Management of Communication in Distributed Software Development Projects: Systematic Literature Review

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Abstract. *Today we realize that communication is becoming a critical factor for successful projects. Given this context, it is noteworthy that the Distributed Software Development (DSD) inherits the problems of traditional development and adds other challenges inherent in their own nature. Among the challenges, the most evident is the high dependence of communication. This paper presents the difficulties, the factors and communication management tools in the design of Distributed Software Development, identified through a Systematic Review, which is especially useful to support project managers and distributed teams. This article includes a description of the process of Systematic Review, systematization and evaluation of results.*

1. Introduction

In recent years, many projects are being developed by professionals scattered in different places, and you can see, in the last decade, a significant increase of this approach, known as Distributed Software Development (DSD). There are numerous reasons for this popularity: the reduction of production costs, economies of scale, access to specialized resources, reduced time to market, improved quality and access to new markets [Katainen and Nahar 2008], [Prikladnicki 2003]. While many organizations came running projects with distributed teams, only some of them have efficacy in established practices to help managers and developers working in this new environment [Binder 2007].

Within this context, this paper shows through a systematic literature review, difficulties in communication management, the factors identified in the teams during the process of communication that influence the design of DSD and tools reported in reliable scientific communities, which are indicated as effective in communication support for the project management of DSD. This systematic review followed the guidelines set by Kitchenham (2007); Travassos and Biolchini (2007), to answer the following questions:

- (RQ1) What are the main difficulties in the management of communication projects in Distributed Software Development?
- (RQ2) What are the key factors identified in the teams that influence the communication process in the design of Distributed Software Development?

- (RQ3) What are the best tools and practices to be adopted in the communication of the teams in the design of Distributed Software Development?

2. Systematic Literature Review

Systematic reviews of the literature are part of evidence-based paradigm realized through systematic and transparent practices. Kitchenham (2007) summarizes the steps of a systematic review of the literature in three main phases: Planning Review, Conducting the review and Presentation of results. The first step to accomplish this review was to define the protocol, which describes the research plan in detail in the following subsections.

2.1. Research Terms

The search terms used in this review were generated from the research questions and the combination of key terms and synonyms (Table 1).

Table 1. Search String

Communication	AND (Communication OR Communication Management)
Distributed Software Development	(Distributed software development OR Global software OR …)
Difficulties	AND (Challenge OR Difficult OR …)
Software Teams	AND (Software teams OR Software group OR …)
Tools	(Tool OR Technique OR ...)

2.2. Search Sources

The search was performed only in digital libraries available on the Internet, which has partnered with the Federal University of Pernambuco: IEEEXplore Digital Library, ACM Digital Library, ScienceDirect, EI Compendex and Scopus.

2.3. Selection Process for Primary Studies

After executing the query, the documents were selected independently by two different investigators, according to the procedure described below:

Table 2. Phases of Selection Process for Study

Phase 1	Reading titles and abstracts of studies by two researchers.
Phase 2	Reading of the summary and conclusion of the studies selected in Phase 1.
Phase 3	Analysis and validation of items for elimination of duplication and complete reading of the selected studies by the researchers.
Phase 4	Fill the form of assessment of each study by researchers.

2.4. Criteria for Selection of Primary Studies

The inclusion of a work is determined by the relevance in relation to research issues identified by analysis of the title, abstract and conclusion. The selection criteria used can be seen in Table 3.

Table 3. Criteria (Inclusion/Exclusion) for Study Selection

Inclusion Criteria	Exclusion Criteria
(1) Studies that focus on managing DSD communications	**(1)** Studies Irrelevant

(2) Studies that are available for access through the online library service	**(2)** Incomplete Studies
(3) Study with sufficient data for analysis.	**(3)** Repeated and / or duplicated studies

2.5. Data Extraction

The primary search conducted during four months returned a total of 6835 jobs, and 118 were considered potentially relevant to the search. After reading the summary and conclusion, and using the criteria for inclusion/exclusion, 85 studies were excluded, bringing the total to 33 primary studies (Table 4).

Table 4. Studies Selection Result

Source	Result	Relevant Potential Studies	Not Relevant	Duplicated	Incomplete	Primary Studies
IEEEXplore	114	22	8	0	0	14
ACM	51	11	4	2	1	4
ScienceDirect	2991	21	15	2	0	4
EI Compendex	3245	41	18	9	8	6
Scopus	434	23	12	1	5	5
TOTAL	**6835**	**118**	**59**	**14**	**14**	**33**

The first chart shows the number of secondary education by source of research according to their respective research questions.

