Distributed Agile Software Development Challenges and Mitigation Techniques: A Case Study

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Abstract—There is a growing interest in applying Agile development methods alongside global software development in order to reap the benefits of both approaches. With this said however, research has shown that software companies are encountering significant challenges when attempting this due to the contradiction between Agile values and the global development environment. This paper focuses on the challenges encountered with this kind of development and discusses several techniques via which these challenges can be addressed. It presents a case study and applies interviews with a software development company adopting the distributed Agile approach. From this study it can be seen that the communication barriers are the biggest development challenge. The development teams and product owners need to work hard to increase the level of communication between them by having a daily, regimented communication schedule. Flexibility with the working hours and location is an important practice with regards to limiting the barriers of the distributed development.

Keywords-distributed Agile; global Agile; global software engineering; Agile software development.

I. INTRODUCTION

Increased globalization has led to greater competition between software development companies around the world. The software development industry is seeing a shift from co-located software development to Global Software Development (GSD), which involves multiple distributed development teams from different locations. GSD facilitates competitive software development prices by using teams from countries that have an abundance of IT developers available at relatively low cost. In addition, research has shown that software companies are interested in applying Agile Software Development (ASD) to develop the software by global teams to have the combined advantages of ASD and GSD [1][2]. The combination of Agile development methods and GSD is known as Distributed Agile Software Development (DASD). Venkatesh defined Distributed Agile Development as: "*Distributed Agile, as the name implies, is a model in which projects execute an Agile Methodology with teams that are distributed across multiple geographies*" [3]. This combination has shown signs of providing IT companies with the ability to meet the critical success factors of the software industry, such as quality, time, and cost. Sutherland et al. [4] detail their experience of applying a distributed Scrum approach and report several advantages such as the high increase of team productivity, an increase in the transparency between team members, better building of trust, and increased project visibility. However, although the potential advantages of GSD are clear, research has shown that software companies are encountering significant challenges by applying this approach. Developers are not always able to apply Agile practices successfully due to challenges introduced through the global development environment including distance and time zone differences [5].

This paper presents the results of a qualitative study involving a company which employs the DASD approach. The study focuses on the challenges of adopting the DASD and discusses some possible techniques to address and minimise those challenges.

This paper is structured as follows: first, the related work will be reported. Following this, the research method will be discussed and explained. Section III will describe the investigated company, before the strategy of development for the investigated company is reported. Results and discussion will be presented in Section VI, whilst the final section contains the summary and conclusion.

II. RELATED WORK

A systematic review studied applying Scrum practices in global software development using 27 literature studies and analyzed the challenges into three categories: communication, coordination, and control [6].

The challenges of using Agile with distributed national teams can be categorized into three types of lack: communication, trust, and control [2].

The effective communication within distributed Agile software development is a huge challenge. The reasons that create the communication challenges could be summarized into four categories: a lack of communication tools, time zone differences, a lack of English language, and a lack of teamwork. Those barriers may limit and decrease the communication in a distributed development [7].

There are current needs for more studies to understand how to adopt Agile methods with global software development. There is a lack of theoretical models of distributed Agile. More studies are needed to address the literature gap by investigating the geographical, cultural, and temporal challenges [8].

Previously, we conducted a systematic literature review focused on the challenges of applying DASD [9]. One of the significant findings of that review was that most of the DASD studies cover the technical perspective of the development and lack coverage of the human perspective. The review also reported that: "The human perspective needs to immediately search to explore the effect of the cultural differences on the relationship between the stakeholders and

the development process" [9]. The present case study aims to address this issue by exploring the challenges and techniques of applying DASD from the developers' point of view (i.e., human perspective).

