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A Case Study of Distances in a Large Co-Located Software Development Organisation

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ABSTRACT

Communication and collaboration is a major challenge for large-scale software development. Cognitive and psychological distance between individuals and teams affect this collaboration and can cause communications gaps. We propose a novel method for assessing distance between teams, and explore potential explanations for these distances. In an exploratory case study of the quality assurance department at Axis Communications, we used interactive posters to collect data and obtained a 52% response rate from the 175 test engineers. We identified low psychological distance as an indicator of a company culture with open and frequent communication, and of a team with good social networking skills and well-functioning points of contact. We found that low cognitive distance is an indicator of differences regarding the responsibilities of a team; within the same system and between different types of systems. We also found correlations between psychological and cognitive distance. Large organisations may apply our concept to assess distance between teams, and our finding can be useful in interpreting these distances. Furthermore, our results provide a basis for further research on how the concept of distances can be used to assess collaboration within large organisations.

CCS CONCEPTS

• Software and its engineering → Software organization and properties • Human-centered computing → Empirical studies in collaborative and social computing

KEYWORDS

software development, collaboration, communication, organisational management, distance

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1 INTRODUCTION

Distance affects project communication within global software engineering [1] and within co-located development spread over different buildings and floors [6]. Even sitting further down the corridor has a negative effect on communication frequency [2]. A distance can also be cognitive or psychological in nature and affect the amount of effort required for software development [5]. For example, ensuring common understanding of goals and requirements requires more effort when team members have different domain knowledge. Cognitive distance can also cause misunderstandings and missed requirements [6].

Our research is part of a long-term collaboration between Lund University and Axis Communications on collaboration within large-scale software development, in particular between requirements engineering and testing. We have previously found that human factors, in particular communication is one of the main challenges in achieving good alignment between software engineering activities [4]. We have also identified that distance between software engineers "requires effort to traverse to accomplish a software development task" [5]. Furthermore, we have found that the concept of distance is useful for considering root causes of "communication gaps and improvements to development practices" [6] and may support stakeholders in understanding each other [21].

In this paper, we present an exploratory case study performed at Axis Communication to investigate how to operationalise our previous research to improve the communication and collaboration within a large co-located development organisation. The goals of this study were to explore

- how to assess cognitive and psychological distance, and
- what this can tell us about a team's ability to collaborate.

The case study uses interactive posters [13] as its main data collection method where the respondents marked their views by placing stickers on the provided posters. Interactive posters are described in Section 2 and other related work in Section 3. The case company is described in Section 4, our research method in Section 5, and results in Section 6. We conclude in Section 7.

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2 INTERACTIVE POSTERS

Interactive posters allow participants to respond by placing stickers or notes on posters and can be superior to surveys in collecting large amounts of responses and in facilitating interaction with participants [13]. Diebold et al. performed and compared an on-line survey and with an interactive poster. The poster by far elicited more data even with more potential survey respondents (more than 2,000 compared to 350). They also identified other differences between these data collection methods, in particular regarding collecting contextual information, the risk of biasing participants, ease of access to respondents, managing the empirical data, and ease of eliciting additional insight from respondents.

Surveys were found to be superior regarding the gathering of detailed contextual information although it is possible to design posters to obtain basic contextual information. While survey questions can assess participants' background etc., these possibilities are limited for interactive posters. This is mainly due to the limited amount of space available on a poster. However, when using the poster concept, participant background can be obtained through use of different posters for different respondent groups, or by asking respondents to distinguish their responses by using colours to represent respondent groups (e.g. coloured stickers). Diebold et al. recommend learning about the targeted population for an interactive survey beforehand to include this in the design of the data collection method.