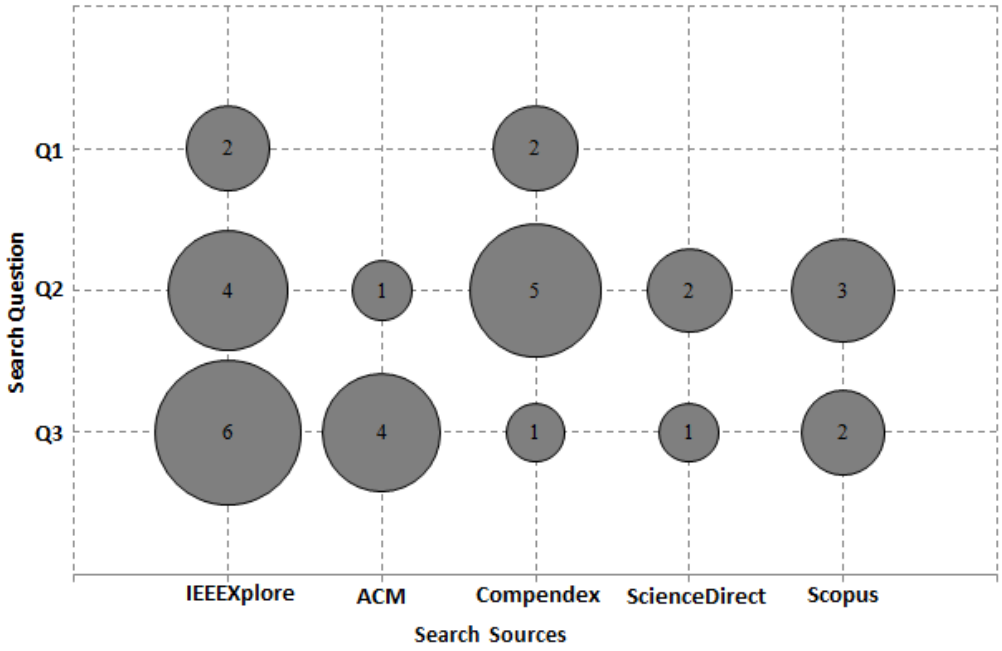

Figure 1. Number of primary studies by research question

This systematic review did not restrict the year of publications, although all the selected studies were conducted between 1998 and 2008, thus showing the importance of this approach. From the 33 selected studies 17 (52%) are Case Study, 12 (36%) Survey, 2 (6%) Experiment and 2 (6%) Industrial Experience Reports, none systematic review was identified (figure 2).

To evaluate the quality of the studies was used the Likert scale, which includes five characteristics: the validity of research, threats to validity, relevance, applicability

and consistency of evidence. To validate these characteristics, it was created a form with 18 questions, which was filled by both investigators for each study selected in order to obtain answers to research questions. The analyzed studies may fall into five levels of quality: Excellent, Good, Regular, Poor and Very Poor. According to the classification level, 14/33 (42%) studies were classified as Excellent, 17/33 (52%) studies as Good, 2/33 (6%) as Regular and no study has been classified as Poor or Very Poor, which means that the evidence found have a reasonable level of reliability (figure 3).

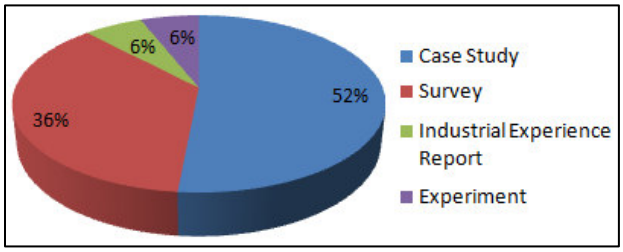

Figure 2. Type of Studies

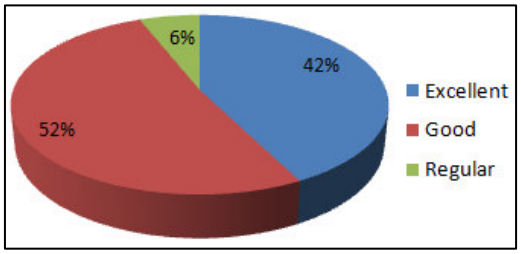

Figure 3. Quality Evaluation

By filling out completed, each form was compared and discussed by both researchers in order to organize the extraction, analysis and data synthesis. It was adopted Mendeley Desktop tool, which provides an overview of the data collected and the sources of the documents or searching digital libraries, facilitating the review of the literature.

