Coordination Issues and its Impact on Project Performance: A Systematic Literature Review

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***Abstract*—Software projects have become increasingly complex and risky caused by the existence of software outsourcing. The complexity of the project is due to the coordination between developers who hindered by a number of issues which then led to affect the performance of the project. Hence, this study intends to synthesize these coordination issues and its impact on project performance. Correspondingly, this paper present Systematic Literature Review (SLR) based on the issues and its impact on performance of the project. Findings indicate there are four main issues, namely, time separation, cultural, organizational and geographic distance which greatly affect project performance.**

***Index Terms*—Collaboration; Coordination; Project Performance; Software Engineering Project.**

I. INTRODUCTION

Coordination is essential to ensure that projects are developed to meet customer requirements. Customarily, in projects, team members are gathered to develop or enhance software [1]. It is challenging since coordination in different phases of project lifecycle involves developers with different understanding about requirement [2]. This is to some extent affect the performance of the project.

For this reason, coordination is considered as an aspect that influence the performance of teams in a project [3]. Performance is illustrated as the process of performing activities [4]. Aspects which greatly influence performance are the designer's competence, knowledge and learning ability [5]. Performance in projects relates to the ability to deliver software within scheduled time and budget constraint [6]. Whereas, in software engineering project, alignment between the social and technical elements assist in achieving good performance [3].

Originally, in order to bridge dependencies between task-derived technical element, it requires the presence of communication of social element [3]. Empirical evidence found that communication is indeed enhancing project performance [6]. It is important to realize, along with the growing demand over software application globally, the coordination between developers certainly will faces issues to maintain its effectiveness.

Hence, this paper aims to examine the issues of coordination that has been circulating in software engineering project over the years.

This paper outlines, method in the first part, which discusses on the research question, searching and keywords criteria and also where this paper is refined. The next part is, reviewing the search result. After that, is the detailed discussion regarding the issues of coordination, which affect the performance of the project. The last part refers to the final conclusion of this research paper.

II. METHODS

A. Research Questions

The following is the research question which guided the study.

RQ1: What are the coordination that occurred in software engineering projects?

B. Searching and Keywords Criteria

This study uses the following databases search engine, in order to find material related to the research stated:

i. ACM Digital Library (http://dl.acm.org/dl.cfm)
ii. Elsevier Science Direct (http://www.sciencedirect.com/)
iii. Google Scholar (https://scholar.google.com.sg/)
iv. IEEE Xplore (http://ieeexplore.ieee.org)
v. ResearchGate (http://www.researchgate.net)
vi. Springer (http://www.springer.com/gp/)
vii. Wiley Online Library (http://onlinelibrary.wiley.com/)

Below are the keywords used in the database searching where it is classified into three main categories based on the paper study:

Table 1
Searching Keywords by Category

Category	Keywords
Issues	Time Separation
	Culture
	Organizational
	Distance
Coordination	Software team coordination
	Team member coordination
	Coordination
	Software team co-operation
	Team member co-operation
	Co-operation
	Software team collaboration
	Team member collaboration
	Collaboration
Aspect Environment	Software development project
	Software engineering project

C. Screening of Papers

Henceforth, the relevant prior research study screened, by using the conditions of inclusion and exclusion. The following are the conditions for inclusion (I) and exclusion (E) used:

I1. Previous paper study associate with research questions, also conditions for search and keyword.

E1. Organization studies, word document, presentations, articles.

Inclusion and exclusion criteria were applied to extract the related scientific prior literature, exclude from other non-scientific findings. The related paper was screened thoroughly as depicted in Figure 1. The first thing the researchers screened at is the title, followed by the abstract, next is an introduction, due to keywords that may not available nowhere at the early part of the paper. Then researchers screened the content of the paper for further information. Out of 75 papers that was screened based on title, 56 papers were filtered by abstract and 45 papers extracted by its introduction and content screening. Last inclusion is 29 papers.

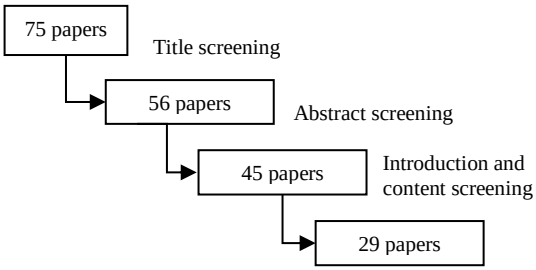

Figure 1: Step-by-step screening papers

III. Results and Discussions

A. Search Results

Table 2 shows the frequency and percentage of related paper published by year. Paper relate to this study was most published in 2006 until 2007, this shows an increasing in the interest of the issue on coordination, which is very vital in software engineering project that is increasingly challenging year by year. Table 2 is significance to depict the improvement number of issues based on years of previous literature.