There is a risk that participants are biased and influenced by seeing how others respond to an interactive poster. This is not the case for surveys, where the respondents do not see each other's responses. However, Diebold et al. observed that some participants made an effort to contribute with responses that were different from those already on the poster. They conclude that the risk of biasing participants is an aspect to consider in the design of the poster and to balance against the possibilities of obtaining larger amounts of data with this method. Furthermore, we believe that the context in which interactive posters are used affect the risk of bias and that the culture among participants and the physical location of the poster need to be considered. For example, the risk of biased responses may be lower in a culture that encourages openness and respect for different opinions.

Diebold et al. found that it was easier to gain responses for an interactive poster than for an on-line survey and provide explanations for this. It is easier to access a physical poster than an on-line survey. The poster covered less questions and did not require much effort to participate in and the practitioners could do this during a break without requiring taking time from work tasks. Diebold et al. also observed that it was easy to motivate people to participate in the interactive poster and that existing data on the poster encouraged participants to respond. Furthermore, the targeted population in Diebold et al's study were agile practitioners who are familiar with the interactive approach used in the posters using physical boards, stickers etc.

Managing the empirical data of an interactive poster requires more effort than that of an on-line survey. The responses on a poster need to be transferred to a medium that allows for data analysis. This requires effort and poses a risk of incorrectly transcribing the data. A poster also poses limits regarding the number of questions. Diebold et al. recommend one to three questions. There is also a physical limitation to the amount of stickers that can be placed on a poster. When designing an interactive poster, these limitations need to be considered.

Diebold et al. also found that an interactive poster facilitates eliciting additional insight from respondents beyond the questions posed on the poster. This was the case both with and without researcher monitoring. In their study, they found that the poster triggered participants to discuss the data with each other while responding, and thus allowing an observing researcher to obtain a richer insight into their view points and responses.

3 RELATED WORK

3.1 Communication and Collaboration

The interaction and communication between individuals and teams plays a vital role in coordinating and aligning the various project activities towards producing a software product that matches the customers' requirements [3][17]. This is a challenge within software development in general [14] and in particular within market-driven [16], large-scale [9] and distributed [7][10][24] development. The coordination of marketing and development roles within market-driven development is impeded by weak common views on the role of and need for requirements details, lack of common vocabulary, unclear responsibility for requirements specification and analysis, and dependencies on individuals [16]. We have found similar challenges in aligning RE and testing activities to ensure that the released software matches the requirements and the customer expectations [4]. For large and complex development settings, these challenges increase, and Kraut and Streeter argue that a combination of formal and informal communication is required to cope with uncertainties and changes [17]. For distributed development where informal communication is limited, most of the reported problems are related to communication, e.g. missing context, weak awareness and missing document information [24]. Awareness of one another's work is important since it leads to information sharing and knowledge gain [12]. Lack of knowledge of on-going activities can hinder a correct assessment of the impact of changes, cause misunderstandings about requirements and reduced trust and productivity in a development team [11].

Requirements communication has been researched using social network analysis thereby identifying communication patterns and roles vital for effective requirements-driven collaboration within software development [19][20] and awareness of communication paths has been suggested to improve the information transfer [18]. Marczak et al. found that the information flow is largely controlled by a few information brokers who through extensive experience of an organisation and its members can bridge communication gaps [19].

Methods for mapping requirements flows have been used to identify bottlenecks and missing communication between key roles [24]. Stapel et al. propose an approach to managing information flows named FLOW Mapping. FLOW Mapping entails capturing the information needs of a project, developing and implementing a communication strategy covering both formal and informal channels, and then monitoring and measuring adherence to this strategy. Schneider and Liskin explore the use of distance measures based on FLOW mapping as an indicator for project communication dynamics [23].

In this study, we explore an alternative approach in mitigating communication gaps. Rather than map and analyse the information flow or consider known challenges for weak communication and coordination we investigate the concept of distance as an underlying cause of communication gaps. In our previous work on generating an empirically based theory of distances [5] we found indications that when there is a long distance between people and between artefacts this has a negative effect on the communication and coordination.

