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Challenges in Geographically Distributed Information System Development: A Case Study

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Abstract—Geographically distributed information system development (ISD) projects are more and more common, especially among organisations operating in global markets. Distributed ISD yields potential competitive advantages by developing new products near the target markets, utilizing global labour markets, and exposing the organisation to innovations, ideas and new paradigms. However, distributed ISD also presents challenges and problems which organisations must take into consideration. The pivotal challenge is usually communication. People working on the same project in different locations find it difficult to communicate due to lack of formal and informal face-to-face communication, different working cultures and languages, and time difference. In this study, we set out to investigate what challenges may rise in geographically distributed ISD, and how these challenges and problems of geographical distribution could be mitigated.

Index Terms—information system development, challenge, geographical distribution, global software engineering, nearshoring

I. INTRODUCTION

Information systems are not merely tools, but have a fundamental effect on how a business operates [1]. It follows that the design, use and support of said systems is crucial [2]. Geographical distribution of development (as opposed to centralized, i.e., colocated) has become common [3], [4], and by the end of 1990s, development practices and technological advances had also made it possible to develop systems in small increments [5].

Geographical distribution has been shown to bring numerous benefits to organisations [6], [7], but distribution is not without challenges [3], [4]. For example, cultural differences [8], lack of communication [9], and trust issues [10], [11] are studied phenomena which hinder development, even more so in a distributed setting. Inspired by the recent technological changes in communication, and the rapid emergence of specialized tools, we set out to investigate *RQ1*) what challenges employees face in a geographically distributed information system development (ISD) project, and *RQ2*) how employees have tried to mitigate these challenges. The study was carried out in a large global organisation by interviewing employees who had participated in a geographically distributed ISD project.

The rest of this study is structured as follows. In the next Section, we discuss relevant prior literature, and in Section III

we describe our data collection and analysis methods. In Section IV we present the results of our analysis, and in Section V discuss our findings in the light of previous studies, as well as threats to validity and future research avenues. Section VI concludes our study.

II. GEOGRAPHICALLY DISTRIBUTED DEVELOPMENT

A. Characteristics

Geographically distributed development refers to information system development which takes place in several physical locations, often in different countries [3]. In the context of this study, the distribution could be further characterized as nearshoring – only national and organisational borders are crossed, but the teams work in the same time zone [12]. Prior literature has identified a number of characteristics related to distributed development, in contrast to colocated development.

First, studies have noted that the role of informal and wanton communication is significantly diminished [13] [14]. Another study [14] has further highlighted the importance of informal communication with agile development methods. Second, if the development teams work in different time zones, it is possible that all teams members cannot communicate synchronously, e.g., via phone calls [13]. Third, social hierarchies may be emphasized, as teams communicate with each other via set liaisons, and not necessarily directly with people involved in a particular task [13]. Fourth, the forming of social bonds and trust usually takes longer, as employees lack informal communication [13]. This consideration was more highlighted in the past, when synchronous ways of distance communication were limited to phone calls [15]. In addition to social effects, it has been proposed as early as 1968 that the system design will reflect the organisational communication structures [16]. If these structures are distributed rather than colocated, it might have an effect on how the developed system eventually works.

B. Benefits

The reasons for geographical distribution are multifaceted, and many prior studies have identified similar benefits. For example, a set of studies [2], [13] discussed more extensive employee pools as a potential benefit – organisations can recruit workers from cities and countries where the employees

live, thus potentially expanding available workforce, and hiring more suitable workers. Furthermore, distributing development to locations where e.g., workforce, infrastructure, or resources are cheaper can serve as a financial benefit [15], [17].

By moving development geographically close to target markets, teams may benefit from local workforce, who may offer insights on cultural differences, and who understand the local customer better [2], [13]. The diverse employee backgrounds is one of the key components towards successful localisation and further product innovation [15], [18].

While a colocated development project usually has relatively set working hours, geographical distribution through time zones enables working around the clock [2], [13], [19]. Although this presents some challenges to communication, system progression is not limited to, e.g., day time in one time zone. Finally, it has been pointed out that smaller teams can react faster and have more flexibility than a large organisation, and it is typical that the geographically distributed teams are working units in themselves [18].

