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UNDERSTANDING THE USE OF EMAIL IN ENGINEERING: A SCENARIO BASED APPROACH

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1. Introduction

This paper is part of a research project to investigate strategies for improving the use and re-use of email sent during the course of engineering work. Using the current literature and empirical studies undertaken during this project the paper presents a non-exhaustive set of requirements for use in assessing such strategies.

The use, re-use and manipulation of information have become key factors in the success of any organisation in an increasingly competitive and global business environment [Hicks 2008]. Ensuring that employees are able to access (or are provided with) the right information at the right time is one of the key challenges facing organisations [Eckert 2001a]; communication is the process that facilitates this timely provision. Increasingly global economy engineering projects are more geographically distributed. This results in effective communication in some projects being increasingly difficult due to the distances, multiple locations and many participating organisations. Amongst the dominant communication methods email fills an important role in facilitating this distributed communication and as such it is a key target for improvement [Loftus 2008]. The rational and effective improvement of the use of email in engineering requires a clear understanding of the current uses and the communication needs of engineers. To achieve this, the work reported in this paper uses scenarios to synthesise literary and empirical sources that report characteristics of the use of email in engineering, to present the challenges associated with clear instances of use of email in engineering projects. These scenarios contribute to the basis for evaluating new tools and approaches that aim to support engineering work and provide clear and effective communication of the challenges to the wider research community and industrial stakeholders.

Eckert and Stacey (2001b) have expressed the need for a scenario based approach when considering communication in design, and have presented a number of dimensions that can be used to describe common communication situations in engineering – developed using their experiences of empirical research in industry. They go on to use these dimensions to make scenarios that show typical work situations to consider when designing and developing tools that intend to support engineering design work. Wild et al. (2010) also used scenarios to "provid[e] requirements for future document support software" in the context of engineering design; noting that they used scenarios specifically to facilitate up-take of findings by the widest set of researchers and industry stakeholders.

Bødker and Christiansen (1997) describe scenarios for use in the context of the design of collaborative software system as "exist[ing] in the borderland between experience and expectation" and that they are also "meant to provoke new ideas" [Bodker 1997, p. 225]. They further prescribe that:

Because scenarios are not empirical situations, they should be 'stories' located in time and space, 'traces' featuring details, not 'novels', and they should be designed based on knowledge about typical ways of doing things, but addressing specific, critical instances of the typical. [Bodker 1997, p. 225]

In the following sections the description of a scenario, as given above will be used to make typical email use scenarios, using sources from the literature and from empirical studies to offer inspiration and detail. The empirical studies employed include interviews, a survey and an analysis of content and are each discussed. The intention being to make scenarios that specifically describe "critical instances" of the use and potential uses of email in engineering, thereby highlighting both challenges and opportunities for improvement.

2. Email literature

Loftus et al. (2008) have conducted a cross-disciplinary review of the literature to identify the opportunities and challenges associated with the use of email in engineering. They reported that, despite the primacy of email little research had been carried out within engineering to understand and to improve its use.

2.1 Findings

The literature review identified a large number of opportunities and challenges and revealed 3 fundamental dimensions that affect all of the issues: context, understanding and behaviour. The following sections will summaries each of these dimensions.

2.1.1 Context

Establishing uniform context between communicating parties is important for the effective transformation of knowledge into information; it is typically a 'lossy' process. The losses come as the result of two factors: first, encoding knowledge as information is a necessarily incomplete process and second, that there will be interpretive discrepancies on the part of the reader when decoding the information. Schutz (1972) described the product of the encoding and decoding of a 'piece' of knowledge to and from information as being affected by many biographical factors of the author and reader, the major ones being: Language, Context and Culture.

Issues such as the representation of design rationale and the relationship of documents to the overarching work processes and design artefacts can only be addressed by the addition of 'more' context to information. Where email is considered these issues are further frustrated by the lack of formal structure, which when considering them as records (rather than in terms of their immediate usefulness), results in lower quality or at least less consistent records. The email content study described in the following section (3) provides insights into the current level of information content available within email and the findings report the same lack of context as described here.

