IMPROVING INFORMATION SHARING ACROSS CONSTRUCTION STAKEHOLDERS: AN ORGANIZATIONAL SEMIOTICS APPROACH

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Construction projects rely on the sharing of large amounts of information between diverse stakeholders. A perennial challenge for construction is managing and coordinating these exchanges, and there is an expanding market of information management tools available to support this process. We describe how organizational semiotic concepts may be used to underpin information systems which can cater for the different requirements of multiple stakeholders. We draw especially on Eco's notion of the 'model reader' (1979). This suggests that information is produced according to the expectations and assumptions held by the producer about the actor (or model reader) who will subsequently 'read' and use it. Enhancing our understanding of this process, and of the ways that different stakeholders interpret and use information within construction contexts offers a potential foundation for information systems which are capable of representing construction information differently according to the particular 'model reader' accessing it.

KEYWORDS: organizational semiotics, information sharing, construction projects, stakeholder interaction.

INTRODUCTION

The design and construction of buildings is a highly complex process involving the creation of large amounts of information, much of which must be passed between various actors and used in multiple ways. In addition, there is often a lack of understanding about precisely what information is required further along the project process (Harty, 2005). This complexity is further increased when recent calls to better integrate the design and construction process with facility and operation management, and to shift towards integrated service provision are considered (Saxon, 2002). Coupled with this is an increasing awareness of the built environment's importance in providing the infrastructural context through which all aspects of life and work are mediated. This has led to an appreciation that construction's products must fulfil wider social, economic and environmental requirements, as well as those of the primary client (Fairclough, 2000 and Cole, 2005).

A recurring challenge for IT systems developers is to produce solutions which will better mediate the necessary information-sharing processes occurring during construction work. This paper seeks to establish how the production, interpretation and exchange of information for through-life building processes may be improved through the use of organisational semiotic concepts. We begin by outlining the challenges of integrating the heterogeneous activities of the construction sector and describe and draw on concepts from organisational semiotics, especially Eco's notion of the 'model reader' (Eco, 1979). We advocate an emerging framework which addresses the need to understand and interact with the different interpretive schemes held by different stakeholders, positioned as different 'model readers'. The implication of this is that designers must provide systems which are capable of representing information from a central repository differently according to the particular 'model reader' accessing it. Finally, we outline our approach to further developing and testing our framework, through empirical research.

The information sharing challenges of the construction sector

The activities required to build are diverse and complex. The project-based nature of construction work requires temporary and inter-organisational constellations of actors to work together. The process utilises a plethora of different skills, knowledge and disciplines, from architecture and design, through construction, to operation and maintenance. Multiple stakeholders influence the process, including clients commissioning work, planners, regulators, eventual occupiers and users, and society more broadly. Each of these actors has to create, access, share and interpret different sorts of information: specifications, visualisations, architectural plans and models, structural calculations, plans of work, bills of quantities, quality assessments and so on. In addition, there is often a lack of understanding about precisely what information is required further along the project process.

Construction projects are information-intensive fields of activity. But the sector is also characterised as lacking coherence in the way it produces, shares and uses this heterogeneous information. There is a long history of high profile reports which bemoan the quality of information and collaboration in the sector. Higgin and Jessop (1965) identified advising clients and managing information and communication within projects as particular problems. Egan (1998) called for "accelerated process improvement" to move away from approaching projects as a series of sequential, separate actions towards integration across multiple stakeholders.

Despite these calls, problems of minimal information sharing between the various construction stakeholders working on the same project remain. Incomplete or inconsistent information results in errors, expensive re-work, misunderstandings and conflict (Love et al., 1999). There are numerous factors which contribute to these problems. The disciplinary basis of construction work produces a 'silo' mentality, where the interactions between different design disciplines, or design and construction, are limited. The nature of the design process is iterative and fluid, and there is an unwillingness to disseminate design information which is still fluid and incomplete.