3.2 Distance in Software Engineering

Geographical, temporal and socio-culture distance has been explored within global software development [1][15]. Research indicates that distributed development is less effective and requires more cycle time compare to co-located development [15]. Even within co-located development, communication frequency drops to that of distributed development already at a distance of 30 metres between offices [2].

The theory of distances for software engineering [5] identifies eight types of distances for software engineering, namely distances between people, between artefacts and between activities. The distances between people are

- **Geographical**. The physical distance between workplaces. This distance can cause delays and misunderstandings in the communication and coordination with distant team members.
- **Organisational**. The distance between people's placement within an organizational structure, e.g. level within a hierarchy of units and departments. Organisational distances can cause difficulties and delays in decision-making, e.g. concerning conflicting views on which requirements to support.
- **Psychological**. The perceived effort to communicate with someone. Psychological distance can cause reluctance to communicate and conflicts and difficulties in agreeing.
- **Cognitive**. The difference in knowledge, competence and understanding between people. For example, when a development team has less domain knowledge than a product owner this can lead to misunderstood and missed requirements.

The artefact-related distances are

- **Adherence**. Differences between the contents of an artefact (e.g. requirements specification) and the actual situation (e.g. produced software).
- **Semantic**. Differences in meaning for two related artefacts, e.g. between a requirements specification and test cases that can indicate conflicting views, or failure to update the artefacts.
- **Navigational**. The distance required to navigate between related parts of artefacts, to perform activities such as impact analysis, test coverage etc.

Finally, the activity-related distance is

- **Temporal**. The difference in time for performing related activities, e.g. defining, verifying and validating a requirement.

4 CASE DESCRIPTION

Axis Communications is a company that offers intelligent security solutions and network products based on an open platform. Axis has over 2.800 employees, with about half of these based in Lund, Sweden. The majority of research and development (R&D) is based in Lund. The R&D unit covers a wide range of fields, from mechanics and electronics to embedded firmware to server software and mobile apps.

There is a Quality Assurance (QA) department within R&D that provide testing for the different R&D departments. The QA department employs about 170 test engineers organised into ten test teams. These teams are responsible for testing either products such as cameras and hardware, or systems including client software for these products. In addition, there is a team that supports the other teams with tools, test environments etc. All of the teams work closely with a development team, while it is also important to organise the test teams within a common department. See Table 1 for a description of the teams.

Table 1: The test teams included in the case study, testing targets, team size and members with senior titles.

Team	Responsibilities	#senior / total
Camera 1	Camera products *This team works in camera development projects*	3 / 20
Camera 2	Video products and future technologies *Consists of two smaller teams.*	2 / 18
Camera 3	Firmware platform for all video products	4 / 19
Camera 4	Firmware platform for all video products	1 / 19
NOTE: Camera 3 and Camera 4 used to be one joint team, but were split into two team as the numbers increased		
Non-video devices	Audio systems and physical access control	*1 / 22*
Client 1	A cloud-based client	2 / 14
Client 2	A video client for small businesses and mobile applications.	2 / 15
Client 3	A video client for midsized businesses and cloud based solutions.	0 / 23
Infrastru-cture	A service organization for the other test teams. Creates tools, maintains test environments, writes automated tests and supports the QA organisation in technical issues.	4 /21
Hardware	Hardware of the products	3 / 14

Axis' way of working is based on a corporate culture of cooperation and openness to change. One example of this is that direct interaction between employees is preferred over fixed documented processes. During the last 10 years, the Quality Assurance (QA) department has grown from 17 to approximately 170 people. This has made direct interaction between employees more difficult. Management has acknowledged these communication challenges and taken steps to address these. The research presented in this paper is one of these, namely to map distances between the teams within the QA department.

One reason why distance between test teams is becoming a concern, is an increasing focus on interoperability between products developed by different development teams. This is in line with an overall trend of an increase in system interaction. For example, the Internet of Things expect more devices to be integrated into a larger system. Another factor that increases the necessity for cooperation between test teams is an increased focus on delivery speed. This is in line with trends such as continuous delivery and deployment.

