

Communication in Distributed Software Development: A Preliminary Maturity Model

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Abstract— This paper presents a preliminary communication maturity model named C2M. The C2M model aims to help organizations to identify the maturity of communication-related aspects and processes providing a tool to reveal what practices need to be improved. The model is composed of three maturity areas respectively organized into factors, goals, and practices. It has been preliminarily evaluated in two steps. First, two focus group meetings were conducted in two organizations aiming to identify how fit the model is to attend its purpose. Second, a diagnosis activity was conducted in two organizations aiming to observe how the model is perceived when used in practice. The experts who participated in the diagnosis activity reported that the application of the model allowed them to become aware of communication issues their teams were facing that they had no knowledge of. Their positive feedback is an initial indication that the model is fit to point out the maturity of communication processes and practices in distributed software projects.

Keywords— *distributed software development; communication; maturity model; empirical study.*

I. INTRODUCTION

Communication is still pointed out as one of the main issues in distributed software development (DSD) [1]. It is well known that, in DSD projects, face-to-face and informal communication frequency is often lower when compared with co-located development [2]. Despite the advances on technology, geographic distance still imposes limitations (e.g., lack of overlapping work hours). Communication, as a social act, is highly dependent of the maturity of the team. Communication processes and practices established by a distributed team, as a consequence, are also expected to mature as the team matures [3]. Therefore, it is important that the team assesses from time-to-time whether its current processes and practices attend its communication needs.

DSD literature is rich in studies about communication; however, most of these studies focuses on the causes and consequences of communication issues and propose practices to minimize them. Little is known on how to identify the maturity of communication, helping team members to identify improvement opportunities. This study aims to fill in this gap. We present here a preliminary version of our proposed maturity model for communication in DSD, named C2M. This model is composed of three maturity areas organized into factors, goals, and practices. It was incrementally developed,

i.e., first informed by literature and then empirically supplemented. Initial findings revealed that the model exposed communication issues that were overlooked by the team members, and that the model could be used as a tool for the promotion of communication improvement in DSD.

II. COMMUNICATION IN DSD AND MATURITY MODELS

Communication is an essential element in software development. It serves the purpose of supporting people working on the same project, by allowing them to share information, to manage knowledge exchange, to solve conflicts, to report to senior management etc. In DSD, team members have to deal with the inherent challenges imposed by distance and, as such, communication becomes an even more critical success factor [4][5].

The type of media (e.g., phone, chat, e-mail) adopted by the team can also affect how communication takes place in a DSD project. Certain media channels such as e-mail are not as rich as others such as phone calls [5]. Despite the richness, the advances on technology allow DSD members to reach one another without having to travel back and forth. In addition to its richness, communication technology can also be a roadblock factor when one of the sites has issues with infrastructure. For instance, power is frequently turned off during Summer time when thunderstorms strike remote locations of Brazil, leaving companies unreachable from a few minutes to a couple of hours in a roll with no previous notice. This unavailability might be wrongly perceived by other colleagues if this contextual awareness is not shared.

Literature also reports other factors that are part of any communication process in DSD (e.g., establishing a common ground in order to allow people to share a mutual understanding of project-related topics [6]) or that affect communication per se (e.g., cultural diversity [7] or lack of trust on remote colleagues [8]). Given its importance, it is expected that teams devote time to assess their communication processes and practices and to reflect upon its improvement needs. We proposed the C2M model as a means to help teams to guide such assessment and improvement communication-related activities.

In parallel, according to Perry et al. [9], the quality of a system or product is widely influenced by the quality of the

adopted processes to produce it. The adoption of quality models is then an organizational strategy to effectively manage its assets, which are, in turn, critical to any business success [10]. A maturity model is a set of good practices that, when properly defined and adopted, can enhance work practices [11]. The maturity itself represents the mastering and the improvement of the practices aligned to the organization businesses. Oliveira [12] adds that a maturity model is a guide for an organization to understand where and how it is regarding a set of practices (or processes) and to subsequently move to a new stage towards continuous improvement and excellence.

C2M is not a surrogate for quality models and should be adopted with other models to maintain the transparency of what is taking place in a project. Its main goal is to relate factors that affect communication in DSD and to allow teams to identify how mature their communication processes and practices are related to these factors.

III. RESEARCH METHODOLOGY

To identify which factors affect communication in DSD and to propose the C2M, we followed the methodological process defined by Dias-Neto *et al.* [13], which proposes a research strategy that combines primary (e.g., case study) and secondary (e.g., systematic literature review) studies as a mechanism to obtain scientific evidences in a specific domain. This methodology can be adapted to any given context considering the particularities of the type of research and the phenomenon under study. Their research strategy has been used in previous empirical investigations (e.g., [14]), and as such, recognized by the community.