C. Challenges

Although a number of potential benefits have been reported, geographical distribution also introduces several potential and realised challenges to the development process [20], [21]. Based on prior works, we identified five prominent challenges specific to (or emphasized in) geographically distributed ISD. First, it has been noted that physical distance negatively affects *communication* [4], and that the role of informal communication is emphasized [13], [18]. On the other hand it has been highlighted that people in different roles should communicate with each other, even if their communication might seem nonessential, to form a more holistic understanding of what is being developed [22]. Communication, in fact, has arguably received the most scholarly attention in regards to distributed development [23].

Second, the *management* of goals, processes, standards, and quality requirements is more difficult with distributed ISD [4], [14], [24], which is a result of the fact that there simply is more to manage [24]. Furthermore, a study noticed that globally working organisations tend to manage processes similarly to colocated organisations [20]. This, in turn, propounds the question of whether in distributed ISD, local management is less controlled.

Third, *coordination* is the effort to control interdependent components in the ISD project [25] (as presented in [26]). When development teams are distributed, the role of coordination is emphasized [18], [26]. Additionally, as reported in [13], distributed teams risk drifting into organisational silos, interpreting requirements, and implementing and testing features without appropriate knowledge of the other teams. Although it has been noted that project planning and documentation potentially remedy problems with coordination [13], [27], the growing trend of shorter and shorter iteration cycles [28] diminishes the effect of this remedy. It has also been reported that junior developers struggle with agile methods [29], [30], although using an agile approach over a plan-driven method

in a geographically distributed ISD project is not without dissenters [31].

Fourth, it has been discovered that *cultural differences* are among the most prevalent challenges in distributed ISD [32]. While cultural differences are potentially beneficial, as discussed in the previous section, virtual work spanning over different cultures causes social challenges [18], [33]. One of the most axiomatic cultural difference is the potential for the lack of a common language. In these situations, it is possible that all employees must communicate in a language other than their native language.

Fifth, issues regarding *trust* have been identified as a major challenge in distributed ISD [13], [14], [18], [19]. Without face-to-face communication, suspicion and distrust were reported towards team members in other geographical locations. This, in turn, begets antipathy towards informal communication – which, in turn, would remedy distrust – and information sharing, consequently slowing down project work [34]. These five challenges form a high level framework of challenges, which is the basis of our analysis reported in Section III-B.

III. METHODOLOGY

A. Data Collection

The data collection process was conducted through semi-structured interviews. The interviewees worked in a large international company specialized in credit management, and the ISD project subject to this study was distributed to teams in Finland and Latvia. The system was an accounts ledger management system, and developed in-house. We chose the interviewees based on select criteria. First, the interviewees were selected among employees who had the most work experience in the project. Arguably, as time spent on a project increases, the number of challenges related to geographical distribution decrease, and the most persistent challenges remain, whereas an employee new to the project may face more challenges. Second, we wanted to capture challenges from different perspectives in terms of job description, and chose to interview employees with different backgrounds. The titles of the interviewees included project manager, Scrum Master, software developer, requirements engineer, tester, and IT expert. Job titles are not directly linked to the interviewees to preserve promised anonymity. Third, we interviewed employees from both Finland and Latvia.

The structure of the interviews is presented in Table I. Some of the interviews were conducted face-to-face, and some over video conference calls (Table II). In cases when an interviewee was not able to formulate challenges related to geographical distribution, we guided the interview by asking opinions about challenges we had identified in existing literature. Although such guidance is typical for semi-structured interviews, we followed the guidelines of not giving the impression of knowing the topic, which could have lead to interviewees not discussing challenges they perceived self-evident [35].

TABLE I
STRUCTURE OF THE INTERVIEWS

Question or topic	Purpose
Begin the interview; promise anonymity; investigate interviewee background	Orientation for the interview
"What kind of challenges has geographical distribution of the system development project presented during the project?"	Answer RQ1
"How, in your experience, have these challenges been addressed during the project?"	Answer RQ2
"How would you say the project has succeeded as a whole?"	Discover additional insights
Announce that the interview is ending	End the interview

TABLE II
INTERVIEWEES AND INTERVIEWS

Interviewee	Works in	Language	Method	Duration (min)
1	Finland	Finnish	video call	15
2	Finland	Finnish	face-to-face	19
3	Finland	Finnish	face-to-face	15
4	Finland	Finnish	face-to-face	29
5	Finland	Finnish	face-to-face	22
6	Finland	Finnish	video call	21
7	Latvia	English	video call	28
8	Latvia	English	video call	16
9	Latvia	English	video call	20
10	Latvia	English	video call	14