When participating in research collaborations, it is a challenge to transfer research results into industrial practice. Within Axis, researchers often interview employees, but otherwise collect data with sparse interaction with other employees, and the resulting academic paper is often only read by a few employees. For these reasons, we wanted to investigate if interactive posters can increase the extent and degree of research involvement among employees, and increase their interest in the research results.

5 RESEARCH METHOD

This case study was performed in close collaboration with Axis Communications to explore the concept of distance as a means to assess the interaction between teams. In particular, we wanted to involve and engage practitioners to increase the organization's direct benefits from the research collaboration.

Our study applied guidelines for case study research provided by Runeson et al and consisted of design, data collection, and data analysis, and finally reporting [22]. The collaboration around the concept of distance has been ongoing for almost two years, of which the case study was performed during four months. During this time, the authors (one research and two practitioners from the case company) have met regularly to design the study and the interactive posters used to collect empirical data of distances between teams. The data was collected by the 2nd and the 3rd authors, and jointly analysed and interpreted by all authors.

5.1 Design of Interactive Posters

We decided to use interactive posters as the main method for data collection since this approach is shown to stimulate participant engagement [13], an important aim for our collaboration. Axis Communications has a long history of working with academia on research initiatives and one of the main challenges is to gain value for the company beyond the few employees that are directly involved in the research collaboration. In the past, the company has observed that when researchers use interviews and focus groups to collect empirical data this creates high engagement albeit only by the few involved employees, while the use of surveys have led to a low degree of employee engagement. We thus selected to explore how the use of interactive posters could trigger interest and involvement in the research.

We assessed cognitive and psychological distance towards test teams with interactive posters. These distances are suitable for this type of data collection since they rely on the individual's levels of knowledge (cognition) and perceived ease of communication. This in contrast to geographical, organisational and temporal distances that can be assessed by studying seating plans, organisational charts and development processes.

We iteratively designed a poster concept using one interactive poster per team with a two-axis graph, one for cognitive distance and one for psychological distance. We used one interactive poster per team, where each team member marked their view of cognitive and psychological distances to the other teams using stickers with the names of the (other) teams, see Figure 1.

Cognitive and psychological distance were assessed on the scale of *easy*, *intermediate*, *hard* using the following questions:

- If I need to perform the work of this team for one week it would be... (for *cognitive distance*)
- If I need to talk to someone from this team it would be … (for *psychological distance*)

5.2 Data Collection using Interactive Posters

We collected data from all ten test teams within Axis Communication's R&D unit, see Table 1. The aims of the research were first discussed with the managers for each team, and agreement was given to perform the study. We then introduced the poster concept to each participating team at a team meeting where the 2nd author presented the aim of the study and explained the poster set-up. One interactive poster was then put up for each team, in a location close to the team's office area, see Figure 2. This was done in two iterations; one for each of the two buildings in which the teams are located. The buildings are 300 metres apart.

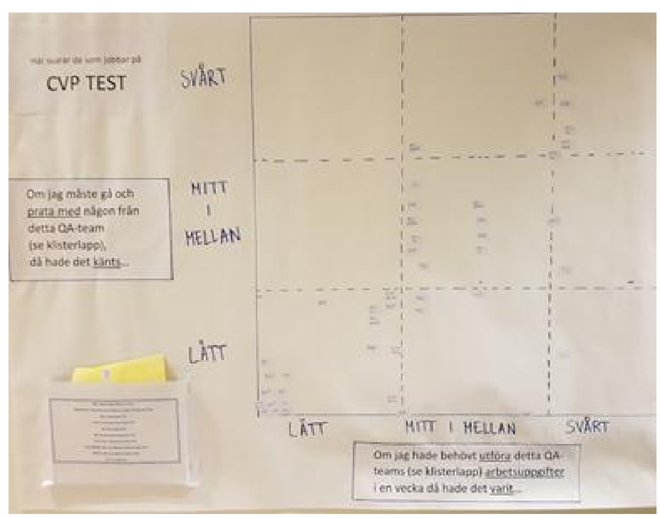

Figure 1: An interactive poster used to assess cognitive (x-axis) and psychological (y-axis) distance.

