

Empirical study of communication structures and barriers in geographically distributed teams

ISSN 1751-8806

Received on 24th August 2015

Revised on 3rd June 2016

Accepted on 8th June 2016

doi: 10.1049/iet-sen.2015.0112

www.ietdl.org

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Abstract: Conway's law asserts that communication structures of organisations constrain the design of the products they develop. This law is more explicitly observable in geographically distributed contexts because distributed teams are required to share information across different time zones and barriers. The diverse business processes and functions adopted by individual teams in geographically distributed settings create challenges for effective communication. Since the publication of Conway's law, a significant body of research has emerged in its relation to the communication structures. When it comes to software projects, the explicit observation about Conway's law has produced mixed results. The research reported in this study explores the communication structures and corresponding challenges faced by teams within a large geographically distributed software development organisation. The data was collected from relevant documents, a questionnaire and interviews with relevant stakeholders. The findings suggest that Conway's law is observable within the communication structures of globally distributed software development teams. The authors have identified the barriers and challenges of effective communications in this setting and have investigated the benefits of utilising an integrated system to overcome these challenges.

1 Introduction

Effective communication is an indispensable function of any large organisation and essential in a competitive business environment. A paradox is evident when an organisation acknowledges the importance for effective communication and faces challenges in practice [1]. Business and organisational communications are intertwined, since they are fundamental domains of communication which enable a collaborative ease to achieve objective-driven tasks [2]. Business communication can be defined as the creation and adaptation of languages to conduct activities, which satisfy business needs by providing goods and services for profit [3]. Organisational communication within a business context endeavours to influence organisational processes, and its unique nature must be differentiated from other forms of organisational behaviour [1]. However, the issue of internal communication heightens when an organisation is comprised of geographically distributed teams working on a common project to achieve business objectives [4, 5] due to its unique challenges [6].

Conway's law states that '*organisations that design systems are constrained to produce systems which are copies of the communication structures of these organisations*' [7]. The deliberate abstractness in formulating the law has given potential for its application to a wide range of systems and hence leading to diverse interpretations [8, 9]. Conway's law is explicitly described in geographical contexts due to communication channels within geographically distributed teams being evidently observable. A study conducted by Harvard Business School reinforces Conway's law and suggests that individual products have structures that can be inferred by an evaluation of the organisation [10]. Blatter *et al.* [8] outline an experiment to test Conway's law in a controlled setting, presenting a set of results that contain variations. The control group produced a complete implementation of a system, whilst treatment groups which had particular constraints to communication had specific deficiencies that were viewed as a result of Conway's law. Herbsleb and Grinter [4, 5] focused primarily on observing coordination problems as they arise and the breakdown of informal communication due to geographic separation. Hadaytullah *et al.* [11] studied construction of software

architecture that conforms to its organisational structure whilst meeting requirements. Oberortner *et al.* [12] argued challenges such as miscommunication and the sharing of information to have a high severity on geographically distributed teams. However, there are various ways to decrease opposing effects of globalisation as Clerc *et al.* [13] recommend where frequent visits between sites are necessary for design decision-making and rationale.

This paper aims to study the communication structures and corresponding challenges faced within a large geographically distributed software development organisation. A case study method was used for observing internal communication within a multi-national IT corporation (hereafter ABC). The contributions of our study are three-fold: (a) case study findings suggest that Conway's law is more observable within the communication structures in globally distributed teams, (b) we have identified the barriers to, and challenges of, effective communications within a globally distributed software development environment and (c) we have ascertained the benefit of utilising an integrated system to overcome some of these challenges.

This paper is structured as follows: Section 2 gives the background to this research, whereas Section 3 states the motivation for the study. Section 4 describes the case study design and Section 5 presents the results. Section 6 discusses the results, Section 7 gives the limitations and Section 8 concludes this paper and the future directions.

2 Background

We considered it necessary to discuss the contextual factors related to Conway's law and the discrepancies in its interpretations [9], before conducting empirical study. In the following, we will review four dimensions related to Conway's law from the literature that were explored in our case study to provide a broad overview of its many influencing factors and impacts on communication structures.

