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A first step to designing a collaborative information system: a case study of the South African construction industry

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Abstract:

Analysis, design, implementation and support are the traditional ADDIE model used for developing information systems. The paper will discuss the design of a collaborative information system, with the focus on the components of an information system. The South African construction industry, from the general contractor's perspective, is used as a case study for the different methodologies.

The construction industry differs from other manufacturing industries. Subcontracting is the norm, no construction design changes are allowed without the consent of the principal agent. The client communicates with the principal agent, but the client is ultimately responsible for all payments to the general contractor. Construction companies also differ in the type of construction performed, and the number of full-time employees has no relationship to the size of the construction work undertaken.

Collaboration between the stakeholders is crucial, and this research will look at some principles that must be considered when designing collaborative systems for the industry. The stakeholders involved and communication methods are the cornerstone for collaboration on the construction project. Other factors such as access to information technology and the attitude and beliefs of the stakeholders influence information systems usage on construction sites.

Keywords:

Collaboration, information technology, construction industry, systems analysis and design

Introduction

Skill and creative abilities are necessary when developing information systems. Designers must consider not only the different components of an information system, but also the systems development lifecycle and the characteristics of the business environment of the proposed system.

This paper uses the South African construction industry as a case study to discuss the different components that must be considered when developing a technology based collaborative system for this industry. The IS-model, created by Johnson and Tate (2004:Online), is used to link and discuss two of the main components of an information system, people and processes. The stakeholders involved in the construction industry, and thus part of any collaborative system, the attitudes and beliefs that must be in place, the information that are used for collaboration and the role of technology will be discussed.

Introducing design thinking and software development

Creating solutions for opportunities and problems is what software designers do. Not only do they need to understand the business environment, technical knowledge and skills are important and they need to

understand how people think, react to change, work and communicate (Satzinger, 2007:10-112). This implies that system designers

- Need to understand the people that are associated with the product;
- Be able to integrate their technical knowledge, people skills, business knowledge and creativity to understand the environment and then to design the solution;
- Collaborate with users of the systems, business experts, technical specialist and others to gain an understanding of the problem, and to develop the most appropriate design.

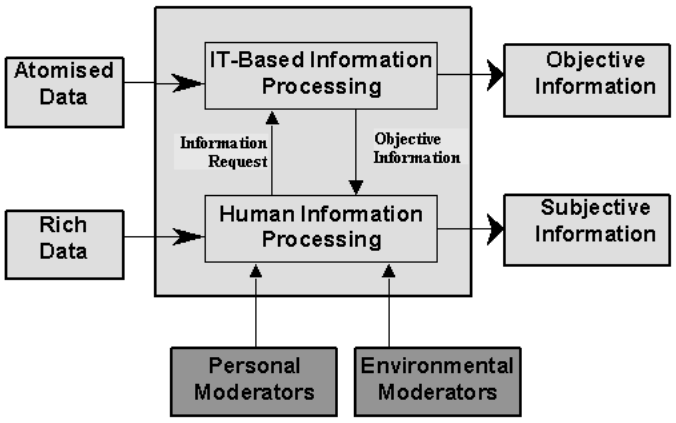
The systems development lifecycle is a well established general methodology used to understand and development software applications. Different variations of the SDLC exist, but common to all these methodologies is the need to identify the opportunity or problem, analysis of the requirements for the proposed software system, designing the system and coding and testing the new system (Satzinger *et al*., 2007:51-62; Shelly & Rosenblatt, 2010:18-24). . Paton (2010: Online) concurs, and lists four necessary steps used to solve software problems:

1. Understanding the problem that must be solved;
2. Creating and considering ideas for alternative solutions;
3. An iterative process is used to refine the ideas; and
4. Validation the solution continually.

Information systems are generally described as consisting of five components. The physical layer consists of the hardware required control and executes the software programs; software that controls the hardware and manages the information processes; data that are transformed into information; the processes that describe the tasks and business functions that people perform in the organization; and the stakeholders consisting of everyone involved in the information system (Satzinger, 2007:8; Shelly et al., 2010:6).

In contrast, Johnson and Tate (2004: Online) argue that the human behaviour is the integral part of an information system. This is illustrated by their model of an information system, depicted in figure 1, that view information processing as consisting of two parts, namely IS-based information processing and human information processing.