Figure 2: Examples of interactive posters.

In the first iteration, the six teams located in one building responded to the interactive posters. These teams are, on one floor: Camera 1, Camera 2, Camera 3 and Camera 4 and on the other floor: Hardware, Infrastructure and Camera 2. The Camera 2 team is spread over two floors. Each floor has one kitchen where the posters were placed for each team. All teams in this building voted during the same 7-10 day time period.

Two weeks later the procedure was repeated for the four teams located in another building, spread over four floors. In this building, the interactive posters were placed in the team area for each team, with the exception of one team who is located on two floors. For this team, the team poster was placed in the canteen used by all teams in that building. These posters were available for 2 weeks, i.e. slightly longer to compensate for Christmas vacation. We judge the time period to be equivalent regarding effective time as for the other building.

When completed, the interactive posters were collected and the responses counted and transferred into a spreadsheet. This transcription was performed by the 2^{nd} author, and validated by the 3^{rd} author. Discrepancies in the numbers were re-checked and the correct values entered into the spreadsheet.

As participants could provide information about anything from one to all nine teams, it is not possible to know the number of participants from the poster data alone. However, a response frequency can be calculated as the actual number of data points provided as a percentage of the maximum data points that would have been provided if each team member had provided information about all the other teams. If all 175 team members had voted on all of the other nine teams, then the posters would have contained 1.575 data points. The actual number was 823 data points, which is a response frequency of 52%.

5.3 Data Analysis of Interactive Poster Votes

We obtained values for the total psychological and cognitive distance per team by combining the votes from all the teams, calculating the mean values, and the 25% and 75% percentiles. The results were visualized using boxplots (see Figures 3 and 4). The 2^{nd} and 3^{rd} authors analysed the data and formulated possible explanations for the distances based on their knowledge of the teams. For example, the technical complexity of a team's responsibilities, a team's involvement (or not) in joint department activities etc. We took care to ensure that all the information concerning the teams used in these explanations can be validated, e.g. by consulting documentation or team managers.

6 RESULTS & DISCUSSIONS

We will now present our results and provide potential explanations for the measured distances based on our knowledge of the case company. We calculated the total cognitive and psychological distance towards each team participating in the study based on the results from the interactive posters and visualise these using box plots, see Figures 3 and 4. In the discussions of the data, we use only verifiable information regarding the case company. For example, information that is confirmed by managers or found in documentation etc.

6.1 Cognitive distance

The empirical data indicates that the cognitive distance is low for most team, with a mean of less than *medium* with the exception for the teams Client 1, Infrastructure and Hardware. For these the cognitive distance is above *medium* for their mean values and for the majority of responses (the 25-75% boxes), see Figure 3. We believe that these higher distance values can be explained by the fact that these teams carry responsibilities that *require competences* that are not required, and thus not commonly found, for the other teams. This is clearly the case for the Infrastructure and Hardware teams, which rely on specific knowledge.

The camera and client teams work on interdependent components where a client uses an API provided by a device, and would be expected to show low cognitive distance. This is the case for Camera 1, Camera 3, Camera 4, Client 2 and Client 3. The Client 1 team is an exception for which the data indicates a longer cognitive distance, which is surprising. We would expect this team to have a similar cognitive distance to that of the Client 2 and Client 3 teams, since they all work within a similar domain. We see two possible explanations for this higher cognitive distance. Firstly, the Client 1 team predominantly works with cloud services as opposed to the other teams that work with embedded software or desktop software. Secondly, the Client 1 team is the team with the largest mean psychological distance to the other teams, which indicates that other teams are not comfortable or used to talking to the Client 1 team. This in turn might mean that other teams are unsure about what this team works with, and thus the higher cognitive distance may indicate an uncertainty about the competence required rather a difference in competence, and thus an actual cognitive distance. Further investigations are needed to determine this, and if it does indeed indicate an uncertainty, the method for assessing cognitive distance needs to be adjusted to consider this.