III. RESEARCH METHOD

The research presented in this paper is from a single descriptive case study. Data was collected by structured interviews. The interviews were face-to-face and were recorded with a voice recorder. Also, notes of the main ideas and answers were taken during the interviews. The data was transcribed from verbal form to textual form. The transferred documents were then compared to the notes from the interviews, to ensure the reliability of the data. Following this, a thematic analysis was applied, which is an approach to identify the themes and patterns from the collected qualitative data [10], [11]. In addition, the data-driven method was selected for the thematic analysis of this study. The data-driven method regarding Asnawi can be summarized into five steps, as follows: *"(i) reducing the raw information, (ii) identifying themes within subsamples, (iii) comparing themes across subsamples, (iv) creating a code, and (v) determining the reliability of the code"* [12]. Finally, to ensure the validity and the reliability of the study's qualitative analysis and to identify any elements of bias by the researcher, two procedures were applied. Firstly, after the final code was developed, it was tested by other researchers, who applied it to the raw data to ensure that the code and theme analyses were correct. The second procedure was having the transcripts rigorously checked by other researchers, comparing them to the verbal records and the notes that had been taken. The aim was to identify any transcription errors or mistakes [12].

IV. THE INVESTIGATED COMPANY

The interviews were carried out at a large, global IT development company. The company has 27 offices distributed throughout 11 countries around the world: Australia, Brazil, Canada, China, Germany, India, Singapore, South Africa, Uganda, the United Kingdom and the United States. The company provides software design and delivery services, as well as development consulting services. It also produces customized software products as tools to support distributed Agile software development, thus helping the development teams to communicate, share information and track progress. The company applies Agile methods in order to develop its global software projects and has been involved in the software industry for the past 20 years. The company required to be anonymous within this study.

Three interviewees with good experience of Agile methods and the distributed development approach agreed to participate in this study. Participant-1 has experience working with more than 15 teams from the entire world covering the east and the west side including countries such as India, USA, UK, and Australia. Participant-2 has 4 years of experience including a special course in Agile development during his Master degree, and significant experience when it comes to with working with stakeholders from different cultures including people from China, Europe,

UK, USA, and Middle East. Participant-3 acquired a vast amount of experience before joining this company as he developed a project while both the product owner and business analyst were away from the development team. He also has experience working with customers from different countries including New Zealand, Australia, and USA.

V. THE DEVELOPMENT STRATEGY

The investigated company applies a development strategy which goes through different stages before starting to develop the software. The first phase is the design phase. The project starts with meetings and the gathering of all participants in one place for a few days to finalize the requirements and estimate the deadline of the project. The inspection phase will come next where all the tasks should be broken into small stories. This involves the Project Manager (PM), the Quality Assurance (QA), the Business Analyst (BA) and software developers. The next stage is the analysis phase. The development stories need to be investigated during this stage to provide a better understanding of these tasks and create links between them. The BA plays a main role in this phase. The development then begins, by applying a weekly iteration to show the development case and update the other stakeholders. Each development team needs to have a daily meeting to track the development and identify any development issues.

VI. RESULTS AND DISCUSSION

The results of the thematic analysis classify the development challenges into four main themes: communications, cultural differences, management and control, and Agile skills

A. Communication and Collaboration Challenges

1) Lack of communication and losing the ability to make immediate decisions (A1): Agile methods require interactive, daily communication among stakeholders. This is difficult to provide within the global environment. The lack of communication and collaboration is a significant issue within the DASD approach [13]. Team members were not able to make immediate decisions, because of the distance between the participants and the lack of communication. As mentioned by Participant-3: *"We lose the ability to have an immediate decision. If we were here at 11am and we wanted to know something straightaway the earliest we could hear from our product owner will be 3pm and that's only if he's got up very early."*

2) Time zone differences (A2): The time zone differences is one of the main reasons that cause DASD's communication challenges [7]. The distance and time zone differences among stakeholders could reduce the available overlap of working hours of distributed teams. Participant-3 reported the issue of having no overlap of working hours by: *"I think if you had two teams where their working days didn't overlap at all, so if you had the UK and the East*

Coast of Australia where there's something like a 10 hour difference, I don't think that would work".

3) The lack of English language skills (A3): In most cases, the English language is not the mother tongue of the offshore team members. The lack of proficiency in English could pose a major challenge for the development teams. The different levels of English among the stakeholders could create misunderstandings [14], in the event of people trying to express or indicate meaning by a hint and expecting the others to understand them. Participant-3 reported that: "*If you're having a discussion and there's a thing that you don't say and you assume the other person knows and it's implied, that's where you get the chance for errors*".

Participant-2 who is not a native English Language speaker described his experience with communication with people with different level of English as hard. Participant-2 stated that: "*The other thing which might be hard is that different people have different levels of English knowledge.*". Also, Participant-2 mentioned some difficulties with understanding native speakers who are speaking with a difficult accent or speaking in a fast way: "*Sometimes it's hard to understand people who are speaking English as their mother language, as well*".