Long-standing and robust power structures between stakeholders (eg. clients and architects, designers and contractors) are enshrined in standard contract forms and inhibit information exchange. Organisationally-based administrative practices and issues of risk and liability distribution across projects also affect information exchange between firms (Miozzo and Ivory, 2000 and Zietsman, 2008). Emerging environmental assessment tools for monitoring such variables as operating energy usage, greenhouse gas emissions and embodied energy

within structures (Cole, 2005), serve to further complicate the informational requirements of construction.

IT and the construction sector

Within this context, information technology is often positioned as able to address these problems, and provide the thread which can stitch together these disparate actors and requirements. This is the cornerstone of Egan's call for process improvement (1998). Gann (2000) observes that contemporary building work revolves around processes and workflow activities between diverse actors more than in the past. The value of better information utilization by construction companies has been recognized as a way to develop further business. This strengthens the case for IT systems which bridge the gaps between design, construction, operation and wider stakeholders. To do so, IT systems need to be more adaptable and integrated with construction processes.

In addition, the landscape of construction does not stand still. Saxon (2002), in his assessment of the Fairclough Review (2000), points out that Integrated Solutions (IS) for clients are beginning to break down the traditional boundaries between property, construction and FM (facilities management). The need to embrace occupier needs is now a major growth niche for the sector, as industry actors recognise the potential worth of maintaining working links with a construction project following completion of their primary project activity. PFI (public finance initiative) projects, which roll together construction with concessions for operation and maintenance of public facilities, also contribute to this shift.

Construction is, in fact, sophisticated and innovative in its use of IT on projects. CAD has been a standard practice for the last two or three decades, collaboration tools such as extranets are increasingly being used and stipulated as part of contractual agreements. Document management is routinely used to coordinate information across projects. Such innovations have been incorporated into the practices of certain disciplines but few innovations have enabled better collaboration and information sharing across construction stakeholders to improve workflows and processes. Radical changes to the way information flows through projects are yet to occur:

> " the construction industry has been quick to use technological developments as a tool to provide support for specific tasks, but has not generalized their application to integrate activities or provide communications through the construction process" (Miozzo and Ivory, 2000).

The development of such an inclusive system must meet the challenges presented by the sector's activities. Importing off-the-shelf solutions or systems from other areas is problematic. The multiplicity of actors involved in construction projects, the often unique nature of any building and the 'one-off' temporary character of project teams produces a different context from more formalized and controlled industries which possess predictable and repeatable patterns of activity, such as the automotive industry. Another more tangible barrier to data exchange across project actors is a lack of inter-operability between the various information tools used within the construction process.

Whilst some commentators (Aouad et al., 2008), maintain that the business benefits of any particular information system may be difficult to determine or express in absolute terms, others argue that new innovations may bring forth more conflict and problems for the industry than solutions (Miozzo and Ivory, 2000). But it is generally accepted that the value of IT solutions which begin to successfully facilitate collaborative work for through-life building processes between construction stakeholders can outweigh any potential problems.

For the rest of this paper, we outline how concepts from organisational semiotics can begin to address the practical problems of integrating information across construction activities and move towards elucidating a framework for system design which mobilises these concepts.

Organisational semiotics and IT innovation

Semiotics may be defined as "the study of signs" or "the discipline of signs" (Peirce, 1960). It is centrally concerned with the generation and construction of meaning, encompassing the inception, analysis, interpretation and representation of signs (Liu et al., 2006). Signs are pervasive throughout human interaction; they are the medium through which information about, and understanding of objects, concepts and ideas are mobilised and shared.

Organisational semiotics (OS) is an extension of semiotics and specifically studies the utilisation of signs within organisational contexts. OS maintains that an organisation may be considered as an information system itself, which incorporates a plethora of actors, technological artefacts and activities. Within such systems, sign generation, use and manipulation is the medium through which these heterogeneous entities interact and exchange information; signs are 'all pervasive' (Liu, 2000). Organizational semiotics does not just focus upon specific information flows occurring within organisations, but allows for a holistic analysis of specific organizational scenarios, allowing all significant actors and influences affecting an organisation to be included, accounted for and explained. Importantly, this offers an approach which considers the socio-technical character of organisational contexts, thus following Stamper`s premise that only a complete understanding of both machine and human information systems will allow existing processes to be understood and improved in any tangible way (Stamper, 1973).

