Identification and Classification of Risk Factors in Distributed Agile Software Development

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Received 16 June 2022; Accepted 07 September 2022;
Publication 09 November 2022

Abstract

Distributed Agile Software Development (DASD) is an amalgamation of Agile Software Development (ASD) with Distributed Software Development (DSD). Although DASD integrates the speed benefits of ASD with the cost benefits of DSD, however, it brings along various risk factors that arise due to the fact that both ASD and DSD works on a different set of principles. These associated risks must be addressed and managed well in time for the successful completion of the project. This paper reviews the current literature and presents the current challenges of Risk Management in the DASD environment. This paper also determines 71 risk factors associated with DASD and analyses them based on their causes and sources. Further, these risk factors are segregated into 11 different categories. Timely management of these risks may reduce the uncertainty of project failure in the DASD environment.

Keywords: Risk management, distributed agile software development, agile software developments, distributed software development.

Journal of Web Engineering, Vol. 21_6, 1831–1852.
doi: 10.13052/jwe1540-9589.2164

1 Introduction

Risks are unwanted events that have negative consequences on project completion [1]. Risks impact the success of the project by affecting the goals and objectives by exceeding time and cost and thereby reducing the overall quality [2]. Risk management is a process of identifying, analyzing and managing risks [1]. The goal of risk management is to forecast any upcoming uncertainty, that may fail in achieving project objectives it helps the management to take timely decisions to mitigate such uncertain situations.

Distributed Agile Software Development (DASD) is a new software developing methodology that blends the features of Agile Software Development (ASD) and Distributed Software Development (DSD). Although DASD combines the benefits of ASD and DSD, it brings along the possibility of various risk factors that must be managed on time to meet the project goals and objectives in limited budgets [3]. These risks emerge due to the difference in the working principles of ASD and DSD [4]. ASD focuses on face to face, frequent communication within small-sized collocated teams [5]. On the other hand, DSD exploits the low-cost talented team across the globe. In DSD, the team members are geographically separated and use internet tools for communication. This situation leads to different risk factors that complicates the project development process.

This paper aims to identify various risk factors in the DASD environment and presents the causes and sources of these risks. The goals of this paper are as follows.

- To carry out a literature review to study the risk management frameworks in DASD and present current challenges in this area.
- To present the risk factors associated with DASD and to segregate them into categories.

The paper is organized as follows. Section 2 presents the literature review and challenges in risk management in DASD. Section 3 presents the various risk factors associated with DASD and explains their sources and causes. Section 4 concludes.

2 Literature Review

2.1 Review

A systematic review has been carried out to find the gap in the existing literature. The review has been carried out as per the guidelines of Kitchenham [6]. The databases explored include IEEE explore, ACM, Springer, Wiley and

Science Direct. Some of the important works have been summarized in this section. In the work by Eva Maria Schon, et al. [7], challenges associated with risk management in geographically distributed agile teams were identified and presented. A tool for risk management in scaled agile was designed. But the work is based on a single case study and authors have claimed to be biased in data collection.

In another work by Esteki, et al. [8], a risk management framework for Distributed Agile Development (DAD) was proposed using PRINCE 2 methodology. The work identified various risk factors associated with DAD and classified them into five categories of software development including software development lifecycle, collective awareness, project management, external stakeholder collaboration and launch of the technology. The work further stated that group awareness, the software development lifecycle, and project management are the riskiest categories.

Wan Suzila Wan Husin, Arzi Azmi [9] proposed an enhanced framework of risk management for a Telecommunication Company by accommodating the distributed nature of the organization. The work identified communication as a major risk followed by cultural differences, knowledge management and coordination.

In the work by Suprka Shrivastava, Urvashi Rathod [10], a goal-based risk management approach for DASD was presented. Taking time/cost/quality as parameters, the study presented the most important risk factors for DAD.

Edzreena Edza Odzaly, Des Greer, Darryl Stewart [11] proposed a semi-automated risk management framework for agile development using software agents. Software agents were used for risk identification, assessment and monitoring. The work explained the interaction between four software agents, i.e. manager agent, identify agent, assess agent and monitor agent, their designated rules and their reaction to the changing environment.

Suprika Vasudeva Shrivastava, Urvashi Rathod [12] developed a risk management framework for DASD by presenting the risks, their causes and mitigation strategies. Further, those risks were ranked according to their impact and criticality. Major risk areas of concern were presented as – Communication for collaboration, Third-party management, Software engineering practices, Team organization and management and communication and infrastructure tools. The purposive sampling technique was used to get responses from experienced practitioners working in DAD projects.