2.1.2 Understanding

The second dimension relates to the opportunity for using Email to improve organisational practice and understanding. Email provides access to otherwise "hidden patterns of collaboration and leadership" [Tyler 2005] and there is potential to use these hidden patterns to inform understanding of how the organisation works. This opportunity was explored in a study which investigated the potential for using automated methods to identify the significant individuals and relationships from a corpus of email [Loftus 2009]. The study concentrates on the potential for the use of this information to support information retrieval by providing a 'human index' in order to address issues with effective organisationally consistent categorisation of email. It can seen that these hidden patterns also have a bearing on the use of email for managing organisation communication, the identification of communities of practice within the organisation and within the wider supply chain and customer base and on understanding the spheres of influence within the organisation.

2.1.3 Behaviour

The third dimension concerns the behaviour of engineers when sending email and the effect the use of email has on their behaviour. A number of the issues identified by Loftus (2008) are associated with users having difficulty using complex Information Systems and working environments. Engineers experience difficulties dealing with the sheer volume of information sent to them. Current engineering

practice is seeing a move to virtual working and increasingly interdisciplinary teams with direct consequences for the importance of electronic communication mechanisms but also for the importance of understanding the behaviour of engineers when communicating. Instances of behavioural issues can be seen in the communication problems resulting from the way different users express themselves and the complex trust issues involved in managing customer and partner relations in complex projects. The survey described in a following section (5) directly addresses the need to gain a better understanding of the practice and perception of engineers' with regard to Email.
To provide a further understanding of these broader literature based issues 3 complementary empirical studies have been undertaken from which the specific understanding necessary to develop typical use scenarios can be elicited. See the following sections for a description of each of these studies and their implications.

3. Email content

Wasiak et al. (2009) have undertaken a study that investigated the "role and characteristics" of email within a large engineering company. Part of the investigation involved the development of a coding schema to mark-up email corpora, to determine their overall characteristics. The re-use of existing schemata and the incorporation of domain specific terminology grounded the schema in the literature. The schema was refined by iteratively applying it to and reviewing it against a sample of email from an engineering project.
The final schema takes the form of 3 questions: *What*, *Why* and *How*. These questions subdivide into a 2 level hierarchy of codes and sub-codes, to allow for detailed coding. The schema was used to code and examine a sample of 800 email from a corpus of 16 000. The corpus contains information pertaining to a single engineering project that consisted of a series of 6 high value contracts for a large overseas client. Each contract essentially required a replica of the work in the first, tailored to the varying requirements of the end users. During the course of the project the Company acted primarily as an integrator negotiating with multiple suppliers. The email corpus used in the study consists of 16 000 email sent over the first 4 years of the project. The corpus represents the email exchanges of 650 senders (1 080 recipients), with approximately 30 of those being core project members. Project participants selected the email during the course of their work, by either authoring the email within an internal project information management system, or coping email from their individual email accounts into the system. Engineers were explicitly encouraged to select all email related to their work on the project.

3.1 Findings

An analysis of the coded email revealed that email contain information that is potentially valuable to project managers and designers, for both medium and long term re-use, such as the identification of risk and discussions for the purpose of problem solving. This information, however, is not explicitly represented within the email, and with regard to the project studied, was not recorded in other project documentation. Combining this insight with the experience of the researchers, who had difficulty when attempting to interpret the content of the email, highlights a wider problem engineers face when trying to interpret information from projects or organisations that they are not familiar with. Although the researchers involved in coding the email were educated as engineers the ambiguity present in email and the use of project/company specific terminology made objective interpretation difficult. More formally, email are a poor source of (re)usable information as they lack the contextual information and consistent (and defined) terminology that are necessary for interpretation. This is particularly important when considering re-use of email i.e. interpretation by actors other than the original recipients. This may also to include original recipients reusing the email after a significant period i.e. after they have forgotten/lost the context of the original use.