B. Communication and Collaboration Techniques

1) Find a time and a way for synchronised communication (B1): It is important to create an overlap of working hours among the distributed teams. The overlap hours will be used as available time for synchronised communication. Participant-3 reported there should be at least 2 hours of overlapping: "*If you have two teams in different time zones their working days have to have some overlap and if they don't have some overlap and if they don't have some overlap then you need to change the working hours of one of those teams so there is an overlap. I think there needs to be, I would say, at least two hours overlap between those two teams so they can talk face-to-face*".

With some cases that require staying late, the project manager and the business analyst could stay late to communicate with the other stakeholders. Participant-1 stated that: "*PM or BA or whoever needs to showcase something to the client, they need to stay for a while.*".

2) Flexibility regarding working from home (B2): Working hours should be flexible; therefore, the team members should be able to work from home when necessary. This flexibility could help to create overlapping hours among teams. Participant-1 reported that: "*Yeah so the company gives you the opportunity and flexibility to work from home. They also provided the broadband. *". Participant-2 stated as well: "*The people are free to do and people are getting flexible times to do work from home or work from somewhere else when they are away from the office*".

3) The communication schedule should be regimented (B3): The development stakeholders should have a daily, regimented communication schedule. Such a schedule would help to increase the communication level. Participant-3 reported that: "*I think you need to do what we're doing here at this company and have a very regimented communication schedule*". The product owner should make himself available to communicate with the development team as Participant-3 said: "*I'd say from our product owner's point of view he's got to make sure that he's very involved and he keeps himself aware with what we're up to*". Communication, as reported earlier, is the main issue with the DASD development, so it is necessary to increase the level of communication among the distributed teams. Participant-3 summarised that by: "*You've got to make sure that you communicate well with the stakeholders*".

4) Ask people to speak clearly and be explicit (B4): Regarding the different levels of English skills among the stakeholders, there is a need to speak clearly and to be explicit about what is wanted. Participant-3 mentioned that: "*It's much better to be explicit and to really make clear what you want*".

5) Apply multi-channels for communication (B5): There is a need to have multi-channels for communication. There should be a choice of method and use of the one best suited, such as phone calls, video Skype calls, voice over IP and texting. Participant-2 reported that: "*We are using voice over IPs and the video services. We use Skype, we use GoToMeeting, we have an internal voice over IP device here*", and reported as well: "*we use our own internal service for chatting*". In addition, software to share the screen and knowledge helps teams to share information and increase the visibility of the development. Participant-2 mentioned that: "*So, I can say, tools are really important in distributed systems*".
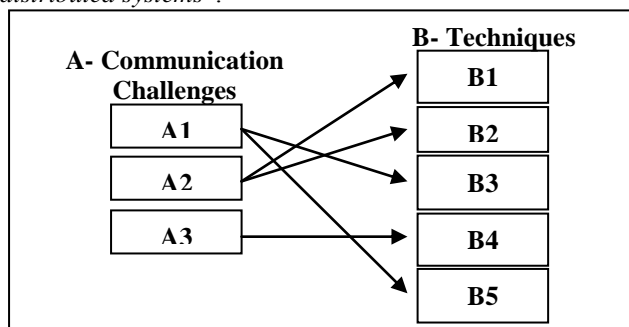

Figure 1.   Communication with DASD challenges and techniques

Figure 1 illustrates the recommended techniques to address communication and collaboration challenges. It links the challenges with the techniques in order to provide better understanding of them. For example, to address challenge A1, techniques B3 and B5 can be employed.

C. *Cultural Differences Challenge*

The cultural differences of the stakeholders could create certain misunderstandings [14]. Participant-2 reported that: "*There are a lot of different things in a culture. Like, in some countries, people really like to talk about politics*". Cultural differences could limit the communication between development participants in order to avoid any misunderstandings. Participant-2 stated that: "*I feel I know, if somebody from a different culture joins our team, how to behave and then how to find the limits on paid programming, how to speak to people, what sort of questions to ask, what sort of questions not to ask. So, these are the things which we learn*".