A. Elbanna, S. Sarker [13] presented key risks which led to the failure of agile-based projects. Reported risks included development and deployment risks & Project Management risks.

In the work by Suprika V. Shrivastava, Urvashi Rathod [14] 45 risk factors were identified and categorized into 5 categories i.e. SDLC risks, Group awareness risks, External Stakeholder collaboration risks, Technology setup risks, Project Management Risks.

Navid Vajdi, Raja Manzan Abbass [15] presented 10 risk categories and their mitigation techniques in DASD. The risk categories were further elaborated into subcategories.

E. Khanna et al. [16] presented a novel Artificial Intelligence based framework for managing risks in Distributed Agile Software Development.

2.2 Current Challenges in Risk Management in DASD

In DASD environment, software development is carried out in different units that are separated in different geographical areas. Risk managers of these independent units work in each sprint to find the risk factors and then manually create risk reports using spreadsheets and word processing software. The risk manager of the project then follows up with each of these units, goes through all the risk reports, gathers the relevant information and creates a report to be presented to executive boards. Manual risk management is purely dependent on the experience and analysis of the person conducting it and therefore is ineffective and inefficient [16]. There is a need for an automated risk assessment framework for risk identification, analysis and prioritization in DASD. A study in the literature has proposed the automated risk management model in agile-based software agents [11]. However, the work does not consider the scenario where agile teams are geographically distributed. One of the works, Artificial Intelligence based Risk Management Framework (AIRMF) is based on user stories, project goals, project environment data and risk database [16].

3 Risks Identification and Classification

This section presents various risk factors associated with the DASD environment. During the literature review, 71 risk factors are identified [6–31]. These risk factors are further classified into 11 different categories as follows:

1. **Requirement Elicitation** – Requirement elicitation is the process of identifying and gathering the requirements of the system from users, customers and other stakeholders [32]. Introspection, interviews, questionnaires, conversation and interaction are the techniques of requirement elicitation [33]. Risk factors in this category include Unclear Requirements in Multiple Development Sites, Conflicts in Requirement

Table 1 Risk category: Requirement Elicitation

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Unclear Requirements in Multiple Development Sites	Issues in requirement gathering phase.	Geographically separated teams	Individual and interactions
2	Conflicts in Requirement due to Multiple Product Owners	Differences in required requirements among client team, Delay in daily meetings with all clients and stakeholders.	Geographically separated teams, time–zone differences	Individual and interactions, customer collaboration
3	Inadequate Requirement Prioritization	Requirements are not effectively prioritized for each sprint.	Communication gaps, temporal and geographical differences	Embracing changing requirements, the project developed in sprints
4	Frequent Requirements Changes	No timely live demonstration to clients, Fluctuating requirements by client-side due to environment changes and competing market.	Large project scope	Embracing changing requirements, customer involvement in each sprint
5	Implicit Requirements	Unclear and unstated requirements	Geographically separated teams, cultural differences	Face to face communication, frequent collaboration
6	Inadequate Communication With End Users About Requirements	Lack of face to face communication due to geographically separated environment	Geographically separated teams, time–zone differences	Face to face communication, frequent collaboration

due to Multiple Product Owners, Inadequate Requirement Prioritization, frequent changes in requirements and inadequate communication. The causes and sources of these risks are presented in Table 1.

2. **Objective statement** – Unclear and ambiguous Objective statement gives rise to several risks which may lead to the failure of the software

Table 2 Risk category: Objective Statement

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Unclear Objective	Lack of face to face meetings	Geographically separated teams	Face to face direct communication, frequent feedback, collaboration with the customer
2	Ambiguity In Objective Meaning Due To Cultural Differences	The difference in language and culture	Geographically separated teams, cultural differences, large team size.	Co-located small teams
3	Inadequate Meetings With End-Users	Lack of direct face to face meetings while stating objectives	Geographically separated teams	Frequent meetings daily standups

product. Ambiguity in the objective statement may arise due to cultural differences and lack of direct face to face meetings in the DASD environment. The causes and sources of these risks are presented in Table 2.