5

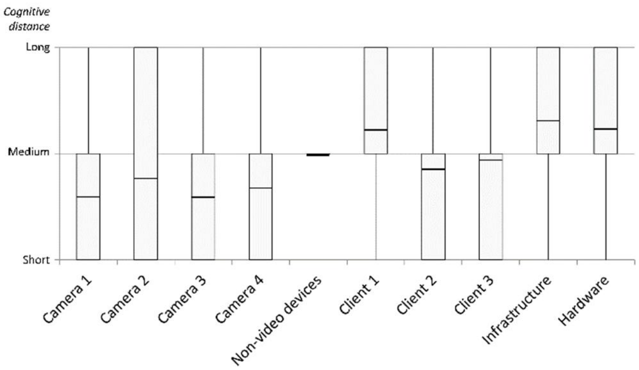

Figure 3: Total cognitive distance per team. The boxplots show 25-75 percentile and mean values.

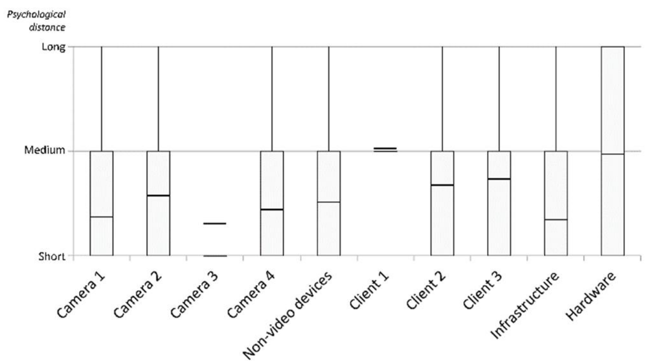

Figure 4: Total psychological distance per team. The boxplots show 25-75 percentile and mean values.

Our data shows that the majority (more than 60%) of respondents experience a *medium* cognitive distance towards the Non-video device team. This may be explained by the fact that this team works with similar API's as the other teams, but focus on physical access control and audio instead of video (the main focus of the other teams). Thus, technically this requires similar competence as for the other teams, although the domain is different resulting in a cognitive distance.

Camera 2 displays the widest variation in responses regarding cognitive distance. 40% of the respondents indicate a *short* distance, 34% a *long* distance, and 26% a *long* cognitive distance to the Camera 2 team. This spread may be explained by the fact that this team consists of two sub-teams with different responsibilities and thus requiring different competences. This may indicate that these two parts of the team should be assessed separately. For the team members that have similar responsibilities as the Camera 1 team, we would then expect to see a similar cognitive distance as that team. In contrast, for the other team members that work with future camera technologies we might then see similar cognitive distances as for teams with differing responsibilities, namely the team for Non-video devices, Infrastructure and Hardware.

6.2 Psychological distance

The empirical data indicates a low psychological distance for the majority of the test teams with the maximum mean value of *medium* distance for all teams, see Figure 4. This is in-line with the company's explicitly expressed culture to encourage openness and dialog between individuals and teams. This would be expected to result in low psychological distance between teams, thus our data confirms the company culture regarding this aspect.

We note a difference in variation of the perceived distance towards the teams Camera 3 and Camera 4; one team up until less than 2 years ago. These two teams are very similar regarding their area of responsibility, physical location and organisational belonging. Even so, the other teams report a *shorter* psychological distance to Camera 3 than to Camera 4. We see two possible explanations for this. Firstly, the Camera 3 team consists of more senior employees than the Camera 4 team. This likely entails that the Camera 3 team members have a larger personal network within the company and thus other teams find it easier to communicate with these people and thus report a shorter psychological distance for this team. Secondly, the Camera 3 team organised the most recent team building activity where all the other test teams participated. This may have resulted in the establishing social connections to this team and thus shortened the psychological distance to them. We conclude that psychological distance may be affected by the extent of individual social networks and networking abilities, and a team's recent exposure and contact with others, e.g. at company events. Further investigations are needed to explore these assumptions.