4. Interviews

As part of the Wasiak (2009) study introduced in the previous section 6 engineers associated with the project were interviewed to triangulate the findings from the content study. The interviews were on

average 40 minutes long and semi-structured. A common set of questions guided responses across all the interviewees; they could elaborate on particular points or raise issues of their own. The interviewees were selected to provide a representative view of the different roles within the project rather than to produce a proportional sample across the project. The roles of those interviewed were: Project Manager, Lead Engineer, Project Secretary, Warranty Manager, Software Engineer, and Service Engineer. While the limited sample size restricts the ability to generalise any findings, the opinions and perceptions of the interviewees represent their collective experience and can provide an understanding of typical sources.
For the purpose of this paper a detailed analysis of the interviews is not published, rather the important findings and anecdotes are introduced to help develop scenarios around the people interviewed (The transcripts for the interviews are available from the authors subject to approval by the industrial partner company).

4.1 Findings

The Project Director revealed that the problem of knowledge churn was significant in the project, with "almost every name chang[ing] apart from mine" over the course of the project. The direct impact of this problem can be seen by relating it to the 3 interviewees who mention that when information seeking they commonly rely on other engineers' understanding of the existence and location of the information they are looking for, rather than using technical retrieval mechanisms.
The interviewees consistently described the primary affordance of Email as being its role as a record keeper, with 4 of the interviewees specifically mentioning this. They referred to it both in the sense of keeping incidental records of ongoing communications and for specific and intentional recording of key points.
The Warranty Manager described his need to track back through projects so that the emails associated with a particular contractual commitment can be identified.
The Service Engineer described how managing the information flow resulting from regular activities such as filing field reports was difficult and not well supported by email.

5. Survey

An online questionnaire based survey was conducted with the aim of better understanding the practice and perception of Email within the engineering profession. The objectives for the survey were to:

1. Understand the perception of the role of email within engineering companies (in combination with interviews).
2. Understand the approaches engineers (and their organisations) are currently taking to manage their email records.
3. Highlight particular activities which require the most support from a system designed to improve the quality of record keeping, with respect to the use of electronic communication methods.

For the purpose of developing scenarios this paper will draw on the results of the survey that addressed the third objective. This paper does not present either the methodology or the results of this survey but rather uses the results to reinforce the scenarios. The rest of this section briefly outlines the extent and associated generalisability of the results of the survey and includes the survey questions that are used in the following section findings section (see Table 1). An internal report on the survey is available by request from the authors.
The survey attempted to take a broad sample of engineers in the UK to understand the extent of email use within the engineering industry. The survey received 96 responses. Of these, ~45 % elected to report their affiliation, showing that the survey reached at least 16 engineering companies. The companies represented are all large international engineering companies. However, when respondents were asked in the body of the questionnaire to report the size of the company they are employed by, 45 % reported that they were employed in companies of less than 250 people. The sample covered a range of roles and areas of expertise, the dominant role and type of work being Managers (36 %) involved in Design work (35 %) (See Figure 1).

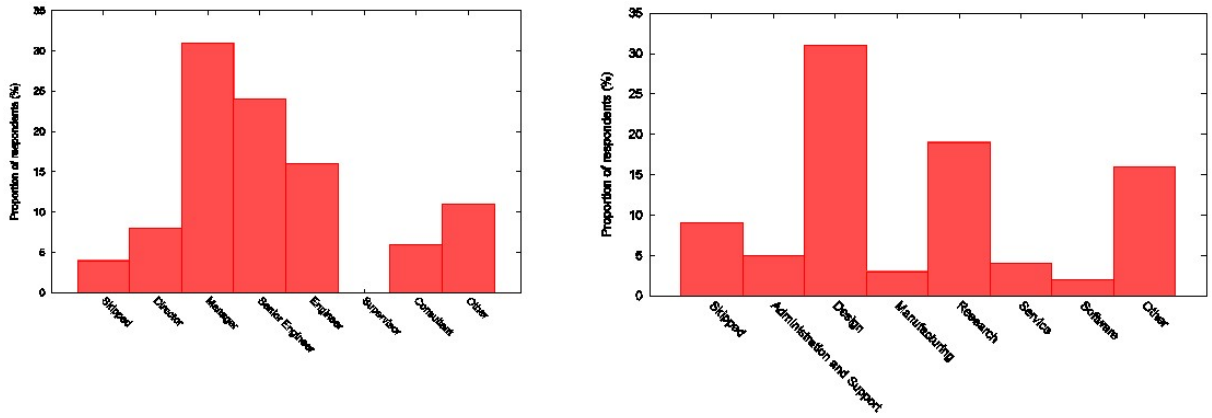

Figure 1. The proportion of respondents in each role and work type.