Our research methodology, illustrated in Fig. 1, consisted of five steps as follows:

Step 1 included an *ad-hoc literature review* that aimed to obtain the main concepts of the area. It formed an initial background for the research continuity. The knowledge acquired allowed us to prepare a protocol to formally investigate the state-of-the-art of communication in DSD.

Step 2 included a *systematic literature review* (SLR) to identify factors (e.g., cultural differences, geographic dispersion, coordination) and effects (e.g., personal relationships, limited information sharing) of communication in DSD. It allowed us to identify a set of candidate factors to be included in our model. A short version of the findings of this SLR was published in [15].

Step 3 corresponded to an *empirical study* with 22 professionals of 11 organizations that conduct DSD projects. Data were collected via semi-structured interviews. The goal was to revisit the list of factors identified in the SLR and to supplement the list based on experts' experience [16].

Step 4 involved the execution of two *focus groups* meetings conducted in two Brazilian organizations located in city of Recife (Brazil) aiming to preliminarily evaluate the C2M by identifying how fit the model is to attend its purpose. We present the findings and details on the focus group meetings and the experts' background in Section V.

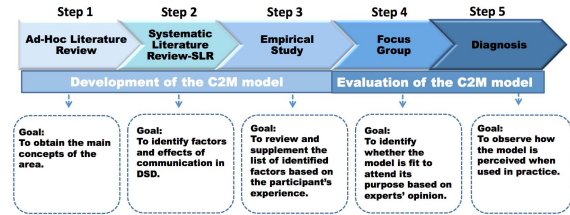


Fig. 1. Our research methodology.

Step 5 involved the execution of the *diagnosis* of communication processes and practices in two other Brazilian organizations, also located in Recife. This was our second step towards the preliminary evaluation of the model, and aimed to identify how the model is perceived when used in practice.

IV. C2M: A PRELIMINARY MATURITY MODEL FOR COMMUNICATION IN DSD

Considering the scope of this research, a maturity model for communication for DSD can be defined as a set of practices adopted by an organization throughout the daily software development activities towards improving communication processes in DSD projects. A preliminary version of our model (*initial version*), the Communication Maturity Model (C2M), is presented in this section.

A. Structure of the C2M

The structure of the C2M model was mainly inspired on the structure of two other maturity models: CMMI (staged representation) [17] and WAVE [10], and it is organized into three major dimensions, namely *maturity factors*, *maturity areas*, and *maturity levels*. In order to reach a level of excellence or quality for communication in DSD projects, it is necessary that a set of *maturity factors* (i.e., groups of related practices and goals), when collectively implemented, meet a certain quality level. However, if the organization is not interested in identifying the maturity level, it can decide which maturity factors are implemented according with its business/strategic objectives.

B. Maturity Areas

Maturity areas are categories that group related maturity factors. The three defined areas are: people, project, and organizational. The *people* area presents human-related aspects. The *project* area is related to managing the entire project and prepping for communication seeking an alignment with the strategic objectives of the organization. The *organizational* area focuses in organizational processes/aspects that should be observed at the organizational level.

C. Maturity Factors

Maturity factors, as previously described, group related practices that, when implemented together, reach a certain goal. A total of 28 maturity factors were identified as presented in Table I. Each factor was analyzed in a detailed way in order to identify associated practices. The maturity factors were initially published in [15] and [16].

TABLE I. C2M MATURITY AREAS AND FACTORS

Maturity Areas	Maturity Factors
People	Cultural differences
	Trust acquisition
	Comprehension of information
	Interpersonal relations
Project	Collaboration tools
	Infrastructure
	Definition of communication media
	Requirements specification
	Configuration management
	Geographic distance
	Temporal distance
	Task distribution
	Selection of communication technologies
	Face-to-face interaction
	Standardization of terms/vocabulary
	Information distribution
	Management of stakeholders
	Allocation of human resources
	Monitoring, measurement and analysis of the project
	Definition of roles and responsibilities
Communication planning	
Management of teams in the project	
Organizational	Continuous improvement of the communication processes
	Perception about the activities and processes
	Language/linguistic barriers
	Coordination
	Communication patterns and policies
Communication training	

D. Maturity Levels

Each maturity level consists of a set of maturity factors that characterize the stage of maturity of an organization regarding communication in DSD. Four maturity levels were defined for the C2M model. *Level 1* is assumed as the **initial level** of any organization, without defined practices. *Level 2* is defined as **partially managed**. The organization usually has basic capabilities, which must be developed to sustain individual abilities to deal with the communication challenges in DSD projects. *Level 3* is defined as **managed**. Individual efforts are driven to reach teamwork, which requires teams mainly aligned to the organization goals. Finally, *Level 4* is defined as **integration**. An organization predicts a constant motivation to improve the performance of each team, since patterns are created and institutionalized in the organizational level (e.g., organizational processes, reports, and media patterns).