3. **Design** – Software design is the software life cycle process in which the requirements from SRS are translated into a description of a software system's internal structure that can be used as a basis for construction [34]. In the DASD environment, frequent changes in requirements are embraced within the life cycle which in turn causes changes in SRS and design. These frequent changes leads to different risk factors. Further, lack of direct communication among team members due to geographically separated teams result in conflicts in design in multiple sites. Design inconsistency is also one of the risk factors that arise due to a lack of team cohesion and communication. Design related risks are presented in Table 3.
4. **Coding** – Inadequate pair programming and lack of coordination are the risk factors associated with the coding phase of the software development life cycle. Lack of trust and lack of mutual understanding are primary causes of these risks. Sources of these risks are presented in Table 4.
5. **Testing** – Software Testing is the process of executing a program or system with the intent of finding errors [35]. Software testing is one of the important activities that is carried out to enhance the quality of

Table 3 Risk category: Design

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Flexible Designs Due To Changing Requirements	Frequent changes in requirements	Geographically separated teams	Embracing changing requirements, incremental design
2	Conflicts In Design	Lack of direct communication among team members, lack of trust	Geographically separated teams, no face to face communication, large project scope	The co-located team, trust among team members, Frequent feedback, simple design
3	Design Inconsistency	Lack of team cohesion and coordination	Large team size, Indirect communication using internet tools	Small teams working together in the same room, Daily standups

Table 4 Risk category: Coding

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Inadequate Pair Programming	Programmers in different units, Lack of face to face communication	Geographically separate teams	Small teams, supports pair programming, technical excellence coding standards.
2	Lack Of Coordination	Lack of trust, lack of mutual understanding	Cultural differences, time zone differences	Self-organized teams, team motivation and support

software [36]. Software testing is based on requirement analysis and design specification [37]. Testing can be carried out manually or can be automated [38]. In the DASD environment, lack of proper documentation in initial software development phases leads to unavailability of requirements documents for testing. Further unavailability of testing data due to security and network issues is another risk factor related to testing in DASD. Use of different testing tools in different development sites, Inadequacy in the transfer of large testing data and integration testing are also some of the risk factors related to this category [39]. The causes and sources of these risks are presented in Table 5.

Table 5 Risk category: Testing

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Unavailability Of Requirements Documents For Testing	Lack of proper documentation during initial phases	Geographically separated teams, time zone difference, language differences	Less focus on heavy Documentation
2	Unavailability Of Real Testing Data	Testing data not available due to security issues	Geographically separated teams, time zone differences	Test-driven development
3	Inadequacy In Transfer Of Large Testing Data	Inability to transfer a large amount of personal data to geographically different locations	Large project scope	Test-driven development
4	Different Testing Tools	Different testing tools used in different sites	Geographically separated teams, large project scope	Team motivation, proper training and support
5	Code Integration	Integration testing of different modules from different sites	Large project scope	Continuous integration and testing (New code is integrated within the system and tested within a few hours of development)

6. **Release and deployment** – Risks in this category include inadequate sprint releases, integration and deployment risks and improper time and cost estimation. The causes and sources of these risks are presented in Table 6.
7. **Project Management** – Software project management is a process of planning, implementing, monitoring and controlling a software project [33]. In the DASD environment various risk factors related to project management arises due to the contradicting properties of DSD and ASD. These risk factors include exceeded project time and costs, infinite sprints, reorganization of teams in every sprint, higher interdependency among teams, growth in team size, unavailability of business analysts, lack of uniformity in team capability in multiple sites Causes and sources of these risks are presented in Table 7.

Table 6 Risk category: Release and Deployment

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Inadequate Sprint Releases	Improper time and cost estimation	Large project scope	Short iteration sprint
2	Integration And Deployment	Different environments in multiple sites	Large project scope	Continuous integration and testing
3	Difference In Agile Practices And Principles At Different Sites	Different teams following different principles	Geographically separated teams and time-zone differences	Self-organizing teams

Table 7 Risk category: Project Management

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Exceeded Project Time(Lower Initial Velocity)	Improper time estimation	Geographically separated teams and time zone differences	Face to face communication, Embrace changes in requirements
2	Exceeded Project Cost(Difficulty To Execute Fixed Price Products)	Improper cost estimation	Geographically separated teams and time zone differences	User story backlog, Face to face communication, Embrace changes in requirements
4	Infinite Sprints	Fluctuating Project requirements	Large project scope	Focus on small user stories
5	Infeasible Project	Requirements infeasible	Large project scope	Frequent collaboration and face to face communication, direct feedback
6	Larger Team Sizes	Unmanageable projects	Large project scope	Small teams
7	Reorganization Of Teams In Every Sprint(Task Distribution)	Inadequate task distribution	Large project scope	Self-organizing teams

(*Continued*)