Compared with other information systems (IS) approaches, in drawing attention to the social processes which characterise interaction, generation and exchange of signs, organizational semiotics offers different insights than a narrower focus on technical, process-driven, information-flow processes might provide. Semiotic analysis has made significant contributions in underpinning the planning and designing of computer systems and its applicability has been demonstrated in several fields, including human-computer interactions, graphic design, and programming (Barr et al., 2004). By also incorporating the social aspects of signs generation and utilisation, organizational semiotics provides a persuasive set of concepts for understanding the complex interactions between multiple stakeholders, and analysis of the extensive production and exchange of information which characterises construction project work. It raises questions about how meaning is (or is not) constructed or shared across diverse actors, as well as accounting for flows of information. An analysis of the ways that different stakeholders interpret information in construction project contexts can provide insight into both the problems of sharing information, and into developing practical techniques to alleviate these problems.

Writing and multiple readers

To develop an understanding of the semiotic processes mobilised by stakeholders to interpret information, the potential for different groups or actors to interpret and understand the same signs or information differently is paramount. The processes through which these meanings and interpretations are produced must be considered. This is not just central to understanding the problems of collaboration in construction, but also in eliciting and reconciling different stakeholders' user requirements for any information system. It is not enough to 'know the

user' (Barr et al., 2004) but to know *multiple users* and produce frameworks and tools which can simultaneously manage these different users.

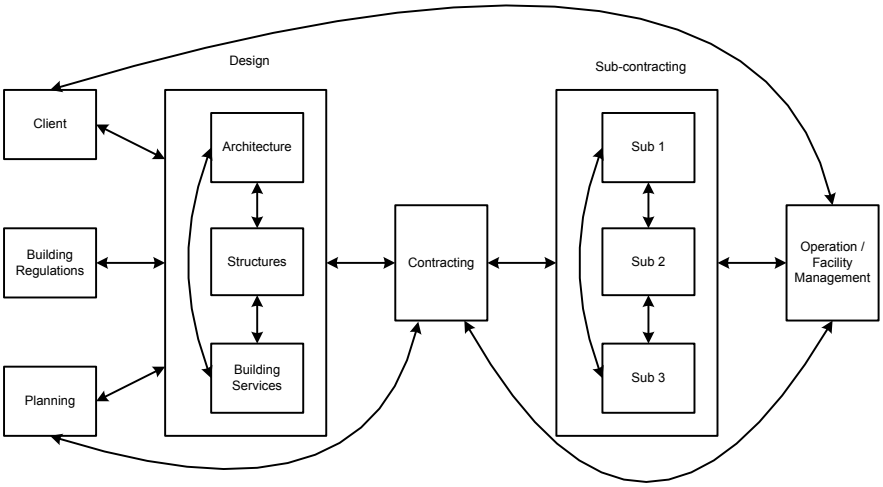

Figure 1: Stakeholders and interactions within construction projects

Fig 1. represents a simplified view of the multiple stakeholders involved, and multiple interactions occurring, within the context of construction projects. Information is passed between these stakeholders, and in doing so processes of interpretation occur. The central contribution of organizational semiotics is in positioning this interpretation of signs and information as emerging from the representational and interpretative knowledges held by different groups and individuals, and by revealing the different norms through which meaning is produced. As Liu *et al.* maintain:

> "Understanding and modelling the behaviour of members of an organisation is essentially understanding and representing norms...a norm-based theory is a good approach to derive a conceptual design for collaborative information systems" (Liu et al, 2001).