E. Goals and Practices

For each factor, a set of practices was defined. A *practice* is an activity that must be met to ensure that the factor will be gradually implemented according to the maturity aimed by the

organization. Each factor has a name and an acronym. In addition, there is a general goal describing its objective. Practices are described for each factor. Such factors intend to show practices of the evolution of the organization's maturity, as well as the understanding of communication planning and effective use of the collaboration tools – among other factors observed in the context of a project with distributed teams and in the context of the cultural differences. Each practice can only be placed in one maturity level.

V. EVALUATION OF C2M

In this section the two-steps evaluation process of C2M model is presented in details. *Step 1* (Step 4 in Fig. 1) consisted of focus group meetings aiming to identify information to improve the model, and *Step 2* (Step 5 in Fig. 1) involved the diagnosis of the maturity of communication in two organizations in order to identify how the application of the model is perceived in practice.

A. Focus Group

C2M was initially analyzed by experts in DSD aiming to preliminarily evaluate it by identifying how fit the model is to attend its purpose by means of two focus groups in order to evaluate the model's *initial version*. For the first focus group, experts should have at least five years of experience in maturity models (or software process improvement initiatives) and at least one year in DSD. In addition, the expert should have sufficient autonomy to answer for a project or a business area of the company. This focus group meeting was executed in a consulting organization where the main business is implementing software process maturity models. The meeting was attended by 7 experts with an average of 8 years of experience in software development. All experts were software quality consultants and had either a Master or a PhD degree in Computer Science. They also had an average of two years of professional experience in DSD.

For the second focus group, experts should have at least five years of experience in DSD and at least one year in maturity models. They should also be able to answer for a project or a business area. We define these criteria to make sure that both DSD and maturity aspects of software processes are properly covered in our model. Invitations were sent out to four organizations and accepted by two of them. This focus group was executed in an organization that develops software projects in DSD context for about 10 years with a total of 6 experts. All experts had a Master degree in Computer Science with experience in DSD.

The same protocol for data collection was followed in both focus group sessions, which were organized as follows: (1) first, it was made a presentation of the C2M model to align the knowledge of all experts; (2) then, the experts were asked what they thought of the model structure; (3) after this step, the experts were asked what they thought of maturity factors; and (4) at the end, the experts were asked what they thought of the C2M model practices. Each topic and subtopic had a limited time for discussion and required that the experts reached a consensus before moving to the next topic. The sessions were moderated by one of the researchers aiming to ensure the pace

of the discussions and a more detailed feedback. Notes were taken, and the sessions were voice recorded and the audio later transcribed for analysis. Next we present the synthesis of the two focus group discussions.

1) *Related to C2M structure*: None of the experts totally disagreed with the effectiveness of the structure proposed by C2M. However, some experts managed to identify that the structure of the model to be flexible and allow for the addition of categories, such as “Product Engineering” to group factors like Requirements Specification and Configuration Management;

2) *Related to C2M maturity factors*: With regards to the maturity factors, none of the experts disagreed on the importance of factors in the context of DSD. However, as a suggestion, it was pointed out the possibility to unifying some similar factors, e.g., Selection of Communication Technologies, Collaboration Tools, and Definition of Communication Media, and then creating others related to the “Product Engineering” category. Respondents who made suggestions have the objective of making C2M more dynamic, light, and easier to use.

3) *Related to C2M practices*: Referring to the practices of C2M, two experts expressed their concerns with the large number of practices in level 2. Their opinion is that the amount of practices can hamper the use of the model in small organizations at first. Another important point raised by some experts is about the identification of the practices. They believe the titles need to be self-explanatory and as such they suggest us to review how we named some practices. It was pointed out the possibility of reviewing some specific practices, aiming to rewrite them or remove others that may be unnecessary.

B. Diagnosis

A second step towards preliminarily evaluating the C2M model was to use it to diagnose the maturity of communication of two other Brazilian organizations, located in Recife. This diagnosis aimed to identify how the application of the model is perceived in practice, i.e. whether the C2M model contributes to the improvement of communication in DSD organizations and what is the cost-benefit realization of its application.

Both companies develop embedded systems. Each diagnosis session, including interviews and analysis of documentation, took an average of four hours. The first organization (*Org 1*) has its projects often globally distributed among Brazil, France, and Singapore. The second organization (*Org 2*) works with projects distributed between Brazil and the USA.

The evaluation process itself included the following activities: (1) to sign up the non-disclosure agreement; (2) to collect artifacts for assessing the organization; (3) to inspect the artifact; (4) to conduct interviews with members of the group; (5) to fill out the evaluation spreadsheet; and (6) to analyze data and generate an action plan. Activity 4 could be repeated if the interviewer/evaluator considers necessary to gather more information.