The respondents also reported on the sector of the company they represent (see Figure 2). From the responses it can be seen that although the sample does cover the majority of the key sectors, there are significant differences in distribution. There will thus be a bias towards the Marine and Aerospace sectors. It is likely that these biases are the result of the contact pool used for the distribution of the questionnaire.

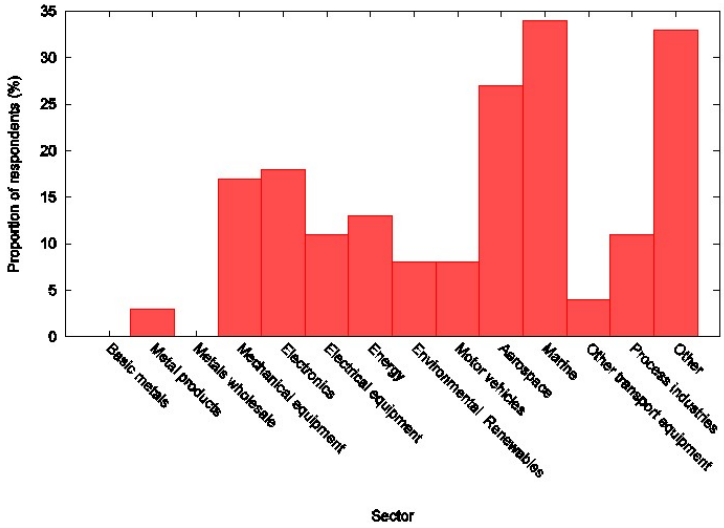

Figure 2. The sector of the companies surveyed in terms of the proportion of respondents.

Table 1. Questions from survey used in the Findings section

#	Question
10	How frequently is each communication method used? With options: Email, Telephone, Fax, Instant messaging, Phone/Video conferences, Arranged meetings and Informal encounters; against frequency options of Daily, Weekly, Monthly, Yearly, Never.
14	What proportion of emails that you receive did you not need to receive?
19	Briefly describe your general strategy for managing email
24	How often do you refer to archived emails?
25	How often do you use email to remind you of events or tasks?
26	Who, primarily, controls the archiving of your emails? With options: Myself, My Organisation, A delegated 3rd party organisation, No archiving is done and Skip question
27	Does your organisation have a policy for email use?
28	Have you received any training in email usage?
31	Do you, on balance, feel that email: Increases or decreases productivity; Improves or degrades communication

5.1 Findings

Responses demonstrated that Email is the predominant electronic communication mechanism in use within the engineering industry (Q10). Further to this, responses on the perception of Email among engineers (Q31) indicated that individuals consider it a useful tool for communication. Many, however, are frustrated by the volume of email exchanged (Q31); particularly by the volume of email that they believe they do not need to receive (Q14).

Responses to questions on the strategy individual engineers use when managing their email show that the use of categorisations that are consistent within the organisation is relatively common i.e. categorisations that make use of terms such as project names and customer names that would be recognisable by most engineers within the company (Q19). This reinforces the finding presented in the previous section on the email content study that suggested that there is value in embedding explicit organisational and contextual information within email.

Of the respondents, 67 % reported that they refer to archived email (Q24, where archiving refers to 'long term storage, with at least the ability to search for and retrieve documents'), with 37 % doing so at least once a week. Again, this reinforces the findings of the email content study (3) that that email is a valuable source of information to engineers, but elaborates by connecting this with actual re-use of the information during their work. However, the finding that 33 % use their email to remind them of tasks on a daily basis (Q25), demonstrates that in terms of information content many email are likely to be of only short term value.