3. Result

Among the selected studies, we have found relevant evidence to answer satisfactorily the three research questions. The difficulties in managing communication in DSD were discussed in 25 of the 33 selected studies, where most of the studies highlighted the difficulties faced in the management of communication in distributed environment, which may be associated with good practice for improving the management of communication presented in the systematic review by C. Costa et.al (2010). Table 5 details each difficulty according to the primary studies; it is worth to note that the main difficulties focus around the geographic dispersion and cultural differences, followed by time zone, confirming the results obtained by Farias Junior (2009).

Table 5. Difficulties in Communication Management

Difficulties	Primary Studies
D1. Cultural Differences	[PS4], [PS5], [PS9], [PS10], [PS14], [PS17], [PS18], [PS19], [PS20], [PS22], [PS24], [PS25], [PS26], [PS30], [PS31], [PS33]
D2. Geographic Dispersion	[PS4], [PS9], [PS14], [PS17], [PS20], [PS22], [PS24], [PS25], [PS30], [PS31], [PS32], [PS33]
D3. Time Zone Difference	[PS9], [PS14], [PS20], [PS22], [PS24], [PS25], [PS30], [PS31]
D4. Face-to-face meeting	[PS9], [PS13], [PS14]
D5. Team Management	[PS28], [PS31], [PS32], [PS33]
D6. Information Overload	[PS14], [PS15], [PS17], [PS26]
D7. Delay Information	[PS3], [PS9], [PS10], [PS14], [PS15], [PS24], [PS26]
D8. Poor Communication media	[PS9], [PS14], [PS15], [PS27]
D9. Communication Planning	[PS1], [PS2], [PS3], [PS5], [PS18], [PS29], [PS32], [PS33]

The main factors identified in the teams that influence the communication process in the distributed environment were discussed in 28 of the 33 selected studies

(Table 6). However, this study did not find sufficient evidence to detail what is job satisfaction as well as personality.

Table 6. Factors identified in Software Teams

Factor	Primary Studies
FA1. Social factors (trust, interaction, integration, motivation, cooperation and cohesion)	[PS2], [PS3], [PS4], [PS6], [PS10], [PS11], [PS14], [PS15], [PS16], [PS17], [PS18], [PS19], [PS21], [PS23], [PS24], [PS26], [PS28], [PS32], [PS33]
FA2. Lack of confidence in the native language	[PS5], [PS9], [PS14], [PS15], [PS16], [PS18], [PS19], [PS20], [PS21], [PS22], [PS27], [PS33]
FA3. Impaired Speech	[PS9], [PS14], [PS18], [PS22], [PS24], [PS25], [PS30], [PS31]
FA4. Preferences in the media text-based	[PS5], [PS10], [PS29]
FA5. Job Satisfaction	[PS9], [PS16], [PS17]
FA6. Expertise	[PS18], [PS19], [PS23], [PS24], [PS33]
FA7. Personality	[PS14], [PS19], [PS23], [PS24], [PS26]

The main tools used in the communication process in the distributed environment were discussed in 28 of the 33 selected studies (Table 7).

Table 7. Tools used in Communication Process.

Tools	Primary Studies
TO1. Audio Conference (conference calls and web conference)	[PS5], [PS9], [PS11], [PS12], [PS14], [PS19], [PS20], [PS21], [PS22], [PS27], [PS31], [PS32]
TO 2. Phone	[PS3], [PS5], [PS9], [PS11], [PS14], [PS15], [PS27],
TO 3. Video Conference	[PS1], [PS5], [PS8], [PS10], [PS11], [PS14], [PS24]
TO 4. NetMeeting	[PS9], [PS15], [PS25]
TO 5. Chat or Messenger	[PS5], [PS6],[PS8], [PS9], [PS11], [PS18], [PS24], [PS26], [PS27], [PS28], [PS29]
TO 6. Data Conference	[PS1], [PS11]
TO 7. VOIP	[PS5], [PS9]
TO 8. Document Sharing	[PS9], [PS10], [PS12], [PS18], [PS26], [PS27]
TO 9. Forums	[PS5], [PS18], [PS24]
TO 10. Intranet or websites	[PS2], [PS5], [PS9], [PS11], [PS12]
TO 11. Wiki	[PS12]
TO 12. E-mail	[PS1], [PS3], [PS4], [PS5], [PS6], [PS8], [PS9], [PS10], [PS12], [PS13], [PS14], [PS15], [PS18], [PS19], [PS20], [PS21], [PS22], [PS26], [PS29], [PS31], [PS32]
TO 13. PowerPoint	[PS11], [PS12]
TO 14. Calendars	[PS5], [PS9]
TO 15. Fax	[PS14]
TO 16. Collanos	[PS27]
TO 17. Bugzilla	[PS15]
TO 18. TeamSpace	[PS7]

Figure 4 shows the relationship between the factors and difficulties, where each bubble size represents the number of studies that have cited the relationship between a particular difficulty and a certain effect.