Meaning is constructed by drawing on the norms and knowledge bases of particular users. To use the terminology of semiotics, individuals (and groups) possess semantic reference models which are operationalised in particular contexts. It is through this context-specific pragmatic knowledge that the interpretation of a particular sign is produced.

If the problems of collaboration in construction projects are positioned around multiple (and potentially conflicting) interpretations of the same signs, then a potential solution is to create signs or representations of information for different users which limit the possibilities for these different meanings to be produced across stakeholders. So by aligning user-specific signs with the semantic and pragmatic frameworks held by the user, the possibilities of interpretation might be limited. This would result in less difference in interpretations across stakeholders, and hence form the basis for a better shared understanding of specific information.

The analogy of writing and reading signs is useful here. Eco (1979) suggests the notion of a 'model reader', where the author or developer generates signs which are specifically oriented

to produce a ‘correct’ or desirable reading in the user. To do so requires a detailed understanding of how that potential reader might interpret the sign:

> “The author has thus to foresee a model of the possible reader (hereafter Model Reader) supposedly able to deal interpretively with the expressions in the same way the author deals generatively with them”

In other words, the pragmatic framework mobilised by the reader must be understood by the designer, and the generation of signs for that reader be aligned to it. This resonates with work on understanding the ways that users approach and utilise artefacts such as computer systems. The notion of ‘configuring the user’ (Woolgar, 1991) invokes a similar process where the artefact’s designer imagines how the potential user will utilise the artefact, and designs it so that it supports that envisaged use, and prohibits others.

The notion of having multiple readers with different interpretive schemes involved in any construction project and accessing information does complicate matters. It cannot be assumed that every actor will be a model reader, and know intuitively what a sign means (Eco, 1979). Different users must be imagined, different model readers addressed and different knowledge bases accounted for. Any system attempting to span the variety of different construction professions and stakeholders must make allowance for this reality.

In any interaction, each stakeholder will have their own knowledge base which includes semantic and pragmatic knowledge. When the stakeholder is involved in the design and production of an artefact then he may be described as a model-writer. The artefact designed or produced remains for readers to interpret or consume. The reader could be another co-worker or another project stakeholder, who in turn might use this information to author signs for other readers. This means there are multiple semiotic processes (semiosis) occurring through a building’s life-cycle. Information might be produced for one purpose - for instance for the architectural design of a building – but also used for others - for instance as a basis for producing bills of quantities or tenders for sub-contracting packages. The intentions and knowledge bases of the ‘readers’ in these different contexts could be very different, and with some ‘readings’ or interpretations lie beyond the uses foreseen by the original writer.

The basic premise is that through gaining insight into the knowledge bases of multiple stakeholders (knowing the users), and by identifying where pragmatic knowledge bases of stakeholders overlap, tailored representations of information can be developed which limit the possibilities for multiple conflicting interpretations, and hence misunderstandings across different groups.

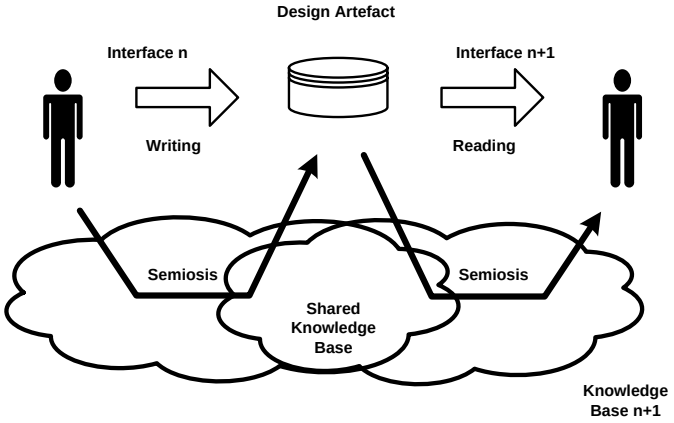

Figure 2: sharing information across knowledge bases

Figure 2 represents this concept. Different interfaces between the central source of information – the design artefact - and multiple stakeholders are developed to align with their particular pragmatic frameworks, particularly drawing on those aspects of pragmatic knowledge which are shared between them. This allows more coherence of interpretation across the stakeholders. It is in the articulation of these users, readers and frameworks that the potential to facilitate better shared understanding and enable increased collaboration resides.