D. Techniques to Address the Cultural Differences

1) Creating an open culture within the development teams (D1): There is need to promote an open culture among the project's stakeholders, encouraging people to be free, flexible and liberal. Team members should accept other cultures and try to understand them. Participant-1 mentioned that: "*our culture rules are very liberal, free, there is no dress code. The people are free to do and people are getting flexible times to do work from home or work from somewhere else when are they away from the office. So this flexibility provides a lot of appreciation to the developers and all the people*". Participant-2 also stated that there is need to be flexible within the people from different cultures: "*people who are working in a distributed team, I guess should be more flexible than people who are working on a one - centralised process*".

2) Move the developers between the teams (D2): Providing the team members with the opportunity to move between global offices could help them to discover and explore other cultures. Participant-1 mentioned that by: "*there is a global assignment program which runs every year and it gives a chance to people to work round in any office in the world. So it's a very diverse culture in the company*".

3) A training course for new members (D3): New team members should have a special training course to provide them with the required Agile skills and make them aware of other cultures. The investigated company has a multi-cultural training centre in Bangalore, India. This could help new members to understand different cultures as reported by Participant-1: "*Once you hire anyone, if it's a fresh then he's a graduate. We send them to a university. There is a university which runs in India, in the Bangalore office*". And Participant-1 mentioned as well: "*All the students around the world gather with a different culture in India. They do works together on the same project for three months. After that we send them across different global assignments*".

4) Choose people who fit in with the distributed development culture (D4): Before hiring new people, they

should be interviewed to ensure that they fit in with the open culture of the DASD. Participant-1 stated that: "*Always choose the people who actually fit with the culture. We don't choose people who don't fit with the culture*".

In addition, new members should have a qualifying period of a few months, to make sure they fit in with the development culture and environment as reported by Participant-1: "*Even after that, there is a probation of three months, okay. So in the three months itself it is enough time to know the person's attitude and whether - how he is behaving in all the steps. So if he doesn't fit in the culture then we don't extend their assignment*".

5) Flexible working hours and places (D5): This practice was mentioned when addressing communication issues and could also help to increase trust between the company and its employees, one of the cultural issues within the DASD. Participant-1 stated that: "*They do - they know all right that the company the flexibilities providing to them it come with a trust. So the company's putting trust on them so they, of course, need to do the work properly and they also need to put the trust in the company*".
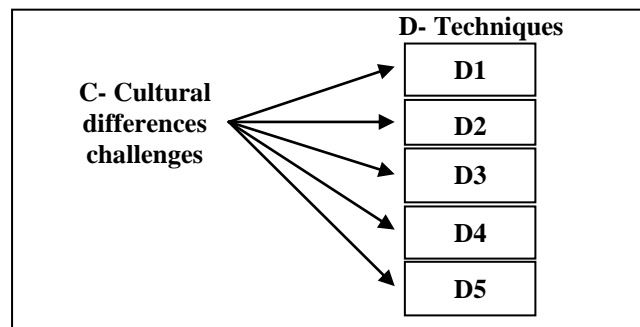

Figure 2.   Cultural difrencess with DASD challenges and techniques

Figure 2 illustrates the recommended techniques to address the cultural differences challenges. Techniques D1 to D5 have been applied by the company to minimize the impact of the cultural differences to the development. The cultural differences could reduce the communication as reported early within this section and limit the collaboration between the team members.

E. Management and Control Challenges

1) Updating the developed story on the online wall (E1): Development participants with the DASD approach usually apply an online story wall to track progress. In some cases, they have issues with not updating the developed story on the online wall. This could lead to duplication when developing the required functions/stories. Participant-2 declared that: "*So, sometimes, you - when you get into a story and then it finishes the phase and you start another story, you may forget to move it on the electronic wall*".

2) Estimation difficulties (E2): The second management challenge is with estimation. Large teams could have difficulties with estimating their stories. Participant-2 explained this issue by: "*Estimation for example is one*

thing that it's hard. So when you have 20 people online and you have 20 people here and you want to estimate stories!!".