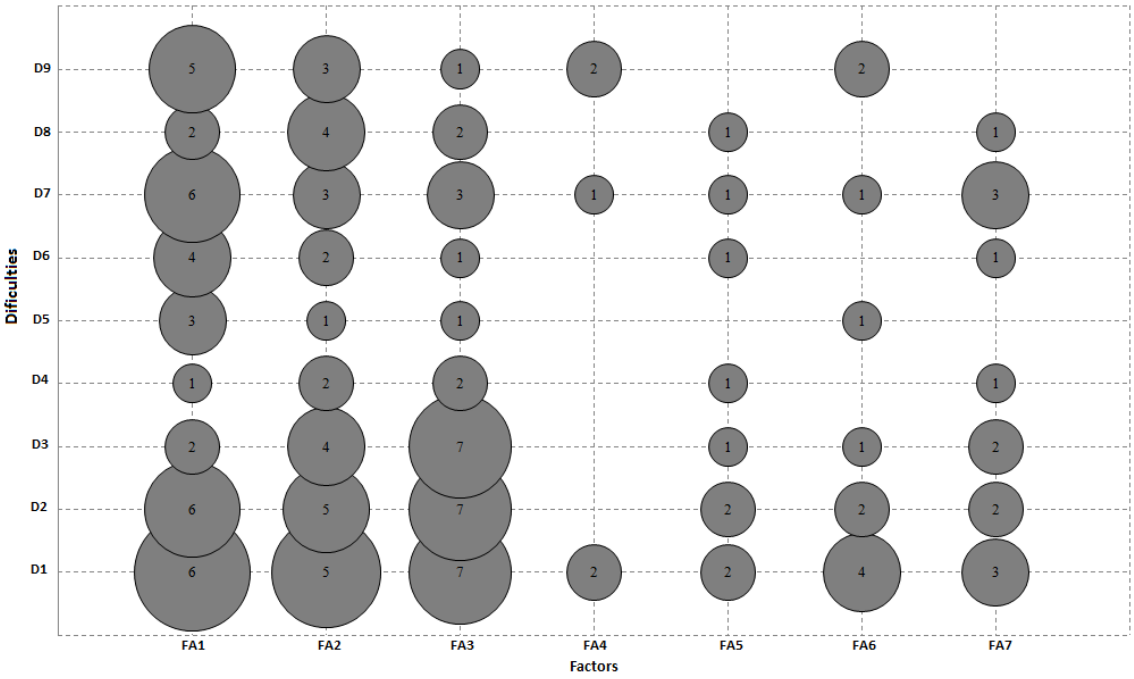

Figure 4. Relation between Difficulties and Factors

Figure 5 shows the relation between the difficulties and tools (synchronous and asynchronous), as well as their respective relationships with the primary studies.