B. Analysis

The interviews were transcribed for analysis. Due to different levels of preconceptions regarding the research question topics, we used two different analysis methods to analyze the data. Based on the *a priori* literature review on the challenges of geographically distributed ISD, we formulated a high level framework of different challenges. This framework (Section II-C) served as a structure for directed content analysis, which we utilized in analysing the interviews in regards to RQ1. Directed content analysis [36] approaches a topic with preconceived insights, and is typically used when existing literature is perceived incomplete. We had identified five challenges, which in turn formed the starting point of our analysis: communication, management, coordination, cultural differences, and trust. When we discovered a concept in an interview not fitting these challenges, we formed a new category.

Conventional content analysis [36], in contrast, approaches a topic with as limited preconceptions as possible. Before the interviews, we were not familiar with ways to mitigate the challenges arising from geographically distributed ISD, and did not know what types of challenges would arise in the analysis for RQ1. For RQ2, we utilized conventional content analysis for uncovering the strategies to combat the challenges. For both analyses, the first author analyzed the interviews and formulated the challenges and their mitigation techniques, complemented by a brief description of each. For RQ1, the analysis was based on the high level framework identified in

TABLE III
QUOTATIONS REGARDING COMMUNICATION CHALLENGES - THE FIRST COLUMN REFERS TO THE INTERVIEWEE NUMBER CORRESPONDING TO TABLE II

#	Quotation
4	People do not answer questions [...] communication descends into monologues.
9	There was no direct communication between the people who made the software and the people who actually make the requirements.
8	[...] there were huge gaps in communication.
2	If we all worked in the same place, we could communicate much smoother.
4	It raises the threshold a lot when I must always start a Skype call to speak to someone.
7	[...] written form can be sometimes misleading [...]
2	If you want versatile communication, it is difficult when you must do it in English.
3	When the person you're talking to answers "yes", one kind of assumes that they understood. But that was sometimes far from the truth.

the literature review, and for RQ2, the analysis was based solely on the interviews. After the initial coding, the second and third author reviewed and discussed the concepts. Any discrepancies were discussed until all the authors agreed on the categories, their meaning, content, and scope. Although the interviewees discussed similar concepts with various terms, we strived to understand meanings behind terms, and group them accordingly. Some concepts contributed to more than one category, i.e., there is a level of overlap between the challenge categories.

IV. RESULTS

A. Challenges

In addition to the five challenge categories discovered from prior works (communication, management, coordination, cultural differences, and trust), we identified two novel categories based on the interviews: tools and processes, and time allocation. Next, we discuss these challenges and provide quotations from the interviews.

Communication. In previous studies, communication has probably been the most prominent challenge in geographically distributed ISD projects. This was the case according to the interviews, too. A salient feature regarding communication was that the interviewees seldom mentioned communication challenges in isolation. Rather, communication challenges often realised as problems in other aspects of development. Based on the interviews, we characterized communication challenges with the following codes: lack of communication, lack of face-to-face communication, misinterpretations, slow communication, language barriers, lack of suitable communication tools, and lack of quality in communication tools. In this particular case, the teams communicated with each other in English, but English was not the native language for either of the teams. Quotations for communication challenges are presented in Table III.

Management. Geographical distribution presented challenges to project management. Based on the interviews, the

TABLE IV

QUOTATIONS REGARDING MANAGEMENT CHALLENGES - THE FIRST COLUMN REFERS TO THE INTERVIEWEE NUMBER CORRESPONDING TO TABLE II

#	Quotation
3	There has been misunderstandings on the distribution of work tasks.
6	Even for project managers, it was unclear who is supposed to do what.
3	We had different understanding on how the working methods should be implemented.
2	If one manager needs to travel to meet the other, it always takes one day during which nothing happens [...]
2	[...] it is difficult to see what is going on in the big picture [...] difficult to distribute supervision [...]