It could arguably (but perhaps not safely) be considered self-evident that training employees on the requirements or expectations of them when producing documents would lead to better conformance with those requirements and expectations. A lack of training is the anecdotal target for much conversation on the issues surrounding Email use, and it is borne out in the survey, with 80 % of respondents saying that their organisations' do maintain policies on Email use (Q27), and yet 70 % say that they have been provided with no training on Email use (Q28). Further weight is given to the concern raised by this finding by associating it with the 53 % of respondents that report that they are responsible for archiving their own email (Q26).

6. Scenarios

The following scenarios have been constructed from the literary and empirical sources described in the preceding sections to capture an understanding of critical engineering uses of email.

1. Process Integration

For the purpose of constructing a complete record of the engineering work carried out within a project the Project Manager needs to understand how the email sent relate to overarching processes and tasks within the project, and the artefacts, such as models, specifications, that are produced during the course of the project. Such integration of informal email with the formal outputs of the project would reduce the fragmentation of information within the project by providing each fragment of information with more context about its 'position' within the project (2.1.1). The presentation within a given information system would have to balance the increased cohesion against potential complexity for the project manager (2.1.3).

2. Capturing design intent

Engineering designers need to be able to understand the reasons why specific design features are present within a design, both for on-going work within a project and for retrospective re-use of a design. With the move to more distributed working these reasons are increasingly being communicated through asynchronous communication channels (e.g. email) rather than in meetings (3.1). It should be possible to use the communication record to better understand the intention of, and the rationale used by the original designers.

3. Traceability of contracts

In the course of exchanging email engineers can unwittingly guarantee a particular level of performance that then contractually binds the organisation without it being recorded within the contract [Loftus 2008]. The project's Warranty Manager needs a way to track the development of contractual responsibilities (4.1), such as through identification of decisions points, as this allows the Company to understand, manage and defend its responsibilities during on-going relations with either their customers or suppliers.

4. Auditing

Related to the need for traceability and for the visibility of design intent, the Organisation has a need for an auditable record of all communications to allow for the recovery of documents resulting from legal action (2.1.2). With one senior engineer stating, "email now has an important central role in contractual situations and is required evidence in any litigation where its content may be very important to establish design intention however unwittingly it was recorded" (4.1). Failure to produce the evidence is not an option; therefore a low cost proactive effort to reduce a large future cost would be prudent. This scenario would require similar changes to current practice as scenario 3, but differs its emphasis on the exhaustive recovery of communication records associated with a particular project or product.

5. Facilitate shared understanding

All participants in a project, both within and outside the Company develop, during the course of the project, a shared understanding of the work carried out (2.1.2). This shared understanding is typically developed, maintained and recorded using conventional design artefacts, such as drawings and specifications, to act as boundary objects between participants. With the increase in the use of electronic communication to exchange valuable design information (5.1 Q10) (separately from the traditional boundary objects) there is a need to make this information, such as the expression of risks that have being identified or on-going problems, more accessible to participants to improve shared understanding (2.1.3).

6. Ability to understand

Email contain valuable information that can remain relevant through (and beyond) the life of long engineering projects (beyond the tenure of individual engineers) and this requires that they be understandable over long periods of time, across multiple disciplines and independent of changes in organisational structure and technology (3.1). The context that email are authored in needs to be better presented to the reader.

7. Monitoring progress

With many actors sending email within a single project, the Project Manager needs a means of gaining oversight of the progress of work and of key decision making and problem solving activities that are on-going (4.1). This could be achieved by using the understanding of activity gained by analysis of aggregate patterns of email exchanges (2.1.2).

8. Managing correspondence

Service engineers and Project Managers need to manage the flow of information between themselves, suppliers and customer (4.1). As well as typical project administration email, specific processes such as resolving a problem may involve multiple actors within the Company and the Customer organisations each needing to provide specific information, within time constraints and often across time-zones (2.1.3). In such situations effective communication of information becomes simultaneously more difficult and more important.

9. Understanding service patterns

As well as managing the correspondence between the different parties in a project, to be proactive, Service Engineers need to identify recurring problems in the Company's products (4.1). To achieve this they need to be able to see and interpret patterns in the problems reported by customers and field engineers (2.1.3).