(a) *Geographically distributed teams:* Both the distribution and transfer of software products over geographic borders are met with

challenges in obtaining successful control, coordination and communication [14]. One of the difficulties encountered by geographically distributed teams is the integration of systems developed separately [15]. The difficulty with exchanging information is defined as an inconsistency of attributes between the sender and receiver, thereby the effective exchange of information between units requires that each team provide and receive similar information attributes [16]. Distributed teams are allocated to complex, interdependent tasks using technology to tackle three commonly known boundaries known as relational, temporal and spatial [17].

(b) *Communication and coordination*: Conway's law explicitly recognises that communication patterns of an organisation are imprinted as an ineffaceable mark on the product built [4, 5]. Parnas [18] clarified the relationship between an organisation and the product it intends to build and highlights that the division of a system consequently impacts on the division of work effort. Hence, product structure acknowledges the need for alignment in development tasks for a specific team [19]. Processes determine the distribution of work when products emerge and evolve between two teams. Whether it be the design or testing phase of a project, it is necessary to have an efficient information system that can inscribe different stages of product development [20]. Whilst Conway stresses the fundamental importance of coordination in development, Brooks [21] identifies its difficulty in practice and suggests that the addition of more resources to product development can ultimately hinder current processes. The use of communication technologies conveys characters of dependability, shared values and reliability [22].

(c) *Integrated systems*: It is necessary to construct and apply a set of 'organisational mechanisms' that will enable separate teams within an organisation to exchange information in a synchronised manner [16]. Nilsson *et al.* [15] define four dimensions of systems integration 'integration technology, integration architecture, semantic integration and user integration'. Standardisation in information management capabilities across an organisation can enable communication to be reinforced.

(d) *Business processes and communication structures*: Communication structures between geographically distributed teams are difficult to establish and maintain [23]. The benefits of establishing a more cohesive organisational structure can enable an increased efficiency in the exchange and flow of information between two teams in different environments. Ever-changing global environments and progressively cost-effective communication technologies have increased communication amongst geographically distributed teams [17]. There are greater benefits for information management and product development when processes are automated. The strains of good business practices and increased business competition force large organisations to re-examine current business processes [14]. Efficient business processes employed by geographically distributed teams, whilst conforming to varying conditions, can improve the proficiency of task execution [20].

3 Motivation

Since the publication of Conway's law, a significant body of research has emerged in relation to the communication structures (types of resources, techniques and design) in organisations and quality of the software [24]. Colfer and Baldwin [25] analysed 102 empirical studies and Bailey *et al.* [26] have provided a comprehensive review of 259 empirical studies to assess how the Conway's law is perceived and understood by the researchers. Kwan *et al.* [19] have observed that when it comes to software projects, the explicit observation about Conway's law has produced mixed results. In software projects there was no significant alignment between software and organisational structures, and this alignment was not perceived to have an impact on the outcomes of the projects [25]. Kwan *et al.* [19] pointed out that software development projects are different from other development projects (e.g. differences in change and knowledge management), and the disparity in the evidence about observation of Conway's law may stem from the

differences in its conceptualisation (task, architecture and organisation levels). The evidence about the Conway's law and its benefits to software project outcomes is not very clear from the existing empirical literature [24]. This calls for more empirical studies that aim to observe and confirm the application of Conway's law in a modern software organisational setting.

4 Case study

The aim of this case study was to observe the application of Conway's law in a modern organisational environment with regard to communication challenges in distributed software development teams. Case study research methodology involves a detailed and holistic investigation of a phenomenon in its real life context. It provides a deeper understanding of the phenomenon under study. With the help of case study research we attempted to achieve the following goals:

- To observe Conway's law in the communication structures of a large geographically distributed organisation.
- To identify barriers of effective communication in geographically distributed teams.
- To find the benefits of an integrated system in overcoming these barriers.

