (2008) suggests that managers should set up regularly scheduled calls for one-on-one feedback discussions and ensure that every time he or she meets a team member face-to-face, a moment is reserved for feedback. He even suggests considering hiring an onsite person to hold face-to-face development discussions. McCarthy (2008) seems to believe that giving feedback is the kind of communication on which

high bandwidth medium is especially important – an opinion which is hard to argue with. Pure asynchronous text messages possess a great danger for a feedback method. If misunderstandings happen, even a positive feedback might turn into a negative one and leave the recipient demotivated. Therefore giving feedback in virtual teams should rely on channels like video calls even more than traditional day-to-day communication.

Monitoring and giving feedback is a critical part of improving performance on any team. Not surprisingly virtualness introduces additional challenges to the topic, mostly in the context of communication, but it also introduces new opportunities for efficient automated real time monitoring. In the end, monitoring and giving feedback in a virtual team should be able to be just as effective as in a colocated one, but it will require quite a bit more effort in setting up the IT-infrastructure and the development discussions.

### **3.6 Human Factors Caused Challenges**

In this section we discuss about virtualness enhanced issues which relate to human factors. *Human factors* are defined in this study as *physical or cognitive properties of an individual*. The question in this section is not only whether the team member is happy to work in the team, but also whether he or she is happy with his life in general. This is of interest because issues in personal life of an individual tend to reflect to the performance on the job as well.

Both Kirkman et al. (2002) and a study conducted by Cisco Systems (2007) bring up that virtual workers face special physiological challenges in comparison to the traditional office workers. Both studies agree that humans have certain social needs, and that in virtual workplace, fulfilling those needs is challenging.

Virtual workplace is missing many normal day-to-day social events that take place in an office environment. These events include for example coffee breaks, lunches, hallway meetings, or an after work get together. For these reasons not everyone will enjoy working on a virtual team. The studies point out that when selecting virtual team members, in addition to assessing task based skills, also interpersonal skills should be taken into consideration. Cisco Systems (2007) suggest that successful virtual (mobile) workers should be resilient extroverts and lists communication, relationship-building, planning, and organization skills together with high adaptability as the key competences. The study states that virtual workers need strong interpersonal skills, not only because communicating in their work environment is challenging, but to fulfil their individual social needs without the common social interaction in the workplace. The study also points out that even the suitable virtual workers need help in maintaining their work-life balance and keeping their self-confidence. Additionally, according to the study they also need attention, recognition, empathy, and a constant sense of inclusion.

Kirkman et al. (2002), Ramesh et al. (2006) and Cisco Systems (2007) all discuss the virtual worker's risk of isolation and alienation from the team. Kirkman et al. (2002) write that in their study managers didn't know at first how to deal with virtual team member isolation. At first the managers even interpreted minimal communication as a sign that everything was well. Over time however, it was recognized that some team members required almost daily communication and that the feelings of detachment and alienation can be overcome with careful attention to social needs. The general conclusion from all the three studies is that a successful virtual team manager will be able to build cohesiveness among team members, offer everyone a great sense of inclusion as

well as take into consideration everyone's unique social needs and reach out to far-flung team members.

In addition to mental health, motivation is another considerable factor in work efficiency. Beecham, Baddoo, Hall, Robinson and Sharp (2008) conducted a systematic literature review on motivation in software development. They found out that the most frequently mentioned motivators for software developers were: *personal identification with the task* (clear goals, interesting and known purpose), *good management* (support, team-building and good communication), *working with others*, *career path opportunities*, *rewards and incentives* (increased pay and benefits linked to performance), *variety of work* and *sense of belonging or supportive relationships*. They also listed the most frequently mentioned demotivators: *poor working environment* (unsuitable or lack of resources, being physically separated from team), *poor management* (e.g. waste of time meetings) and *uncompetitive pay or unpaid overtime*.