F. Management and Control Techniques

1) Increase communication (F1): There is a need to increase the level of communication in order to manage the work and to resolve any misunderstandings. Participant-3 mentioned that the communication is required to better apply DASD: "*If we do a lot of communication then we can apply all the practice of Agile globally*". Participant-2 reported that as well: "*There should be a lot of communications between the teams as well*". In addition, Participant-1 stated the same thing to manage the distributed Agile development: "*Any company you go there would be the challenge to manage such a vast distributed work, right? It requires a lot of communications; it requires a lot of co-ordinations between all the offices to work together right*".

2) Use software management tools (F2): Using software management tools is required to apply different Agile practices within the distributed development environment. Those tools support the development, make it more visible and easier to track. The tools usually have an online wall for the development stories, which is required to keep it coordinated with the normal story wall. Participant-3 declared that: "*So we have story wall, but that's all replicated in an online tool and we make sure that we keep those two in sync so that the product owner at any time can look at our entire story wall and see what's in progress*". And Participant-2 mentioned the same as well: "*is really important and there are not - and you should be able to first of all, be responsible for updating the electronic wall*".

3) Split large teams (F3): Having a large number of participants could make it difficult to apply some Agile practices, such as estimation. Therefore, splitting large teams could be a solution. However, this requires a lot of communication and coordination between the divided teams. Participant-2 agreed with that by: "*You split the team, you have two PM, you split the number of developers, you will add a new BA. But there should be a lot of communications between the teams as well*".

4) Estimation cards (F4): This practice aims to address the estimation issue. The participants would have a card to estimate each story and they would then show their cards and discuss issues. Participant-2 mentioned that technique by: "*we talk about the story and we count to three and everybody should show a card, or show their hands*".
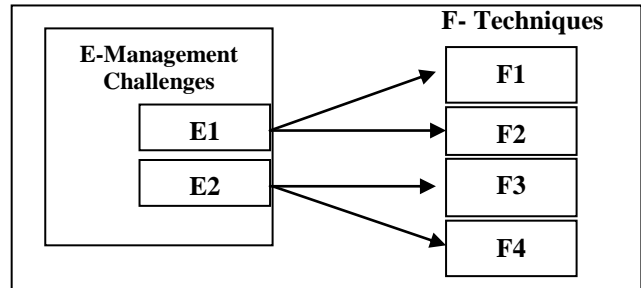

Figure 3. Mmanagment with DASD challenges and techniques

Figure 3 links the management challenges with the recommended techniques in order to provide better understanding of them.

G. Agile Level Challenges

1) Lack of a close relationship (G1): The distributed development could result in losing the main aspect of Agile, which is the close relationship between the development participants. Participant-3 mentioned that by: "*I think the main problem with global is - with Agile it's very important to maintain a close relationship to your customers*".

2) Working with traditional organisations/ customers (G2): Traditional organisations/customers may not accept the Agile way of development. They may be used to traditional development approaches, such as the waterfall model [4]. This could decrease the Agility level of the development. For instance, traditional organisations may take their time to allow the developers access to their database or to the necessary information. Participant-2 reported that: "*We speak a lot with tech team, with manager's team, with anyone who can - but they are traditional companies. They have a lot of paperwork for just getting one server, access to one server, or access to a database. But, in an agile company you just ask for something. In our company if you need to access anything...we just ask and we get it as soon as we can. But it's sometimes in other, in client side, in the companies which we are working for they have their own database team which we - a manager should give you permission*". And Participant-2 stated that as well: "*There have been problems with those things. Like database is the obvious one that we can say, you don't get the access to them. You need to go through their process*".

3) Difficulty in applying some Agile practices (G3): The global development setting could make it difficult to apply some Agile practices [14]. For example, the stand up daily meeting is difficult within the distributed Agile development, because of the large number of participants and the lack of visibility among the meeting attendees. Participant-2 reported that by: "*I guess the whole point of stand up is visibility so that you can see somebody and you can ask a question*", and by: "*So imagine if 100 people want*

to talk for one minute each, it would be a bout two hours while people are standing".