A relatively large psychological distance is seen for the Hardware team. This may be indirectly related to the difference in required competence for this team. Due to the difference between hardware and software testing many of the competence building activities organised at the QA department level have not been relevant for hardware testing. Thus, the Hardware team has not attended these events and missed these opportunities to network and get to know the other teams. However, there is a wide variation in the reported distance to the Hardware team with 40% stating a *short* distance and 30% respectively stating a medium and a long psychological distance. This distribution indicates that there are Hardware team members with good connections and communication to the other teams.

From an organisational standpoint, the wide variation in values seen for the Hardware team is preferable to the distinct *medium* distance seen for the Client 1 team. We interpret the wider range of values as an indication that there are well-functioning communication channels to the Hardware team, i.e. that each team knows someone within the team that they can communicate with. We believe that it is a good strategy to encourage specific communication roles per team rather than expect everyone within a team to act as contact points.

Finally, the Client 1 team stands out as the team with a distinct value of medium psychological distance, thus the majority of respondents report this (same) distance towards this team and very few indicate a *short* distance to them. The cause of this is unclear and is of interest to explore in future work.

6.3 Limitations

We now discuss the threats to validity of this study and its results based on guidelines by Runeson et al. [22]. We also discuss risks connected to interactive posters as identified by Diebold et al., in particular space limitations and risk of biased responses [13].

Construct validity. There is a risk that the measurements, i.e. the questions on the posters, do not correctly assess cognitive and psychological distance, or may not have been perceived as was intended. This risk was partly mitigated through iterative design of the poster and validating the poster design with random practitioners prior to performing the data collection, as recommended by Diebold et al [13]. Further research is needed to identify appropriate and cost effective distance measurements.

The physical limitations of interactive posters regarding the number of questions and amount of contextual information that can be covered had a large influence on the design of our data collection instrument, i.e. the poster set-up. We adjusted the scope of our study to cover two distance types only (cognitive and psychological) due to this limitation. The final poster consisted of two axes and in total nine possible responses. This simple design facilitated participation since it was easy to understand and it did not require much time to respond.

To separate data points between test teams we decided to use one poster per test team and to provide stickers marked with the names of the other teams. In this way, we can connect the responses to the individual teams and in future we plan to also analyse distance between specific teams. This also reduced the total amount of stickers placed on each poster.

There is a risk that respondents were influenced by each other or by not being anonymous, thus affecting the measurements. This risk is inherent to interactive posters and was partly mitigated by placing the poster in areas common to each team, but not directly in their work space, i.e. where others can directly observe team members responding. Furthermore, we did not moderate the interactive posters but rather left the posters up for a period of time. In general, we believe that the risk of biased responses is low due to the open and transparent culture encouraged by the company. This risk will be investigated further in the next step of our research.

Internal validity. When attempting to understand and explain the assessed distance, there is a risk that we have drawn incorrect conclusions or missed factors, or correlation between factors that may provide alternative explanations. We have partly mitigated this risk by basing our explanations on the knowledge of long-term employees of the company and on information that can be confirmed by sources within the case company, e.g. managers or documentation. This risk was further mitigated by having a senior employee at the case company (other than the authors) review the article. Further research (e.g. focus groups at the case company) is planned to provide more empirical insight into factors influencing and correlating to cognitive and psychological distance, and how these affect collaboration.

External validity. Since the concept of cognitive and psychological distance is sprung from an empirically based theory [5], we believe that the observations of this case study are of interest beyond the studied case. Since contextual factors, e.g. size, culture, work practices, influence how engineering teams communicate and collaborate, theoretical generalisation needs to be applied to assess the extent to which the results are applicable also to other (similar) cases, i.e. large, co-located organisations with a similar company culture that develop embedded software.