7. Discussion

A categorisation of the scenarios presented in the previous section; this categorisation is not intended as a robust attempt to simplify the problem space. It is included to aid the following discussion of the potential for focusing interventions on the different scenarios (see Figure 3).

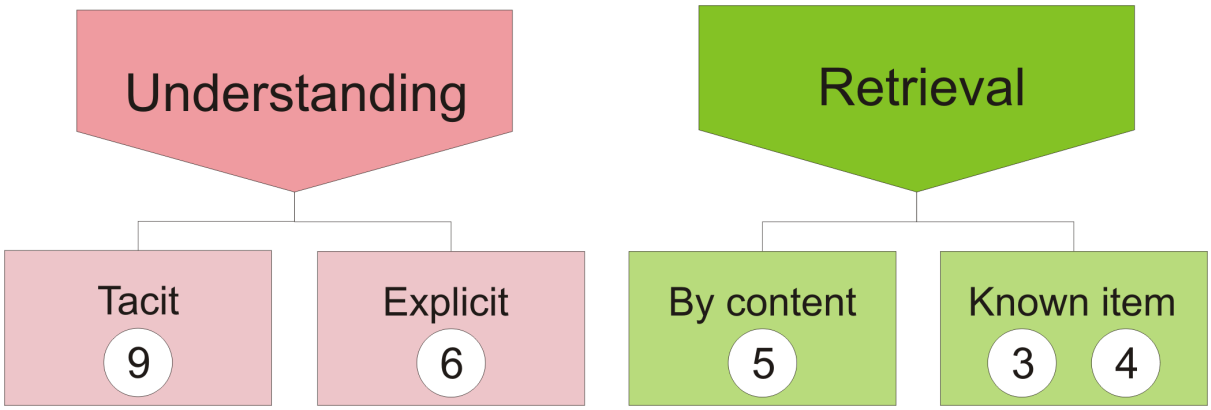

Figure 3. A diagram showing a categorisation of scenarios

The scenarios can be divided into those associated with the retrieval of email and those associated with the improving the understanding of email. The retrieval scenarios divide into those associated with the retrieval of information by the content of the email as opposed to those that retrieve based on particular characteristics of the email. This is a well known distinction made in the classification field [Broughton 2004, pp.4-5] i.e., "known item retrieval" vs. "subject retrieval" and it suggests the potential for using single interventions to address multiple scenarios. It also points to the application of existing solution 'types' to address the scenarios, i.e. the use of classification to aid retrieval by the content of the email and the use of extended meta-data schemata to aid known item retrieval. The understanding scenarios divide into those that support the understanding of an individual reusing email and those that explicitly extract 'organisational understanding' from an email or collection of email.

7.1 Policy environment

For the scenarios present in the previous section to be relevant the policy environment in which they are situated must be considered. We know from the survey that the large majority of respondents organisations did have a policy on email use in place (5.1 Q27) but that a similarly large majority had not any specific training on the use of email (5.1 Q28). One example of a policy constraint is that most of the scenarios assume access to all of the correspondence exchanged. However, the responses to the survey (5.1 Q26) show that currently the majority of engineers are responsible for archiving their own email and therefore it is at their whim (or upon their value judgement [Zhao et al. 2008]) to what extent email are retained.

8. Conclusion

This paper contributes a set of 9 scenarios: Process Integration, Capturing design intent, Traceability of contracts, Auditing, Facilitate shared understanding, Ability to understand, Monitoring progress, Managing correspondence and Understanding service patterns. These scenarios can be used:

- to represent a method for assessing the appropriateness and eventual success of implementations proposed to improve the use of communication in engineering,

- for developing a new proposal specifically designed to meet the communication needs of engineers by providing a set of requirements for a holistic approach,
- to provide the basis for the testing of specific implementations of such proposals both in terms of fitness for purpose and performance.

The paper has highlighted the importance of Email as an electronic communication method for engineers, and described the root causes behind the problems currently associated with Email use. The different scenarios for improving the use of email have been presented and the paper has argued for the need for a better understanding of the characteristics uses of email within engineering. The paper draws on a mix of literary and empirical sources for the inspiration and development of a set of scenarios that describe key engineering activities that could be better supported by email.

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