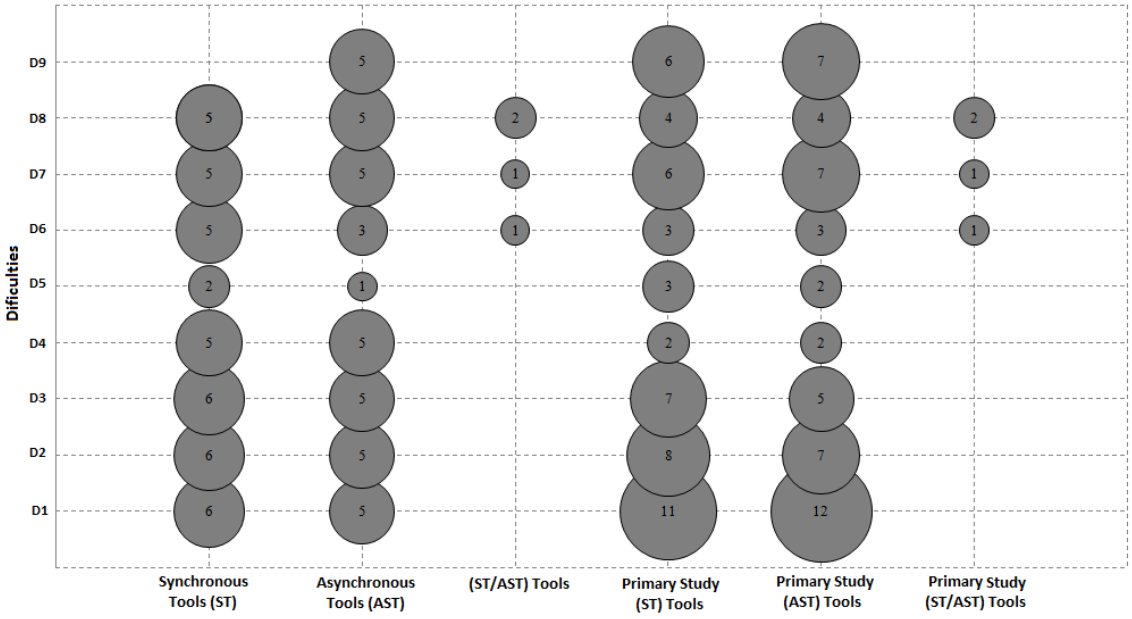

Figure 5. Relation between Difficulties and Tools

Figure 6 shows the relationship Between the Factors Identified in the teams and the tools used, as well as their respective relations with the primaries studies.

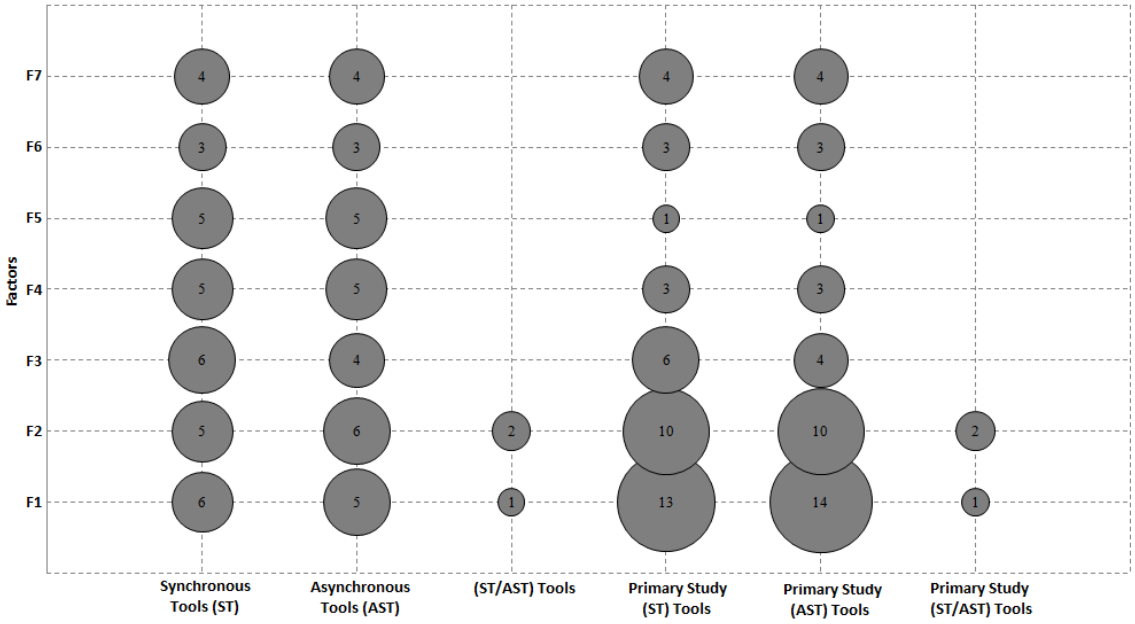

Figure 6. Relation Between Factors and Tools

4. Final Remakes

This research has identified the difficulties in communication management, the factors identified in the teams and the tools used in DSD communication process. These results were identified through a systematic literature review conducted from August to November 2009, involving 33 studies published between 1998 and 2008. One possible explanation for not having relevant studies in 2009 is that the publications and relevant work has not been indexed in the search sources.

According to the selected studies, the major difficulties faced in the management of communication difficulties were the Cultural and Geographic Dispersion, having a significant influence of social factors and lack of confidence in the native language identified in the teams. Some difficulties, however, can be mitigated through the tools such as conferencing, email, among others.

As future work we intend to suggest a set of practices to improve the management of communication; further research to cover a more significant sample of studies, which will allow broader analysis and comparison between studies and validation of this review through a field research to compare and confirm the results identified in the literature by means of practices to make the communication process for DSD more consistent.

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