Table 2
Prior Paper Published (by year)

Year	Percentage (%)	Frequency
1968	3	1
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	3	1
2000	3	1
2001	10	3
2002	3	1
2003	10	3
2004	8	2
2005	10	3
2006	15	4
2007	15	4
2008	3	1
2009	8	2
2010	0	0
2011	0	0
2012	3	1
2013	0	0
2014	3	1
2015	3	1
2016	0	0
Total	100%	29

Table 3 lists the issues of coordination, which are time separation, cultural, organizational and distance. Most issues finding is critically discovered on distance and time separation.

Table 3
Issues List

Issues	Paper ID
Time Separation	[7][8][9][10][11][12][13][14][15][16][17][18]
Cultural	[9][15][16][19][20][21][22][23][24]
Organizational	[9][16][19][21][25][26][27][28][29][30]
Distance	[7][9][12][16][17][21][28][31][32][33][34][35]

B. What are the coordination that occurred in software engineering projects? (RQ1)

1) Time Separation

In general, communication is an important element in the coordination process [7][8]. However, in the event that the development is distributed, the communication became less effective. Distributed project with a time separation depends fully on the technology-based communication to increase project performance [9].

Originally, time separation relates to the time zone difference. Prior to this, although it is just a slight time difference, it could cause an enormous issue forthcoming [7]. Prior study clarified that, time separation is costly due to rework cost [7]. In this case, time zone caused the developers unable to communicate regularly when a misunderstanding arises led to delay in production [7]. Subsequently, whenever requirement is vague, forcing developers to clarify issues with further communication which add to the delay cost [10]. Whereas, these things are preventable if the task is simple and clear. Prior studies in agreeing that distributed task could save labor expense by taking advantage of lessened wage rates, nevertheless these vulnerable to another hidden coordination cost [11] [7] [12].

In addition, distributed project teams demanding extra effort to organize a schedule to hold meeting with overlap time between sites [13]. This is a huge challenge when involving more than two time zones [13]. In like manner, when a developer cannot reach the other developer in different time zones during issues emerge will result to project falls behind schedule [10]. This is not essential in a situation where the time zone overlapping [10]. Empirical studies show that, when there is less overlap causes a decrease in the speed of task performance, in contrast to fully overlap [14].

This emphasize that distributed project completion is more than twice collocated project due to the communication barrier, while project development always requires a quick response to solve issues [15] [12]. For example, when fixing bugs during integration, developer need to obtain data coding from another site using media like email or calling [16]. The media then leads to time dragged caused by the shift work in the time zone of separation. Besides, project that depends on communication media inclined to engage in miscommunication than face-to-face meeting [7]. Prior research suggests that the selection of communication media is based on the time separation, urgent communication, and also a language barrier [17]. Small time zone difference might be adequate with simple scheduling work hours and telecommunication, on the contrary, this is a difficult task for large time zone difference [18]. Due to the complex collaboration, the timing to interact between different time zone become urgently important [18].

Empirical evidence found that time zone span contributes

to coordination delay give an adverse effect on performance [18].

2) Culture

Prior study referred culture dispersion as cultural, linguistic and background variety between members [19]. It is important to realize that distributed team members indeed come from different countries with different cultural background [15]. Distributed project increases the need of coordination markedly through cultural borders [20].

However, cultural compatibilities also may cause problem such as language barrier and others remote member holidays and festival [15]. Additionally, it is harder to know whether the person related to the task is available at what day and time, along with cultural barrier, awkwardness getting worse [21]. If such this mismatch does not get a compromise of all involved will cause problems with the development of the project. Moreover, team members from distributed countries surely have their own way in managing issues, hence it is difficult to understand and work as a team [22]. As a matter of fact, different people tend to give a different interpretation of the situation based on their culture [20].

In like manner, Asian and Western culture tend to develop confusion which impedes project accomplishment [22]. For instance, in regard the agreement and disagreement, and ask questions, European and American always thought that they had responsibility while Asian team is merely courteous [16]. Likewise, Canadian constantly interprets the German way as rude because of their blunt and stubborn in giving opinions, conversely, German disappointed over the Canadian way [23] [24]. Despite, most of the team members aware of this situation, they are still frustrated over the other party's behavior [24].