TABLE V

QUOTATIONS REGARDING COORDINATION CHALLENGES - THE FIRST COLUMN REFERS TO THE INTERVIEWEE NUMBER CORRESPONDING TO TABLE II

#	Quotation
3	Not sitting around the same physical table makes coordination more difficult.
5	Business or system analysts interpreted our requirements, which were then translated to software developers and that turned out to be a game of broken telephone in the end.
4	[we] seldom know who to approach [with a question]
4	[...] they had developed something we did not even know about.
5	It has been very difficult to communicate the business needs and requirements to the other team.
9	[...] there was no direct communication between the people who made the software and the people who actually make the requirements.

distribution of project management resulted in employees working on managerial tasks even though it was not a part of their job description. Based on the interviews, we characterized management challenges with the following codes: lack of common direction, delays, and distribution of management. Quotations for management challenges are presented in Table IV.

Coordination. Project coordination challenges had a relatively large overlap with the challenges regarding communication and management. Based on the interviews, we characterized coordination challenges with the following codes: misunderstandings, slow communication, language challenges, lack of knowledge transfer, and unsuitable work processes. Quotations for coordination challenges are presented in Table V.

Cultural Differences. The interviewees had relatively subjective viewpoints on what types of challenges cultural differences presented, and whether they presented challenges at all. Although the two locations had no time difference due to the same time zone, working hours were different. In Finland, it was common to work from 8 AM to 4 PM, whereas employees in Latvia preferred working in the evening. Based on the interviews, we characterized challenges arising from cultural differences with the following codes: language differences and different levels of English skills, lack of informal meetings, different working cultures, and different working hours. Quotations regarding cultural challenges are

TABLE VI

QUOTATIONS REGARDING CULTURAL DIFFERENCE CHALLENGES - THE FIRST COLUMN REFERS TO THE INTERVIEWEE NUMBER CORRESPONDING TO TABLE II

#	Quotation
2	[...] not working on either team's native language surely affects.
9	[...] the different levels of English can be a bit challenging sometimes
1	We did not get to know each other.
3	[...] their working culture seemed more bureaucratic and roles were strictly hierarchical.
5	The other team started work later and worked much later into evenings than us.

TABLE VII

QUOTATIONS REGARDING TRUST RELATED CHALLENGES - THE FIRST COLUMN REFERS TO THE INTERVIEWEE NUMBER CORRESPONDING TO TABLE II

#	Quotation
2	We did not have a very clear understanding of how they performed over there [...]
5	We did not know what the other team was doing in the current sprint, what had been completed, or what issues they have had.
4	We just formulated the high level requirements over here and delivered them over there. Then we did not hear from them for a long time.
4	They had implemented something no one had commissioned.
10	At the beginning, I think we were tiptoeing around each other and it took a longer time [than it would have in a shared workspace] to get to contact.

presented in Table VI.

Trust. The interviewees perceived that geographical distribution impeded the forming of trust between the teams. For example, the lack of meeting co-workers face-to-face was seen to undermine trust and common understanding of common problems and how to solve them. Additionally, project managers were not able to supervise work efficiently from remote locations. Based on the interviews, we characterized challenges related to trust with the following codes: lack of face-to-face communication, distribution of project management, not getting to know one's coworkers. Quotations regarding trust are presented in Table VII.

Tools and Processes. A new category of tools and processes emerged from the analysis of the interviews. These concepts, e.g., communication and data management tools, and decision support and project management frameworks lie at the heart of ISD projects, distributed or otherwise. Based on the interviews, we characterized challenges related to tools and processes with the following codes: low quality tools, lack of tools, and unsuitable processes. Quotations regarding tools and processes are presented in Table VIII.

Time Allocation. The other new category of challenges discovered from the analysis was related to time allocation with meetings, communication, and productive work. On a general level, time allocation is related to work tasks which would be time-wise non-significant in a centralized environment, but which are slow with distributed development. Based on the interviews, we characterized time allocation challenges

TABLE VIII

QUOTATIONS REGARDING CHALLENGES WITH TOOLS AND PROCESSES - THE FIRST COLUMN REFERS TO THE INTERVIEWEE NUMBER CORRESPONDING TO TABLE II

#	Quotation
4	We always relied on Skype, phone calls, email and Slack even though we should have been physically present.
2	It is not possible to arrange workshops where one could just use post-it notes [...]
4	We had no means of communicating with the software developers.
8	Team even had to work from documentation first kind of approach where everything should be described [...]