Reliability. We have partly mitigated the risk of researcher bias in the collected data and in the analysis by involving multiple people in the study. The posters were presented to the participating test teams by the 2nd author who may inadvertently have imposed his views on the participants. However, since this risk was identified early on in the study this was discussed with this author before these meetings. The risk of incorrectly transcribing the responses from the interactive posters to the spreadsheet was mitigated through triangulation. The 2nd and 3rd author independently transcribed the responses, and then discussed and agreed on how to handle the differences.

7 CONCLUSIONS AND FUTURE RESEARCH

Improving communication and collaboration between teams in a large organisation can be a challenge due to varying opinions and viewpoints on the current situation and what should (or should not) be done to improve it. In this paper, we present one way of providing an objective view of the situation by the use of interactive posters for assessing cognitive and psychological distance between teams. In this way, the current situation can be described based on empirical data elicited from the organisation itself. This provides a common starting point for discussions. The measurements in themselves do not prescribe a course of action, but rather illustrate differences between teams. These differences raise interesting questions and may trigger constructive discussions within the organisation. For example, how come one team has a longer distance than another one? Is this good or bad? Do we want to change this, and how?

We have performed a case study at Axis Communications with the aim of exploring what cognitive and psychological distance measures can tell us about a team, and how these distance can be measured in a large organisation. We designed an interactive poster that enabled us to gather large amounts of empirical data from the company's QA department consisting of approximately 170 employees divided into ten test teams.

We conclude that psychological distance is an indicator of *social networks* and the extent of *recent contact with others*, while cognitive distance mainly indicates differences in the *competence required* to manage a team's responsibility. A company with a culture that encourages open and frequent communication between individuals and teams should display consistently short psychological distance. This indicates that there is a well-functioning social networking within the organisation. One that can be further strengthened, e.g. by asking teams to host team-building activities for all the teams within a department.

Short cognitive distance indicates similar competences, while long cognitive distance indicates dissimilar competences. We find that teams with *competences within the same system* (same execution stack) tend to have similar competences, and thus shorter cognitive distances. We see this for teams such Camera 1, Camera 3, Camera 4, Client 2 and Client 3. In contrast, teams that work of different *types of systems* such as cloud-based, embedded or desktop software display a higher cognitive distance. We see this for the Client 1 team that displays a relatively long cognitive distance. A medium cognitive distance may be an indication of having a *different technical focus* while still working on the same technical system as others. An example of this is the Non-video device team that focuses on audio rather than video functionality. A wide variation in views of cognitive distance may be an indication of that this team covers a wide range of competences.

Finally, there may be *correlations between psychological and cognitive distance* where one type of distance indirectly creates the other. For example, when there is a long psychological distance to a team this may indicate a reluctance to communicate, which in turn leads to being less familiar with the competence required to perform the work of that team. An example of this is the Client 1 team that display high values for both cognitive and psychological distance. Similarly, a long cognitive distance to a team may lead to organisational-level activities such as competence building events being less relevant for this team. They thus do not attend these events and miss the opportunity to network with other teams, which then leads to a long psychological distance.

The results from this case study provide the basis for further research into how the concept of distance can be used to improve collaboration by supporting a company in identifying specific improvements. We will present the results of our research at the company and initiate focus group discussions on the relationships and collaboration between teams. We expect such a discussion to result in identifying a course of action to improve the communication and collaboration within the QA department.

In closing, one of the objectives of this study was to increase the engagement of employees in our research collaboration by using interactive posters as a data collection method. Further research is needed to determine how posters as a data collection method can increase practitioners' research engagement over time. However, we found that the interactive posters did create a discussion at the company on the subject of distances in software engineering, and plan to further explore how this concept can be used to enhance academia and industry collaboration.

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