(a) *The organisation*: ABC is a multi-national IT corporation. The company provides software, hardware and services to consumers, small, medium and large sized enterprises including customers in the health, education and government sector. ABC currently operates in more than 170 countries around the globe. ABC is driven to provide product innovation in core markets, focusing primarily on cloud computing, enterprise security and big data and offers both government and private sectors greater cloud and managed services, ensuring customers are able to function efficiently in a widely competitive global market.

(b) *Unit of analysis*: Within ABC, we are focusing on two teams, Team A (global product team) based in the United States of America and Team B (regional payments hub) in Australia (Fig. 1). The two teams in essence collaborate to form efficient card and payment services to the clients. Team A designs and develops products that offer a full range of capabilities that solve large-volume, transaction-driven, card-based payment management with an end-to-end solution. Fundamentally, Team A develops products and offers software development capability. Team B uses these capabilities to successfully serve the needs of their clients. These capabilities are enhanced with adaptive technology, global secure processing environments, a global product team and channel-independent delivery, where maximum flexibility is provided for packaging products and services. The products distributed by Team A to Team B are functional; however, may not be entirely operational to fulfil the requirements of Team B clients. If a service request is sought by the client to Team B, and a local solution cannot be applied, change requests are sent to Team A and the change is to be completed. Both Team A and Team B store necessary data regarding service and change requests; however, due to the teams' local organisational structures, they utilise different methods and systems to manage data. Thus, necessary knowledge sharing is prohibited and the current systems of communication developed by the respective

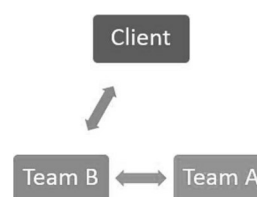


Fig. 1 Communication structures between teams and the client

teams primarily reflect their own organisational structure, preventing a more collaborative structure.

(c) *Case study design*: To adequately address the planned objectives for this research, methodological and data triangulation was utilised [27]. Data is collected using three sources: documents, questionnaire survey and interviews.

(i) *Document analysis*: Document analysis was used to better understand the process flows used by Team A and Team B in initiating service requests. Through an in-depth analysis of current business processes, a better perspective and insight was obtained regarding team interaction and how processes could potentially improve team communication, decision-making and the automation of some tasks to enhance efficiency.

(ii) *Questionnaire*: Questionnaire was used to gather an overview of the research topic, primarily focused on geographically distributed teams and communication issues. The target population was selected on the criteria that they are involved in the communication between teams A and B. The questionnaire survey was administered via email to the consenting participants of the organisation. Questions were designed to develop an understanding of team interaction and the effects of distance and time constraints on communication. The questions used in this investigation consisted of scaled questions, and open-ended questions suited for preliminary fact finding activities. Five questions were constructed (Appendix 1), consisting of a combination of scaled and open-ended questions to gather both quantitative and qualitative data. Once the questions were finalised, six participants who had previously agreed to complete the questionnaire (including a programme director, service delivery executive, release analyst, project manager and business analyst) were emailed the questionnaire to respond in their own time.

(iii) *Structured interviews*: The aim of the interview was to follow-up on previously conducted questionnaire. All participants of the questionnaire consented to further participate in the interviews. This was helpful in achieving further opinions and insights on the research topic. Seven open-ended questions were presented to all the participants (Appendix 2). Once a time and date was agreed, one-on-one structured interviews were conducted. The concept of the research topic and purpose of the case study were explained to all interviewees to clarify its purpose and intention. Interviewees were assured of their privacy and confidentiality when participating in the interview in consideration to UTS research ethics policy [<http://www.gsu.uts.edu.au/policies/research-ethical-conduct-humans.html>]. All answers were recorded. Probing was utilised to gather further insight on answers provided and to elaborate on ideas and suggestions for improvement. Distance and time zone constraints associated with the American team (Team A) denied the opportunity to have a phone interview with the business analyst. Therefore, the questions were answered in written form and emailed, still contributing an intuitive perspective with some similar corollaries.