Table 7 Continued

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
8	Insufficient Knowledge At Certain Sites.	Unwillingness to share all the information due to lack of trust, inefficient communication.	Geographically separated teams	Team motivation, training and support, Adaptable self-organizing teams
9	Higher Interdependency Between The Teams	High coupling	Geographically separated teams	User story backlog, Embracing changes in requirement
10	Team Recognizing In Every Sprint	Outsourcing of modules	Geographically separated teams, different time zone	Frequent collaboration
11	Growth In Team Size Or Development Site	Fluctuating project requirements	Large project scope	Self-organizing team
12	Unavailability Of Business Analyst	Outsourcing of modules	Large project scope	Small teams
13	Lack Of Uniformity In Multiple Teams Capability	Outsourcing of modules	Large project scope	Small, self-organizing teams
14	The Emergence Of Excessive Competition Between Teams Or Scrum Masters	Lack of trust	Geographically separated teams and time zone differences	Self-organizing teams

8. **Communication** – Communication is an essential activity that presents the flow of information throughout the project. Communication is the crucial factor that is responsible for successful risk management [8]. In the paper by Wan Suzila Wan Husin, Arzi Azmi [8] communication was identified as a major risk followed by cultural differences, knowledge management and coordination. Risk factors related to communication are presented in Table 8 along with its causes and sources.
9. **Technology-Based** – Risks in this category includes Lack of training, inadequate tool selection and improper utilization of tools. The causes and sources of these risks are presented in Table 9.

Table 8 Risk category: Communication

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Lack Of Communication Among Team Members	Indirect communication among multiple teams, lack of face to face communication	Geographically separated teams and temporal differences.	Face to face communication, frequent collaboration
2	Lack Of Communication Between Client And Team	Lack of face to face communication, time zone differences	Time Zone Differences	Face to face communication, frequent collaboration
3	Poor Communication Skills	Lack of face to face communication, Difference in the native language, time zone differences	Geographical differences	Frequent collaboration
4	Use Of Different Languages (Language Barriers)	Lack of common language	Geographical differences	Frequent collaboration
5	Delayed Feedbacks	Lack of communication, Lack of trust	Individual responsibility of own role, no collective responsibility for overall project	Collective code ownership, self-organizing teams, face to face honest communication
6	Misinterpretation Of Message	Lack of communication, lack of trust, lack of mutual understanding	Cultural differences, time zone differences	Face to face communication, direct collaboration
7	Difference In Terminology	Different words have different meanings	Cultural differences, time zone differences	Face to face communication, direct collaboration
8	Inadequate Documentation	Lack of proper documentation during initial phases	Geographically separated teams, time zone difference, language differences	Less focus on heavy Documentation

(*Continued*)

Table 8 Continued

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
9	Poor Coordination	Lack of trust, lack of mutual understanding	Cultural differences, time zone differences	Self-organized teams, team motivation and support
10	No Face To Face Meetings	Use of ICT tools for meeting due to geographical differences	Geographical differences	Face to face communication, direct collaboration
11	Lack Of Trust Among Different Teams	Lack of trust, lack of mutual understanding	Cultural differences, time zone differences	Self-organized teams, team motivation and support

Table 9 Risk category: Technology-Based

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Lack Of Training	Lack of time and budget	Geographical Differences	Shorter sprints
2	Inadequate Tool Selection	Lack of budget	Geographical Differences	Shorter sprints
3	Lack Of Communication	Lack of face to face communication, Difference in the native language, time zone differences, geographically separated teams	Geographical differences	Frequent collaboration
4	Improper Utilization Of Tools	Lack of training, lack of time and budget	Geographical Differences	Shorter sprints

10. **External Stakeholder** – In DASD, many stakeholders are involved which influence the progress of the project. Inappropriate user story estimates by different vendors, Poor coordination among multiple vendors, outsourcing of modules and dependency on the third party are risk factors associated with this category. The causes and sources of these risks are presented in Table 10.
11. **Group Awareness** – These risk factors related to this category along with their causes and sources are presented in Table 11.