Figure 1: The modified IS model incorporating both atomised data and rich data as system inputs, processed by the IT-based and human components (Johnson & Tate, 2004:Online)

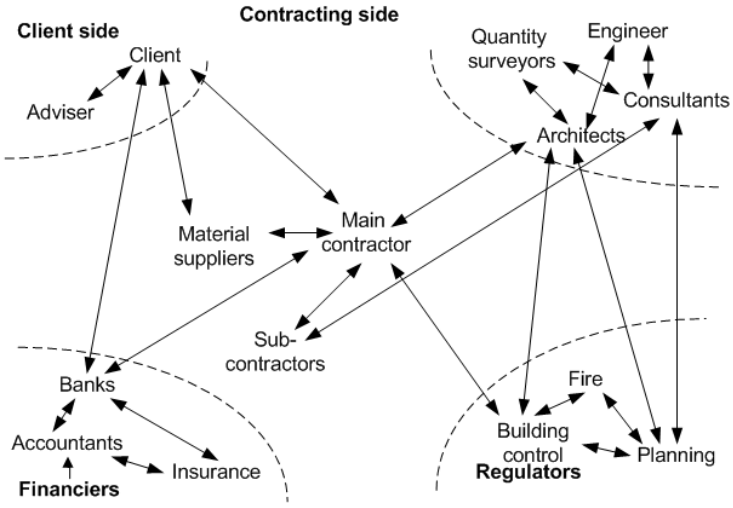


The Johnson and Tate model of an information system will be used to guide the identification of the components of a collaborative system for use in the South African construction industry. The focus of this article is on the people involved and the collaboration processes that are used in the South African construction industry.

Designing a collaborative system for the construction industry: a first step

The construction industry depends on the interaction between stakeholders, the information that is required for the building process in order to complete the construction project on time, within budget and with the expected quality (Hjelt & Björk, 2007:289; Sampson, 2007: Online). Sommerville and Craig (2006:51), describes the communication processes in the industry as chaotic, as depicted in figure 2.

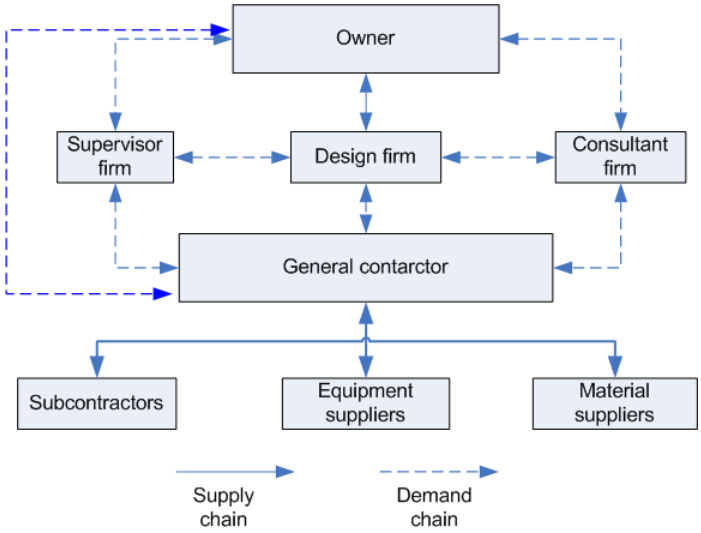
Figure 2 Traditional chaos in communication within the construction industry (Adapted from Sommerville & Craig, 2006:51).



Authors such as Lehto and Himanen (2002:216), Emmitt and Gorse (2003:23) and Turk (2006:188) highlights the interaction between human behaviour and technology as factors that affect the information flow the construction industry. The advantages and disadvantages of the use of information technology are discussed by various authors (El-Mashaleh, 2007: 289; Goh, 2004:9-10; Love *et al*., 2004: 514-517; Oladapo,2007:268; Samuelsen, 2008:14-15). The lack of information technology knowledge, skills and the changing environment brought about from the use of information technology are some of the stumbling blocks to the use of information technology in the construction industry. According to Yang et al. (2006:104-105), smaller construction projects also tend to use less information technology.