(d) *Data analysis*

(i) *Document analysis*: For this investigation, separate process flowcharts for service requests were analysed, a chart utilised by Team A and another by Team B. Each process flowchart was carefully analysed by deconstructing the process, and categorising the tasks into key entities, roles and responsibilities. In doing so, it provided a greater understanding of how requests are raised, requirements signed off, project request forms completed and projects initiated. This clarified the roles and responsibilities of the separate entities, portraying communication structures by emphasising the instances and requirements for communication in a service request process.

Furthermore, as organisational boundaries were identified, tasks, flows and storage were outlined in the process. Cycle times, process times, idle times and work in progress were all key factors observed through the document analysis to potentially increase flexibility, reduce bottlenecks and automate storage processes to improve cost, quality and time-to-market of products. The analysis of the process flowcharts in addition to discussion conducted with

users of the process, assisted in an improved understanding of current communication structures between the teams, as well as independent organisational structures. Hence, it was observed that the distinct processes used by the teams could reach an optimal efficiency by streamlining current processes, developing an integrated information system to store data related to service requests, and initiate more collaborative business practices.

(ii) *Questionnaire*: Questions were phrased appropriately and provided suitable options for responding, where the content of the questionnaire was closely related to the investigation, and intended to gather insight on individual opinions and personal experiences on factors which affect the day-to-day roles of geographically distributed teams. Hence, the data and answers collected from the questionnaires successfully predict a specific criterion, with results consistent with previous results of established measures. The answers to the questions were summed up to observe the frequent patterns.

(iii) *Structured interviews*: A fairly large body of information must undergo inductive reasoning, sorting and categorising to develop underlying themes. Data was analysed through transcribing interview notes and utilising thematic and content analysis to develop a synthesis of common ideas. Each questionnaire and interview question, even though answered vertically and independently by separate individuals, were viewed and analysed horizontally, that is, each answer to a particular question was viewed altogether to find similarities in concepts and ideas. Additional notes were written and linked to the thematic codes based on the observations from document analysis.

Data gathered from questionnaire and interviews was organised by collapsing large bodies of answers into smaller units, by highlighting individual words such as 'time-to-market' and 'collaboration' to identify common ideas and themes. The entire data was perused by reading through the material several times, capturing notes and synthesising preliminary thoughts and interpretations. General categories and themes were identified, classifying each piece of data accordingly to present findings in a cohesive approach, developing patterns in answers. Finally, the findings were presented in written form with graphs and diagrams to emphasise concepts, integrating and summarising ideas. Informal observations were detrimental to draw valid conclusions and enabling findings to be reported and presented in an appropriate manner.

5 Case study results

In this section, we present the findings from our analysis of the empirical investigation:

(i) *Document Analysis*: Document analysis provided insight on the sequential flow of tasks and the submission of service requests in differing organisational structures, through the representation of process flowcharts which show the various roles of teams in a service request process. Some challenges observed and analysed involve the processes associated with service requests, potentially at times, not providing acceptable time-to-market deliverables for clients. To efficiently continue the service request process flows, one focal point, i.e. an integrated system, can ensure and maintain a consolidated list with target dates across both teams, and hence consistent with the product development and organisational structures of the teams. It was concluded that sufficient time allocated to resourcing can reduce overall development time, increase time-to-market and better facilitate the communication of target dates for service requests. The re-prioritisation of service requests is necessary to improve communication issues within geographically distributed teams, as client service requests with urgent changes must continue to meet project deadlines.

(ii) *Questionnaire*

(a) *Number of meetings per week*: Fig. 2 presents the number of times individuals in different roles interact with other team members within distributed teams on a weekly basis. The number

of times individuals contact their counterparts reflects on their day-to-day role and tasks that need to be completed. Contact between teams may increase or decrease depending on the time period and phase of development projects. For instance, business analysts in Team B on an average time-span of 12 months will contact Team A twice a week. However, during critical stages of development, the development cycle contact may increase between 3 and 4 times per week.

(b) *Primary medium of communication:* The primary medium of communication utilised by various individuals includes the following:

- Lync meetings/conference calls.
- Email.
- Instant Messenger.
- Telephone calls.