TABLE IX

QUOTATIONS REGARDING TIME ALLOCATION CHALLENGES - THE FIRST COLUMN REFERS TO THE INTERVIEWEE NUMBER CORRESPONDING TO TABLE II

#	Quotation
4	The system had received additional features which we had not commissioned, and the other team had used work hours in a sprint to implement those [...]
10	The meetings took more time because everyone was so busy and everything had to be agree upon beforehand.
1	[...] takes a couple of hours or a day before you can sort out a single thing and that slows things down.
9	Common understanding would be reachable much faster and answers would be much faster if somebody could just stand up and talk or walk to the other room.

with the following codes: lack of knowledge transfer, different working hours, and difficulties in finding mutual time slots. Quotations regarding time allocation challenges are presented in Table IX.

B. Mitigation

Using conventional content analysis, we identified three techniques the interviewees had used or had seen used to mitigate the challenges presented by geographically distributed ISD. The analysis revealed three techniques: increasing the number of meetings and visits, process improvement, and tool development. Next, we discuss these techniques in more detail, and present quotations representative of each technique in Tables X, XI, and XII, respectively.

Increasing the Number of Meetings and Visits. Almost every interviewee mentioned that the number of meetings and visits was continuously increased during the project. Employees were encouraged to use different virtual ways of communication, even with informal meetings, and contact people directly involved with the issue, rather than set liaisons, to decrease bureaucracy. We characterized this mitigation technique with the following codes: increasing visits, emphasizing direct ways of communication, encouraging discussion, and increasing the number of meetings.

Process Improvement. At the initial stages of the project, a more traditional, plan-driver framework was used, and the most notable improvement regarding processes was perceived to be the implementation of the Scrum development framework. Effectively, the implementation of Scrum realised in a

TABLE X

QUOTATIONS REGARDING THE INCREASE OF MEETINGS AND VISITS - THE FIRST COLUMN REFERS TO THE INTERVIEWEE NUMBER CORRESPONDING TO TABLE II

#	Quotation
4	[...] increase the number of visits here and there, in turns.
4	Slack was used to facilitate communication with the software developers.
5	Scrum Masters have tried to communicate to the developers that they should ask questions when they arise.
8	We don't use any kind of additional layer here in Riga to communicate [...] we then communicate with the business we have a direct communication channel [to]
2	[...] regular demonstrations via video calls [...]
5	Well, demonstrations during which they demonstrated the features implemented [...]

TABLE XI

QUOTATIONS REGARDING PROCESS IMPROVEMENT - THE FIRST COLUMN REFERS TO THE INTERVIEWEE NUMBER CORRESPONDING TO TABLE II

#	Quotation
4	Twice a week we have a so-called refinement, in which we discuss what needs to be improved.
5	We have a sprint retrospect at the end of each sprint now.
4	Now teams have more clear responsibilities and we know who to contact.
3	[...] we deal with smaller parts of the problem now [...]
7	Well, it (Scrum) were implemented to try to save the project [...]
2	[...] now they require good English skills in the recruitment.
1	[...] hired new QA specialists.
6	We investigated unambiguously who is the product owner, and decided with the executives who is the project manager responsible [...]

more efficient recruitment strategy, improved software testing conventions, and streamlined project management. We characterized this mitigation technique with the following codes: improving ways of communication, the implementation of agile methods (i.e., Scrum), more efficient recruiting, improved testing, and streamlined project management.

Tool Development. We discovered five techniques related to tool development which were utilized to mitigate the challenges: adding ways of direct (i.e., synchronous) communication, implementation of data and test management tools, and new communication channels. Employees were encouraged to utilize Slack, and Skype with video to increase personal input in conversations. In the beginning of the project, documents were mainly stored as Microsoft Excel files and sent via email. Later, this was replaced with Confluence and Jira tools, and testing was refactored into TestRail test management system.