Thus, when the project is complex and critical, early face-to-face meetings are very effective for team with different cultural [22]. Though the teleconference meeting is a powerful tool in most distributed projects, its functionality is declining due to cultural border limit the number of the participant [24]. Prior study state that the US project manager is able handling projects across distance and time zone, yet their obstacles are regarded with cultural awareness [9]. Although it demands for extra cost and effort to cope this deficit, the effective team implements frequent meeting and travel, detail specification and others [9].

Generally speaking, cultural dispersion affects project performance negatively, such as, lead to excessive time and budget, also costly [9]. Therefore, to maintain good performance, it requires compromised culture from members involved with the project [20]. Where every individual understanding about others' frames of reference when making decision is crucial for project success [20].

3) Organizational

Effective coordination between teams is crucial, in line with team function as a determinant of organizational performance [25]. That is to say, coordination is a main aspect in organizational unit, where coordination is referred as the connector between each task and organizational unit [26].

Whereas, software engineering project may involve member from various organizational unit in a mutual task [19]. Correspondingly, this caused dispersion, as their objective, strategy, structure, and responsibility is different according to their organizational unit [19]. Henceforth, lead to coordination problem when their goal is mismatched and misinterpreted of the tasks [19]. Another issue organizational boundary faced is probably when management lack of experience about service provider, which cause delay and unrealistic in the project plan [16]. In other word, less informal communication in organization dispersion reduces chances to help provide revision with good planning [16]. Although manager can assign developers, their knowledge is limited on developer skill of other organizations, thus raised concern on the ability to develop project within schedule [16]. Despite difficult, organization have to believe the project can be completed in time with quality [16].

In the case where organization co-located expertise of different area, then certainly each cycle of development is conducted at distributed sites [21]. Each cycle created different dependencies, where this is a problem in distributed project especially, to manage each of them [27]. Coordination breakdown in organizational level is likely to happen when decisions do not involve other's decision [28].

Apart from that, the role of project manager also differs based on the organizations which results in confusion [16]. For example, an organization assigns a manager full control of a project, while the service provider organization, assign their manager to other project with no line responsibility [16].

Previous study argues that, good organizational structures that participated many programmers in development will increase the output [29]. Hence, excess work can be invested in design structure [29]. The relationship between organization and software design is very close as stated by Conway law that organization tend to design a system which is a copy of the organization's communication [30].

Although many organizations will improve performance, through help in reducing the risk and bring competitiveness, but it also influences how task coordinated [9]. For instance, in the event where team leader was sent to other sub-organization and required to be responsible for the work of that organization [9]. After all, to achieve better performance, organization boundary demand for extra effort to maintain the coordination between developer.

4) Distance

Effective Media communication has been providing team project with various media in the form of audio, video, text and others [31]. However, geographical distance has impaired interactive communication, hence limited the capability of the team to manage the dependency of task [7].

Interdependencies of tasks require team members to coordinate further distance project, however it will reduce awareness of other's activity from different sites [32][28]. Henceforth, the team member is unfamiliar with the other members and context of distance sites [33]. Thus, less interaction between developer, inhibit their working experience significantly [33]. Additionally, when the team less communicate spontaneously, the task will take a long time to be completed as waiting for the reply and resolve any miscommunication [34]. Prior study found that, technical problem within the project is due to dependencies between task, and lessen coordination [17]. Another study argues, distance certainly accounted for the decrease of project productivity by taking lengthy cycle time to complete the project [17].

Other than impair communication, distance also causing high cost in communication [21]. Due to the high reliance on media communication like a computer, coordination is costly because it tends to miss host of non-verbal cues which effect

message receiving [12]. Besides that, coordination cost also likely to increase in a distance project caused by overhead of multiple management [28]. Nevertheless, it is necessary in the development of project to have multiple management in ensuring projects are always supervised. Other than that, distance also make difficult to judge the individual's expertise, notably at a distance, establishing trust has become crucial in distributed project [16]. This is in contrast with the collocated project as they can judge individual's expertise easily with the gradual interaction [16].

Despite quite costly, the use of various technologies are vital to facilitate communication and improve project performance in project at distance [9]. Thus, although distance is intricated by the interdependence between task, nevertheless they have to coordinate across this barrier to accomplish product as desired by their client [35]. Eventually in geographical collaboration, trust distance team member is said to bring better outcome on the project performance [9].

IV. CONCLUSION

In summary, this paper covers the issues that circulate during coordination in software engineering project. Common issues like time separation, culture, organizational, distance have been affecting project performance since a decade ago. Hence, this finding is significance in order to determine the issues in the spectrum of developer coordination activities in software engineering project. After all, these issues will determine the successful of a project development. Also, this paper contributes to the mapping prior research paper that is published by year. This paper is updating the coordination issues and its impact on project performance. Then, the study will further assess the relationship between socio-technical congruence, which is an approach in measuring developer coordination, and the project performance in the software development lifecycle. Through studies on another aspect of software engineering projects, we will demonstrate the vital role of socio-technical congruence in software engineering project.