The listed mediums of communication are used primarily because of geographic distance and different time zones, where email is considered an ideal option for communicating. To accelerate the resolution of issues and increase communication time, conference calls may be scheduled outside working hours, either before or after.

(c) *Challenges in working within a geographically dispersed team:* Key challenges in working within geographically distributed teams:

- Time zones.
- Lack of face-to-face contact – hard to establish a personable relationship for good communication.
- Physical absence altering response time and effecting prioritisation.

Time zones were considered the greatest challenge by most individuals due to a large gap in time differences. Furthermore, the competitiveness of business today requires organisations to be more ‘agile’ and dynamic in responding to customer needs. The lack of face-to-face contact between teams can promote negative predispositions and highlight the absence of body language, potentially effecting the formation of positive team relations. Physical absence can influence response time between teams, making it easier for individuals to create prioritisation lists and not immediately respond. However, physical presence emphasises higher accountability, taking into consideration the need for prompt responses.

(d) *Circumventing the challenges of working in geographically dispersed team:* To circumvent these challenges various suggestions were provided, showing a cause and effect relationship with the number of times individuals interacted on a weekly basis. Some suggestions included:

- Planning meetings in advance.
- Working flexible hours.
- Resolving complicated issues through conference calls.
- Constant communication.

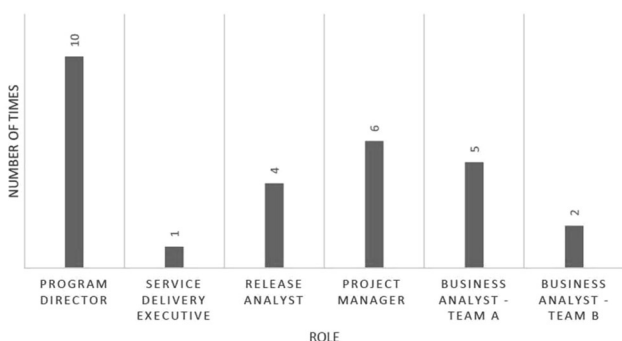


Fig. 2 Weekly team interaction according to job role

- Adjust working days to communicate and accommodate individuals’ needs.
- Using collaboration tools for sharing information.
- Establish and maintaining a good working relationship via phone calls.
- Mutual respect.

(e) *Impact of time and distance:* Participants agreed that physical distance and time zones affect day-to-day roles. Some opinions concerning this issue included:

- Organisational structures dictate areas of expertise and specialisation; however, teams interdependently work together. Time-to-market would considerably improve if teams were collocated.
- Decision-making and problem resolving is extended.
- Holidays and different work events effect the completion of tasks.

The participants pointed out that one of the reasons for the impact was a delay in receiving a response. A neutral impact indicated that time zones were still a prevalent issue, yet varying responsibilities in different roles would determine the need to contact other teams. One individual disagreed with the statement, explaining that the current communication technologies in place permit tasks associated with their role to be completed efficiently.

(iii) *Interviews:* Thematic analysis of the interview data provided following insights to the questions.

Q1: Conway’s law and differing organisational structures: Team objectives govern organisational structures where one team designs and builds and the other tests and delivers to clients. Development and testing need to be closely aligned, and at times, is challenging as Team B is the primary consumer of Team A (global product team) products; however, Team A is disconnected from the client (Fig. 1). Disconnection can lead to assumptions made through miscommunication causing significant implications. According to a release analyst, Conway’s law is believed to illustrate the issue of communication and is ‘*compounded by a natural tendency to give preference to one silo*’, with individuals directly reporting to and working with each other. Hence, the client, Team A and Team B are governed by strict communication structures limiting interaction. Furthermore, it was gathered that both teams are still very much isolated in their approach, and the teams must develop a cohesive environment to move closer to the mechanisms of Conway’s law. Though there may be some level of moderation in common modules and the building of products through architecture, there are evident constraints highlighted by organisational structures. Both teams follow independent, well-defined business processes which in effect emphasise limitations to interaction.