In the spreadsheet, each practice received a letter by the evaluator. After categorizing the data, the sheet “Consolidated Result” was automatically filled out. This sheet presents some of the following statuses to the practice: “Not Implemented (N)”, “Partially Implemented (P)”, “Largely Implemented (L)”, and “Totally Implemented (T)”, being the last two considered as implemented with success. These definitions were defined based on the CMMI assessment method named SCAMPI [18].

C. Results

We found that *Org 1* has strongly invested in the “Organizational” maturity area, and spent some effort to reach “Projects” maturity area. No additional practices were identified in this organization. *Org 1* obtained the following quantitative result in the evaluation: in “People”, that contains 4 factors and 12 practices, only 3 practices were implemented, covering only 25% of this maturity area; in “Projects”, that has 18 factors and 54 practices, only 27 practices were implemented, covering 50% of this maturity area; finally, in “Organizational”, that contains 6 factors and 18 practices, all the practices were implemented, covering 100% of this maturity area.

Org 2 also invested in the maturity areas “Projects” and “Organizational”, obtaining a better maturity level in C2M. Again, no additional practices were identified in this organization suggesting that the model is self-contained. *Org 2* obtained the following quantitative results: in “People”, that contains 4 factors and 12 practices, only 3 practices were implemented, covering only 25% of this maturity area; in “Projects”, that has 18 factors and 54 practices, only 36 practices were implemented, covering 67% of this maturity area; finally, in “Organizational”, that contains 6 factors and 18 practices, 16 practices were implemented, covering 89% of this maturity area. Therefore, the maturity area that received less attention in both organizations was “People”. However, processes of this area are comprehensive and their efforts for consciousness and preparation of their employees are still incipient. “Organizational” was well explored by both the organizations. On the other hand, *Org 2* got better results in the maturity area “Projects” when compared to *Org 1*. However, although *Org 2* had been more effective, it still lacks effort to attain some factors to the DSD context, e.g., stakeholder management, project monitoring, measurement and analysis, and configuration management in global scale.

D. Discussion

Over the evaluation process, the two organizations said they that created a focal point to facilitate communication between project teams and with clients. This action clearly reduced the overhead of rework caused by the lack of understanding of the delivered requirements for the software development team and the lack of understanding of the activities descriptions. Even during the evaluation process, some difficulties occurred. The most important issues were: *understanding of the factors’ nomenclature* and *understanding of C2M practices*. Regarding the maturity factors, they can take to a wrong evaluation, or to a redundant information, due to similarity (e.g., *Collaboration Tools*, *Definition of Communication Media* and *Selection of Communication*

Technologies), causing an unnecessary overload of activities. About the model practices, it was found that some of them need to be refined in order to be measurable and tangible to be able to generate an organizational asset. In other words, the organizational process assets are the results of the implemented processes in the organization in which the project takes place.

Given these results, it is suggested an improvement in factors' naming conventions and in making some model practices tangible to allow formal evaluation processes in the future. In addition, organizations with different cultures and objectives in fact differently evolve their maturity in DSD. An important perception from interviews was that the evaluation of C2M is simple and can quickly help the organization to find the points of improvement inside the communicational process in a relevant way. So, initiatives to diffuse the model in the industry could be feasible.

VI. FINAL CONSIDERATIONS

Communication in DSD is a challenging activity. In order to help improving communication in such setting, our research proposes a preliminary maturity model for communication in DSD named C2M. This model aims to help organizations that are running DSD projects and want to improve communication processes. C2M was developed first informed by literature, next supplemented from empirical studies. We observed that there are indications that the C2M maps communication aspects of real-life projects and it is feasible to be applied in practice.

The main motivation for the development of C2M was the lack of studies on how to evaluate communication in DSD [2], as well as organizational difficulties in dealing with communication issues in this scenario (e.g., [4][5][10]). This research proposes the first maturity model for communication in DSD. Our work offers the following contributions to DSD industry and academia: (i) we provide a consolidated understanding of communication practices in DSD; (ii) we provide a maturity model to support communication processes in DSD; and (iii) we report on real-case projects demonstrating that the C2M is feasible in practice and can add value to a software organization.

Our study itself has some limitations, which are: (i) the limited number of experts who participated in the empirical study (*Step 3*) and (ii) the reduced number of experts of the focus group meetings (7 and 6). As future work, we intend to use the C2M to evaluate communication in other DSD organizations, identifying how they behave regarding the model's practices. A web-based tool is also pointed out as a future work aiming to allow organizations to conduct their own diagnosis (*gap analysis*).

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