Furthermore, applying the retrospective practice with the distributed development is difficult as well. Participant-2 stated that: "*Retrospectives are getting affected. Because retrospectives in an agile team are, I guess I feel it's the most physical thing happens because what we do is that we practice different type of RETROS. So what we do is that every iteration that we have RETROS we change them. So we try a lot - because we don't want to make it boring*"

H. Techniques for the Agility Level

1) Use software tools to enable some Agile practices (H1): Usually, development teams adopt various software tools to help them to apply Agile practices. Participant-3 reported that: "*We've done some remote pair programming with him. We use tmux which is a UNIX tool for sharing terminals and we used a VNC client called Chicken and we also use Skype and SSH to set up the connection. So with a combination of those we can have a live pair programming session and that worked quite well*". In addition, Participant-2 stated that as well: "*Tools are really important,, learning how to work with tools are taking time. You may need more efforts*".

2) Dealing with the issues of traditional organisations (H2): Sometimes, IT development companies avoid working with a traditional product owner who is not able to understand Agile values. Sometimes, they try to provide the traditional product owner with some training about the Agile approach before the project begins. Participant-2 mentioned that: "*So the way that we work is that we try not to accept projects in our company that clients don't give us the chance of working in a way that we want. But some projects it happens that we try - so in some projects when the clients accept that we work for them, but they are not working in agile way. So usually we try to teach, teach the team which we are going to work with them. We communicate a lot, we talk a lot, we have lots of meetings in our team. So we try to settle these things before accepting a project*".

3) Practice for the stand up daily meeting (H3): Practice includes throwing a ball during the meeting. The member who has the ball is the one who is allowed to speak. This practice aims to manage the meeting by allowing one person to speak at a time. In addition, they hold computer tablets, such as iPads, during the meeting to see the distributed members. This practice reported by Participant-2 as: "*we use iPad and we ask them to be online and they talk about it. So we have a ball as a token. We throw it to each other when someone is going to talk.*".

4) Apply simple documentation (H4): One of the techniques in the DASD approach is doing simple reports to share information from the meetings with participants who were not able to attend. Participant-2 declared that by: "*Usually one person writes a simplify - a very simple report*

that this happens, this decision has been made. This is the reason that we make this decision. So we just read that email every night for example and we get updated about what's happening. If we don't like it, we can state it the day after, or we can send an email and discuss it".
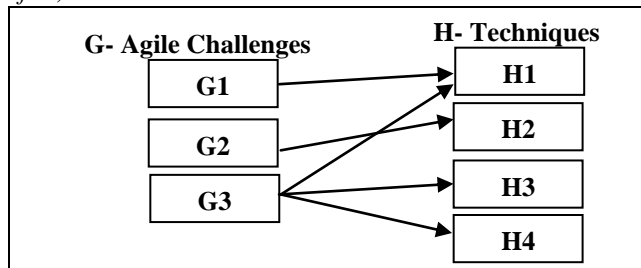

Figure 4. Agile challenges and techniques with DASD

Figure 4 reports the Agile challenges and links them with the recommended techniques to award better apply for Agile methods with the distributed development.

VII. SUMMARY AND CONCLUSION

The reported results suggest that communication barriers are the biggest challenge faced when employing the DASD approach. A number of techniques were reported by the participants to address the known communication issues with this approach. Most of the issues related to the lack of communication between stakeholders. The development teams and product owners need to work hard to increase the level of the communication between them.

The other main issue was the lack of Agile skills and knowledge from the developers and the product owners. The global setting makes this issue more clear because of the distance between the stakeholders. There is need to improve the Agile knowledge by applying training courses and Agile coaching to ensure the sufficient application of Agile practices.

The management issues are also related to the distance and the size of the development teams. Improving the communication level and Agile skills could reduce the management difficulties. Splitting the team may be applied with teams which have a large number of developers.

The issue of cultural differences is the least important problem because most of the stakeholders are aware of the other cultures and have the ability to work with different people. However, some misunderstanding could arise, particularly with the lack of communication. Thus, it is essential that the development participants are clear, flexible, and open with other cultures. The experience with DASD from the investigated company helped to understand the cultural differences challenges. The applied techniques such as training courses help to minimize the cultural differences issues. Moving the team members around the development teams throughout the world will help them to better understand the other cultures and could address this issue.

In conclusion, this case study highlighted some of the major challenges of applying DASD. It has also listed development practices to award a more effective application of this development approach. The discussion showed that

the study findings are in agreement with existing literature for most of the investigated points.

Future work will involve further investigation in order to develop a better understanding and guidance towards applying Agile practices within a global setting.

VIII. ACKNOWLEDGMENT

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