Q2: Barriers to communication: Communication barriers are prevalent when different leaders are consumed by varying organisational drivers. Single decisions with minimal consultation can instigate a significant level of autonomy, whilst cultural anomalies were considered to be a barrier to some extent. Physical distance, time zones and the lack of collaboration removes the natural communication found in collocated teams. A service delivery executive suggested that physically remote teams are subjected to developing an ‘*us and them*’ mentality, becoming problematic due to the lack of knowledge sharing. Communication barriers can be overcome through identifying issues and sharing a sense of purpose through understanding organisational objectives. Clearly defined roles and responsibilities reinforce accountability, forming a collaborative environment where there are functional goals and key outputs to measure performance.

Differing priorities can be challenging and a barrier to communication, as the two teams driven by a common objective have different priority lists, inherently affecting the delivery of projects. The sharing of data sources and a greater flexibility of working hours can ensure tasks are completed, modifying work practices or tools with in-built processes. The lack of face-to-face contact is difficult as constant follow-ups, whether formal or informal, are required between team counterparts, designers and

lead business analysts. Furthermore, the lack of contact can lead to a product which is not operational, effecting service level agreements, end-to-end functionality and multiple clients. Using case diagrams, workflows, reviewing requirements and documentation reviews were some approaches to improving communication barriers so requirements are understood and operational products produced. Requirements must focus on client needs; therefore, face-to-face communication is necessary to observe the same processes and remove ambiguities. However, time zone differences entail the need for continuous communication through email, calls and document sharing.

Q3: Benefits of integrated systems: The use of an integrated system to support a process is beneficial to overcoming issues related to different physical locations, forcing accountability and conformity, where there is a greater level of cohesion between business units, and explicitly, around roles and responsibilities. It is necessary to identify challenges and form solutions through integration, forming greater flexibility to change and becoming more dynamic. To reduce the effort of continuous communication challenges between the two teams, an integrated system is a logical solution for sharing data and ensuring all team members understand current states, phases and issues of development projects.

A project manager stated the importance of *'terminology to become standardised'*, by removing any discrepancies and differences. Integration of standard terminology within a central system would facilitate a unified approach to information sharing. The central system could also support tracing design documents where required information can be accessed in timely manner to complete project tasks.

Q4: Business processes affect communication structures: Separate business processes cause inefficiency and duplicate effort, forming a level of distrust and possible feedback loops due to the disparate nature of business processes. Financial costs and budgets can become clearer when the two teams work closely from a commercial perspective. Hence, if the two organisations are closely linked, it would prevent complete separation and responsibility. Differing business processes force different communication flows, emphasising the separation of organisational structures. There is no sequential process used by both teams, thus they are treated as two separate entities. Requirements gathering is a challenge as requirements need to be transferred between clients and the product team, with no tool for traceability. There are gaps in knowledge and requirements transfer as there is a lack of integration to one system, affecting the spread of information between the teams. Business analysts suggested that without clear requirements, *'the development team can work in a vacuum'* and thus not provide a solution to truly meet the clients' expectations. Current business processes dictate communication between individuals as it is driven by roles and thus role-dependent. Hence, business processes limit who individuals can communicate with, enforcing strict adherence and automatically limiting communication structures.

Q5: Effective exchange of business information: The use of integrated, consolidated tools can ensure clear owners with roles and responsibilities which can prevent particular activities to reduce duplicate effort, with clear reporting structures to business units. A service delivery executive suggested that the *'introduction of metrics'* can measure performance against estimated goals and objectives. A process oriented organisation must have teams which use the same tool sets, emphasising the same platform for a better interchange of information. Hence, a common communication platform for projects, scheduling, costs, releases, resource utilisation and prioritisation is beneficial to geographically distributed teams. The practice of video conferencing was believed to contribute to effective business information exchange, creating a virtual team and emphasising a face-to-face environment. Furthermore, regular visits by senior managers between sites are effective for team familiarisation and collaboration as one team. Workshops, using tools such as Lync screen share, conference calls, virtual rooms and working flexible hours is necessary for active interaction, accommodating for different time zones. Clear and concise requirements gathering must involve all parties

involved in a project. The two teams have inconsistent knowledge as their expertise lie in different areas; therefore, increased communication can better transfer these requirements.