What comes to the effect of virtualness to the motivators found by Beecham et al. (2008): As the team virtualness increases, there's an increasing change that team members do not get motivated from working with others or from sense of belonging. Also the attributes of good management (support, team-building and good communication) are exposed to the key challenges presented in this study. From the study we also find out that being physically separated from the team is considered a demotivator. This could be linked to feeling of being isolated from others and inequality, which would not be the case in a virtual team on which all team members work equally virtually. The other motivators and demotivators do not seem to gain or lose from team virtualness. Virtualness in itself might be a motivator for some people though. Being able to

work at home with flexible working hours is something that strictly colocated teams can't provide.

Levin and Rad (2006) have also studied team members' motivation. They refer to the work of McClelland (1961) when writing about a motivational approach that classifies team members' behaviour into three categories: the need for achievement, affiliation, and power. Basically, people with high need for sense of achievement get motivated by completing and working on challenging tasks and are therefore the most suited for virtual work. Affiliation junkies, on the other hand, like to interact and work with others, while the power hungry people are the ones that feel themselves motivated when they get to be in control and have a say on key decisions. The McClelland's (1961) approach shows that when caring about team members' motivation, manager has to be able to distinct different personalities from each other and to take the individual's motivational clues into account.

While virtualness causes considerable challenges to work comfort, it also introduces noticeable opportunities. Virtual work can ease the life of physically crippled and of those who need to stay at home for their families. A key finding in this section should be that opposed to what might be the common belief, virtual work is not for the socially quiet people.

## 4 SUMMARY AND CONCLUSION

Because of the many alleged benefits of virtual teams, many software development companies are nowadays tempted to organize their projects virtually. Building efficient virtual teams has however proven out to be a difficult task and companies have found out that the alleged benefits may not always come true. The purpose of this study was to research the virtual software development literature and find key challenges that virtual software development teams face as well as to investigate possible solutions to these challenges. Additionally, grouping of six key challenge categories was formed.

The findings of this study are summarized in the following table (TABLE 1) and further explained in the rest of this section.

**TABLE 1. Challenges and solutions**

	<b>Challenges</b>	<b>Solutions</b>
<b>Technological Challenges</b>	Technical incompatibilities Unequal access to testing and development environments Problems in ensuring electronic transmission confidentiality and privacy Lack of technical skills	Careful selection of technologies on a team basis Training and technical support
<b>Communication Challenges</b>	Informal communication Knowledge sharing outside the scope of the formal mechanisms	Utilizing automated knowledge sharing

**(Continues)**

TABLE 1. (Continues)

	<b>Challenges</b>	<b>Solutions</b>
<b>Work Coordination Challenges</b>	<p>Team member awareness</p> <p>Work distribution</p> <p>Work synchronization</p>	<p>Explicit team structure</p> <p>Architecture of the developed software partitioned by the team structure</p> <p>Formal development process</p> <p>Explicitly documented goals</p>
<b>Trust Challenges</b>	<p>Building trust</p> <p>Maintaining trust</p> <p>Detecting the lack of trust</p>	<p>Sharing task relevant background information of the team members</p> <p>Leveraging the abilities of super connectors</p> <p>Utilizing online team building games and/or shared graphical virtual office environments</p>
<b>Challenges in Monitoring and Giving Feedback</b>	<p>Monitoring team members behaviour</p> <p>Giving feedback to the team members</p>	<p>Utilizing communication and collaboration technologies for automated data gathering</p> <p>Scheduling one-on-one feedback calls</p> <p>Hiring a special onsite person to conduct feedback discussions</p>
<b>Human Factors Caused Challenges</b>	<p>Maintaining team members mental health</p> <p>Keeping team members motivated</p>	<p>Building the team around achievement oriented resilient extroverts with good communication, relationship-building and planning skills as well as high adaptability</p> <p>Offering team members attention, recognition, empathy, and a constant sense of inclusions.</p> <p>Helping team members in maintaining their work-life balance and self-confidence</p>



*Technological Challenges* include technical incompatibilities between separated team members, unequal access to testing and development environments, problems in ensuring electronic transmission confidentiality and privacy, and lack of technical skills required to efficiently utilize the communication and collaboration technologies. If the team members don't know how to utilize the used technologies efficiently, effort needs to be put into training. Additionally, the technologies need to be selected on a team basis, so that they meet the unique requirements of the team. Moreover, the organization the team works in needs to be ready to support the technologies for continued usage. In the end, when correctly utilized, the current technologies seem to be capable of supporting successful virtual team work.