Mobilising a writing / reading framework

Having outlined the problems of collaboration and information sharing in construction, and sketched out a conceptual framework to address this, attention must turn to practically mobilising this approach. To develop this, empirical work is focussing on a real and current construction project - the construction of a new office building in central Reading, UK. Using a specific project allows easier identification of stakeholders, and provides both real instances of information exchange to focus discussion and analysis and insight into the extent (and problems) of sharing information in a live context.

The central aim of the approach is to examine and clarify the complex information interpretation and exchange processes occurring between construction stakeholders throughout the entire life-cycle of the project. To achieve this firstly requires an investigation of current work processes and existing data flows and ruptures between the various stakeholders. This necessitates consideration not only of design, construction and operation activities, but also includes the project clients, local government planning, building regulation inspection, and eventual users. Secondly, the interpretive frameworks of these stakeholders need to be analysed to lay the foundations on which the development of interfaces which mobilise the ‘writing for multiple users’ concept can be based.

But gathering such data is problematic, as much of the process of interpretation is tacit and experiential, and as such difficult to make explicit. A pragmatic approach is being taken in which stakeholders are interviewed using specific instances of information interpretation and exchange as the primary focus. The interviews are oriented to reveal the sorts of information produced and required by different stakeholders, why it is needed, what it is being used for and the forms it takes. Through focussing on specific and real information and on the practical activities of participants, a more grounded understanding of how existing information is generated and interpreted can be gained.

The interviews provide a backdrop against which to position multi-stakeholder workshops. These are intended to bring together a range of stakeholders and facilitate debate around what problems and ambiguities of interpretation are being experienced on the project. Again, specific examples will be used and the workshops represent an opportunity to observe the process of interpretation and interaction across stakeholders in action. The workshops also will allow debate over areas where interactions can be improved, to which all of the participants can simultaneously contribute.

The next step is to begin to develop practical IT tools which build on the analysis of current information flow, stakeholder frameworks and areas for improvement. For this, established methods of requirement capture can be deployed. Practical analysis tools based upon organizational semiotic theory for system development processes have been developed under the MEASUR (Methods for eliciting, examining and specifying user`s requirements) programme. They include PAM – Problem Articulation Model for domain scoping, SAM – Semantic Analysis Method for domain modelling and NAM – Norm Analysis Method for capturing business dynamics. Consequently, complex problems may be de-constructed and potential solutions formulated as the basis for developing practical applications (Stamper et al., 2000).

However, there are potential problems in terms of moving between the detailed qualitative assessment of stakeholders' interpretive frameworks, and the more standardised methods of requirements analysis. A key consideration is therefore to continually check and test emerging tools with project actors. Obtaining continued stakeholder participation and co-operation in the research project process is essential if research findings or recommendations are to be valid and effective. This also mitigates against requirements capture techniques becoming separated from the analysis of stakeholders conducted previously.

CONCLUSIONS

Construction informatics is an evolving and growing field of study, with research programmes active across Europe (Turk, 2007) and the methodological approach described here is also still developing and evolving. But approaching collaboration and information sharing in construction from an organizational semiotics perspective draws attention to the different processes of interpretation and meaning creation occurring across disparate actors involved in the process. In particular, the writing and reading framework holds much potential to contribute to the field through elucidating the information exchange issues occurring during a construction project life-cycle, and the production of meaning across multiple stakeholders. We are developing a fresh analysis and perspective from which innovative IT solutions for the construction sector may be based. Such a research approach promises to focus attention upon the root cause of collaborative project problems: the generation, manipulation and exchange of information.

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