Q6: Communication structures and enhanced product development: Improved communication can lead to enhanced product development, ultimately contributing to a greater speed-to-market, faster revenue and satisfied clients. Poor communication can hinder the achievement of goals, hence a programme director emphasised that an *'end-to-end process view can identify constraints during the process'*, beneficial to identifying communication improvements. The identification of prioritisation and effort contributed to a particular product is necessary to identify the importance of certain features when working productively. A rapid, scrum development approach rather than a traditional waterfall approach is essential to optimise testing and working collaboratively, improving organisational environments, hardware infrastructure and leveraging the skillset of various people to optimise time-to-market. Too much information can at times be burdensome; however, regular opportunities for raising issues are needed as spontaneity can discover good input not previously planned, with good ideas born through rapid conversations and unexpected plans. Communication structures are important to view current and future states of development, emphasising gradual transitions and the improvement of capabilities, by working with multiple teams such as project management, interface development and production support. Enhanced communication structures can improve the overall response time and speed time in delivering to clients, as better products would be developed with less rework and delays. Currently, tasks are driven by roles and add to the time dedicated to resolving issues.

Q7: Collaborative working environment: A collaborative working environment is needed as every project requires individuals to work cohesively. It is imperative that geographically distributed teams are co-dependent on each other, and when all teams form closer relationships with clients it is less likely that time, money and expertise will be wasted. Collaborative working environments are developed with workshops, where actions are taken to optimise processes across the business. Delivery is met by team effort and every individual has an important role, as their own expertise and understanding of a particular area are crucial to successfully complete development projects. Collaboration and communication is important for understanding client needs and managing requirements. Requirements and solutions are mutually constituted, so teams must work effectively to create tailored solutions through iterative approaches and workshops. Finally, a business analyst noted that *'the delivery of a workable solution for minimal cost leads to greater client satisfaction as solutions can be developed at a faster rate'*.

Personal challenges: High level of stress was identified to have been experienced by many individuals working within geographically distributed teams in ABC. Teams can encounter varying levels of stress when relying on tasks to be completed by colleagues or client expectations to meet strict project deliverables.

A project manager noted that communication drivers revolve around concept development, solution analysis and the accuracy involved in requirements gathering. These observations can equally be observable in any software development project teams that are not geographically dispersed, but the observation is that these emotions can be exacerbated in globally distributed working teams.

6 Discussion

Communication structures inevitably are a part of any organisation, and it is the articulate structure of these communication medium, which enable organisations to collaborate and function in a cohesive environment. The focus on improving organisational structures is emphasised through the analysis of geographically distributed teams, as even though the teams are within the same organisation, their organisational structures and processes differ.

Our study confirms the pre-existing knowledge in the literature by exploring the effects of Conway's law in modern organisations and communication issues within geographically dispersed teams. Concerns held by stakeholders involve claims that suggest particular teams have definite problems and deficiencies. All changes encompass inherent risks and if teams do not possess appropriate control measures such as protocols to maintain software and information reliability, proposed changes may affect the quality of products developed. Furthermore, the current structures within both teams are implemented as they provide both a feasible and optimal local efficiency, but may not necessarily provide an ideal global efficiency. Therefore, the application of Conway's law endeavours to improve organisational structures to enable geographically dispersed teams in reaching a global efficiency.