V. DISCUSSION

A. A Comparison of Results

The analysis regarding challenges in geographically distributed ISD (i.e., RQ1) supported findings of previous studies reported in Section II-C, as all previously reported challenges were mentioned by several interviewees. Additionally, the analysis revealed two new categories, tools and processes, and time allocation. The new categories provide timely insights

TABLE XII

QUOTATIONS REGARDING TOOL DEVELOPMENT - THE FIRST COLUMN REFERS TO THE INTERVIEWEE NUMBER CORRESPONDING TO TABLE II

#	Quotation
3	Now we use Skype with video calls [...] more non-verbal communication.
5	We have now used Slack to communicate more quickly.
9	We actually started to use Slack more intensively and a real way try to use email not so much because it's such a delayed conversation.
1	Sure now we have Trello boards and Scrum and agile tools from Jira.
4	I don't think we had much more than email and Excel at the beginning of the project, and using Jira and similar tools was not the case [...]
7	[...] we've been using Confluence, Jira, Microsoft Lync or Skype how it is called, also the Slack [...]
5	TestRail in testing, test documents were in Excel in the beginning, very laborious and difficult, and then we got TestRail.

collected by closely working in the distributed ISD project. Although not mentioned by the interviewees, the emphasis of concerns for the lack of suitable (especially communication) tools may reflect the techno-social leaps in recent years. If employees are more and more used to more synchronous ways of remote communication in their personal lives, potential lack of tools of similar level in professional environments may be perceived as a challenge to effective communication – an issue touched also earlier [2], [3]. Regarding the challenge of time allocation, the organisation subject to our case study utilized nearshoring with no time zone differences. However, cultural differences in working hours resulted in limited shared working hours between the two locations. These observations provide confirmatory evidence on similarities between offshoring [37] and nearshoring, regardless of time zone differences.

The three techniques for mitigating the challenges in geographically distributed ISD (i.e., RQ2) were derived from the interviews rather than from prior studies. *A posteriori* comparison of results appears to validate the techniques. For example, several studies have stressed the importance of communication in distributed work [4], [34], [38], as well as suitable communication tools [34]. Regarding the technique to process improvement, the formulation of communication protocols, allocation of responsibilities, and unified quality standards, all of which were discovered in our analysis, although using different terms, have been proposed earlier [38]. Finally, tool development has also been discussed earlier [38], [39], and the shift from unsuitable and general to specialized tools during the ISD project subject to this study was apparent based on the interviews, as were the perceived benefits of said shift.

B. Limitations and Threats to Validity

As it is typical for a case study, only employees from one organisation working in a single project were interviewed. This might affect the generalizability of the results to broader contexts, for example, to geographically distributed projects spanning multiple time zones. A case study, however, typically provides more in-depth look into a topic. Furthermore, a

narrower scope does not necessarily imply weaker research [40]. The relatively low number ($N = 10$) of interviews might be perceived as a limitation. However, our results show a certain level of saturation in both the challenges and mitigation techniques, implying that increasing the number of participants might have had no significant impact on the qualitative content analyses in terms of new challenges or mitigation techniques.

Hsieh and Shannon [36] discuss several threats to validity concerning content analyses. Arguably the most severe threat to directed content analysis are the preconceptions of the researchers. We tried to mitigate this threat by conducting a semi-structured interview, and thus allowing the interviewees verbalize their thoughts with minimal input from us. In terms of conventional content analysis, the failure to formulate understanding of the whole phenomenon under study is considered as one of the main threats. As the first author of this study is part of the organisation subject to this study, his prolonged exposure to the research topic provides validity to the results. Furthermore, as explained in Section III-B, we used multiple coder triangulation to further validate the results.

C. Future Agenda

At the time of writing, the COVID-19 global pandemic has forced national employees to remote work, and closed a large portion of international travel. Arguably, the situation facilitates even faster technological and social changes in remote communication. We believe that from a research perspective, distributed ISD deserves a revisit in order to more timely account for the changes in technology and communication culture.

VI. CONCLUSION

In this study, we set out to map challenges introduced or emphasized by geographically distributed information system development, and explore how these challenges were mitigated. Our results provide evidence supporting previous findings, and complement prior observations by offering timely insights on the importance of tool and process development, and time allocation concerns in distributed development. These discoveries may be utilized, for example, *in research* by further developing the models and theories related to geographical challenges, and as a starting point for measuring the effectiveness of discovered mitigation techniques; *in industry* by preparing for the discovered challenges prior to geographical distribution; and *in teaching* by emphasizing communication skills, the importance and iteration of processes, and the use and development of suitable tools in capstone and other project based courses.

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