APPENDIX

Appendix A
Literature Review Issued

Citation	Author	Year	Topic
[7]	J. A. Espinosa and E. Carmel	2003	The impact of time separation on coordination in global software teams: A conceptual foundation
[8]	K. Nakakoji, Y. Ye, and Y. Yamamoto	2009	Comparison of coordination communication and expertise communication in software development: Motives, characteristics, and needs
[9]	W. Delone, J. A. Espinosa, G. Lee, and E. Carmel	2005	Bridging Global Boundaries for IS Project Success
[10]	J. A. Espinosa and E. Carmel	2004	The Effect of Time Separation on Coordination Costs in Global Software Teams: A Dyad Model
[11]	M. Helander, G. Valetto, and C. Williams	2008	An Analysis of Congruence Gaps and Their Effect on Distributed Software Development
[12]	B. K. A. Metiu	2001	Distributed Knowledge and the Global Organization of Software Development
[13]	C. P. Espinosa, J. Alberto	2006	The Effect of Time Separation on Coordination Processes and Outcomes- A Case Study
[14]	J. A. Espinosa, N. Nan, and E. Carmel	2007	Do gradations of time zone separation make a difference in performance? A first laboratory study
[15]	S. Sarker and S. Sahay	2004	Implications of space and time for distributed work: an interpretive study of US–Norwegian systems development teams
[16]	J. D. Herbsleb, D. J. Paulish, and M. Bass	2005	Global Software Development at Siemens: Experience from Nine Projects
[17]	S.-O. Setamanit, W. Wakeland, and D. Raffo	2007	Software Process Improvement and Practice Using Simulation to Evaluate Global Software Development Task Allocation Strategies Research Section
[18]	J. A. Espinosa, J. N. Cummings, and C. Pickering	2012	Time separation, coordination, and performance in technical teams
[19]	A. Nguyen-Duc, D. S. Cruzes, and R. Conradi	2015	The impact of global dispersion on coordination, team performance and software quality – A systematic literature review
[20]	P. J. Ågerfalk, B. Fitzgerald, H. Holmström, B. Lings, B. Lundell, and E. Ó. Conchúir	2005	A Framework for Considering Opportunities and Threats in Distributed Software Development
[21]	R. E. Grinter, J. D. Herbsleb, D. E. Perry, B. Labs, L. Technologies, B. Labs, L. Technologies, M. V. Drive, and M. Hill	1999	The Geography of Coordination: Dealing with Distance in R & D Work
[22]	J. A. Espinosa, W. Delone, and G. Lee	2006	Global boundaries, task processes and IS project success: a field study
[23]	B. Ramesh, P. Cao, L. Mohan, and K. Xu	2006	Can distributed software development be agile?
[24]	D. Damian, J. Chisan, P. Allen, and B. Corrie	2003	GSD'03 The International Workshop on Global Software Development Session 1: Tool Support
[25]	L. S. Samer Faraj	2000	Coordinating Expertise in Software Development Teams
[26]	G. Software	2001	Tactical Approaches for Alleviating Distance in Global Software Development
[27]	J. D. Herbsleb	2007	Global Software Engineering: The Future of Socio-technical Coordination
[28]	S. S. F. Mohd	2014	Developer Coordination in Software Engineering Projects
[29]	S. Koch and G. Schneider	2002	Effort, co-operation and co-ordination in an open source software project: GNOME
[30]	M. E. Conway	1968	How do committees invent
[31]	J. N. Cummings, J. A. Espinosa, and C. K. Pickering	2009	Crossing spatial and temporal boundaries in globally distributed projects: A relational model of coordination delay
[32]	J. Feller, B. Fitzgerald, S. Hissam, and K. Lakhani	2003	The 3rd workshop on open source software engineering
[33]	J. A. Espinosa, R. E. Kraut, J. F. Lerch, S. A. Slaughter, and J. D. Herbsleb	2001	Shared Mental Models and Coordination in Large-Scale, Distributed Software Development
[34]	J. A. Espinosa, S. A. Slaughter, R. E. Kraut, and J. D. Herbsleb	2007	Team Knowledge and Coordination in Geographically Distributed Software Development
[35]	K. C. Kellogg, W. J. Orlikowski, and J. Yates	2006	Life in the Trading Zone: Structuring Coordination Across Boundaries in Postbureaucratic Organizations

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