*Communication Challenges* in virtual teams are either about the lack of informal communication or knowledge sharing. Enforcing informal communication in virtual teams seems so challenging that teams should rather aim to reduce the need for it than try to facilitate it too much. An efficient way to reduce the need for informal communication is to include as much automated knowledge sharing as possible. While informal communication is the Achilles heel for virtual teams, the usage of technologies for most, if not all, of the team's actions greatly supports the usage of such systems.

*Work Coordination Challenges* include problems in the field of team member awareness and work distribution or synchronization. To encounter these problems, it is suggested that the team should have an explicit structure and the architecture of the developed software should be partitioned to reflect it. Additionally, virtual teams require a more formal development process than colocated teams and need even more explicitly documented project goals. It was also found out, that integration of agile development to the virtual work

will most probably be a considerable additional challenge for work coordination in virtual teams.

*Trust Challenges* include building trust, maintaining trust, and detecting lack of trust. While it does seem possible to successfully build trust in a fully computer mediated environment, the type of trust will be different from the trust in colocated teams. Because the trust in virtual teams is based on peer's competence, professionalism and reliable behaviour, it is suggested that task-relevant background information regarding the team members would be provided to the team. Additionally, leveraging the abilities of super connectors, team members who are especially skilled in forming strong social relationships, is seen as a powerful way to solve trust challenges in virtual teams. Additionally, an emerging practice to build trust via shared experiences is to utilize online team building games or shared graphical virtual office environments.

*Challenges in Monitoring and Giving Feedback* are more of challenges in increasing virtual team's performance than actually making it successful. Virtualness brings challenge to monitoring as watching team members' behaviour is not possible, but information must be gathered via other means. A solution would be to utilize the used communication and collaboration technologies for automated data gathering. In addition, virtualness also introduces challenges to giving feedback, as face-to-face development discussions might not be possible. Therefore, it is suggested that scheduled one-on-one feedback calls or even a hired onsite person would be used for feedback discussions. At the bare minimum, giving feedback should be conducted via a video call or other medium with similar communication bandwidth.

*Human Factors Caused Challenges* are about maintaining team members' mental health and motivation while they work virtually. Special attention is needed, because virtual workers face unique challenges on these areas, as virtual workplace lacks a lot of the usual social interaction of a normal workplace. It was found out that successful virtual worker is to be resilient extrovert with good communication, relationship-building, planning, and organization skills as well as high adaptability. However, even the suitable virtual workers still need attention, recognition, empathy, and a constant sense of inclusions as well as help in maintaining their work-life balance and self-confidence. Additionally, to get motivated from virtual work, one should be a person with a high need for sense of achievement and a lesser need for feelings of being part of a team. In addition to the sense of achievement, some people may also find the ability to work from home to be a motivational factor itself.

This study grouped the key challenges into six categories and presented some possible solutions to them. The practical implications of these results are to help virtual team managers and personnel to acknowledge the state of their team in relation to the key challenges, as well as to understand how to improve the team's chance for success and/or how to improve its performance. Additionally, the intuitive categorization presented, should make it easier to understand and communicate the team's issues.

The study, is however limited in the sense that obviously all of the relevant available literature could not be researched. The suggested solutions to the challenges are especially subjective as no thought was put on which of them are valid, but rather all of the suggestions found from the studied literature, and even some additional ones, were included. Therefore follow-up research should be conducted to validate the solutions in real world virtual teams. Additionally,

further research could be conducted to build up a model of challenges' criticality for virtual team's success and/or performance and of difficulty to solve a challenge in a virtual team's context. This kind of information would help virtual team managers to prioritize solving the challenges that affect his team the most and are the easiest ones to solve. This way, the team's performance and chance for success could be increased with the minimum amount of work.

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