Table 10 Risk category: External Stakeholder

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Unavailability Of Product Owners	Lack of face to face meetings with product owner for feedback	Time zone differences	Frequent collaboration
2	Poor Coordination Between Multiple Vendors	Lack of meetings among different vendors	Large project scope	Frequent collaboration
3	Inappropriate User Story Estimates By Multiple Vendors	Changes in requirements and resources	Large project scope	Embrace changes in user requirement
4	Code Integration Risks With Multiple Vendors	Integration testing of different modules from different sites	Large project scope	Continuous integration and testing (New code is integrated within the system and tested within a few hours of development)
5	Dependency On Third Party	Outsourcing of modules	Large project scope	Collective code ownership, self-organizing teams, face to face honest communication

Table 11 Risk category: Group Awareness

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
1	Lack Of Communication Between Team And Client	Indirect communication among multiple teams, lack of face to face communication	Geographically separated teams and temporal differences.	Face to face communication, frequent collaboration
2	Lack Of Communication Between Team Members	Lack of face to face communication, time zone differences	Time Zone Differences, geographical differences	Face to face communication, frequent collaboration

(*Continued*)

Table 11 Continued

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
3	Under Investment On Travel By The Management	Lack of planned face to face meetings	Time Zone Differences, geographical differences	Face to face communication, frequent collaboration
4	Lack Of Documentation	Lack of proper documentation during initial phases	Geographically separated teams, time zone difference, language differences	Less focus on heavy Documentation
5	Lack Of Face To Face Communication	Teams scattered in different locations, Differences in the native language, time zone differences	Geographical differences	Frequent collaboration
6	Poor Collaboration Between Different Sites	Lack of planned face to face meetings	Time Zone Differences, geographical differences	Face to face communication, frequent collaboration
7	Issue Of Coordinating The Members Of Scrum Masters And Product Owners Team	Lack of planned face to face meetings	Time Zone Differences, geographical differences	Face to face communication, frequent collaboration
8	Lack Of Trust Between The Client And Offshore Teams	Lack of trust, lack of mutual understanding	Cultural differences, time zone differences	Self-organized teams, team motivation and support
9	Lack Of Trust Between Onshore And Offshore Teams	Lack of trust, lack of mutual understanding	Cultural differences, time zone differences	Self-organized teams, team motivation and support
10	Lack Of Collaboration Between Developers And Quality Assurance Members	Lack of planned face to face meetings	Time Zone Differences, geographical differences	Face to face communication, frequent collaboration

(*Continued*)

Table 11 Continued

S. No.	Risk Description	Cause of the Risk	Source of the Risk	
			DSD Property	ASD Property
11	Ineffective Scrum Of Scrum Meetings	Lack of planned face to face meetings	Time Zone Differences, geographical differences	Face to face communication, frequent collaboration
12	Poor Coordination Between Multiple Teams	Lack of planned face to face meetings	Time Zone Differences, geographical differences	Face to face communication, frequent collaboration
13	Unsuitability Of Agile Approach For Large Organizations	Agile principles difficult to apply in a distributed environment	Larger project scope	Face to face communication, frequent collaboration
14	Delays And Problems In Group Decision Making	Lack of open communication, delayed feedback, formal communication	Individual responsibility of own role, no collective responsibility for overall project	Collective code ownership, self-organizing teams, face to face honest communication
15	Uncommon Language	The difference in the native language, time zone differences	Geographical differences	Face to face communication

4 Conclusion

Risk management is an important task that directly affects the cost and quality of the software. Bohem [1] defined risk management as "a discipline that aims to identify, address and eliminate risk items before they turn out to be a threat to a successful software project or become the main sources of software rework". Lack of importance of risk management by project managers hinders the success of the project [8]. It has been observed that industrial risk management practices are not up to the mark of recommended risk management best practices. This gap is also observed in DASD. In Distributed Agile Software Development (DASD) environment, many risk factors arise due to the contradictory nature of Agile Software Development (ASD) and Distributed Software Development (DSD) principles. These risks must be identified well on time and must be analyzed for smooth completion of the DASD projects.

In the existing literature, several DASD related risks have been reported. These risks are further classified into several categories like communication risks, project management risks, external stakeholder risks, Software Development Life Cycle risks. These risks, though identified have not been mapped to software development tools. Practicing proper risk management in software development is one of the crucial factors for its success.

Risk management is one of the umbrella activities that is performed in each agile sprint to increase the efficiency of the software. Risks if identified and managed in time, decrease the threats of project failure. In a DASD environment, different categories of risk factors are faced at different periods. This work enlists all the risk factors associated with DASD available in the literature and classifies it into 11 different categories i. e. Requirement Elicitation, Objective statement, Design, Coding, Testing, Release and deployment, Project Management, Communication, Technology Based Risks, External Stakeholder, and Group Awareness. The work also presents the current challenges in risk management in DASD. The work further discusses the shortcomings of risk management practices in DASD.

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