Geographically dispersed teams are continuously confronted with communication issues, primarily because of differing time zones and geographical distance. Whilst the use of modern technologies enabled dispersed teams to regularly communicate, the lack of face-to-face interaction is problematic. The benefits of incorporating the use of an integrated system in the current processes used by the teams, in addition to streamlining business processes, can prevent duplicate effort and succinctly gather and collate requirements to adequately address client needs. The exchange of business information is critical as it develops a set of metrics to measure performance against specific goals and deliverables, but most importantly minimises inconsistent knowledge and draws teams closer. Improved communication and a collaborative working environment create a synergetic relationship for achieving enhanced product development. The benefits of incorporating the use of an integrated system in the current processes used by the teams, in addition to streamlining business processes, can prevent duplicate effort and succinctly gather and collate requirements to adequately address client needs. In modern organisations today, businesses are driven by satisfying client needs, hence minimal delays and an increased time-to-market rate is necessary to ensure the success of any organisation. Communication is important in any environment, especially in an environment where product development is paramount and specific milestones must be met in order to satisfy client needs. Conway's law is not to be treated as quintessential for dramatic changes, but rather as an observation for change and to understand current processes within the organisation to initiate improvements.

With all the research effort and advancement of technology, the communication barriers are almost the same as those reported in previous studies [28]. The question is why all the research effort in this area has not made a tangible difference. Perhaps it is because the focus has either been purely on technical or merely social aspects. More effort are being exerted in providing technological solutions to the communication barriers, whereas communication is a highly social activity and the issues related to the social aspect are inevitable. There is a need for socio-technical solutions to overcome communication barriers in globally distributed teams. A solution to any problem should involve three perspectives in parallel, organisational, technical and individual [29]. Ignoring one of these aspects will only shift the problem rather than solving it and the solution will be of limited use.

7 Limitations

Our case study just like any other has inherent limitation of non-generalisability. However, our results do confirm what other researchers have stated previously. As an outside observer, it is probable that information obtained from the analysis of organisational documents could be misinterpreted. To overcome potential errors encountered in data collection and analysis, findings were discussed with professionals familiar with their organisational structure. Through discussion, queries were solved and more insight was provided with further explanations and demonstrations of actual workings of processes for service requests. Furthermore, informal questioning and day-to-day

observations further facilitated the conclusions drawn from research. Some of the known issues were overcome through previous observations clarifying some statements made during the interview.

8 Conclusion and future work

In this paper, we have reported a case study of communication structures and barriers in a geographically distributed software development organisation. Our objective of this case study was to observe the application of Conway's law in a modern organisational environment with regard to communication challenges in distributed software development teams. Geographically distributed teams are continuously confronted with communication issues. Whilst the use of modern technologies enables distributed teams to regularly communicate, the lack of face-to-face interaction is still inherently problematic. We observed the communication issues within the organisation in its real-world setting and explored the various dimensions of geographically distributed teams in all their complexity.

In this paper, we can still observe that the communication barriers are almost the same as those reported in previous studies. Further investigation is needed for the success of using a potentially developed integrated system, and how an integrated system shared between the two teams can further improve communication structures. The investigation has demonstrated the importance of communication in any organisational environment, with advances in organisational structures and business processes increasing business efficiency and profitability.

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10 Appendices

10.1 Appendix 1: The questionnaire

Job role: _____

Q1. How many times in a week do you contact your colleagues in other team? Please circle one option?

1 2 3 4 5 6 7 8 9 10

Q2. What is your primary medium of communication?

Q3. What do you think is the greatest challenge in working within a geographically dispersed team?

Q4. How do you circumvent these challenges?

Q5. Do time zones and physical distance impact your particular role? Please tick one option.

(1) Strongly agree (2) Agree (3) Neutral (4) Disagree (5) Strongly disagree

10.2 Appendix 2: Interview questions

Q1. Conway's law states: 'Organisations which design systems are constrained to produce designs that are copies of the communication structures of those organisations.'

How do you think this statement applies to the differing organisational structures of Team A and Team B?

Q2. What do you think are the greatest barriers to communication between the two teams? How do you believe they can be overcome?

Q3. How beneficial do you think the adoption of an integrated system, i.e. where data concerning projects is stored in one location would be for the two teams?

Q4. In your particular role, how do you think separate business processes used by the teams affect communication structures?

Q5. What practices do you believe could be employed for the effective exchange of business information, despite the inevitable challenges associated with geographically dispersed teams?

Q6. Do you believe the improvement of communication structures between teams can lead to enhanced product development? If so, how?

Q7. How important is a collaborative working environment when meeting the needs of clients?