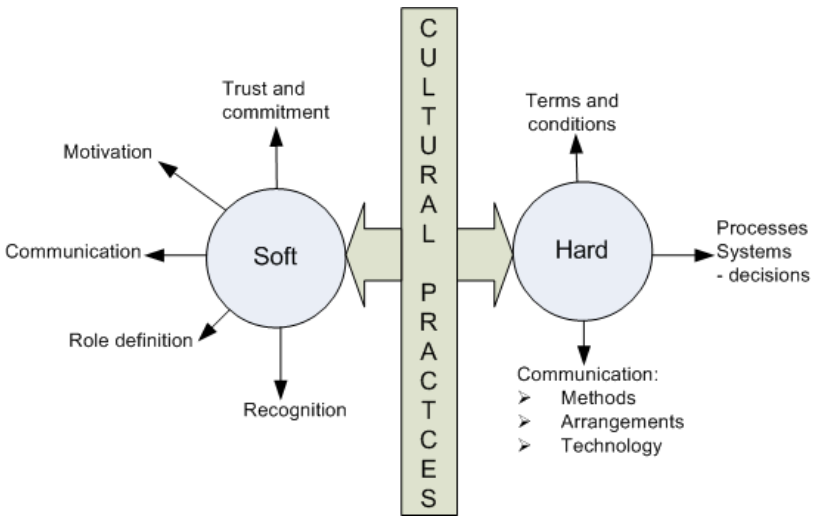
Human participation is an integral part of an information system, according to the Johnson and Tate model. Different stakeholders are involved in any construction project as discussed by Tserng, Dzeng, Lin and Lin (2005:245), Bennett (2003:13). Wang, Lin and Lin (2007:571), Josephson and Hammarlund (1999:682). Figure 3 depicts only one example of the typical stakeholders of the construction project.

Figure 3: Construction supply chain framework for the general contractor (Adapted from: Tserng, Dzeng, Lin & Lin, 2005:245)



Collaboration depends on the interaction between the stakeholders. The personal and long-term relationships between the different stakeholders, commitment to the communication processes in place, a trust in the environment and other participants influence the communication process (Chong *et al*., 2009:157; Kern & Kersten, 2007:567; Paulraj *et al*., 2008:58; Lee-Kelley *et al*., 2004:654; Rezgui & Zarli, 2006:771). Hard and soft issues, as depicted in Figure 4, influence the working relationships among virtual teams (Lee-Kelley *et al*.,2004:654-655).

Figure 4 Competing factors for virtual teams (Adapted from Lee-Kelley *et al.*, 2004:654)



There is thus an opportunity to create a technology based system that can assist with collaboration between stakeholders. Before designing such a system, the system requirements must be understood and defined. A first step towards the analysis process would be to determine:

1. *Who are the people involved in the construction project?*
2. *How does the industry use information technology?*

Research methodology and results

The South African construction industry was used as a case study to identify the stakeholders involved and the information processes that are shared between the different stakeholders. Various authors, such as Benbasat, Goldstein and Mead (2002: Chapter 5:82), Blaxter (2001:73) and Yin (2009:8, 13) discussed reasons for the use of a case study research methodology. A case study methodology was considered as appropriate because of:

- the social nature of the problem, and
- the emphasis in the industry on the communicative relationship between the stakeholders.

The study was limited to

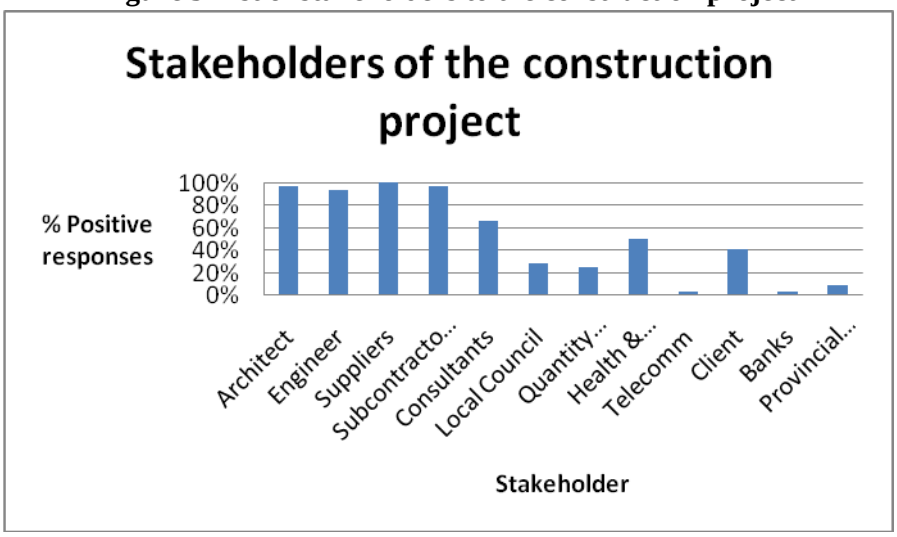
- The communication practises in use between the general contractor and the other stakeholders of the construction project, and
- Information sharing processes used by the general contractor and the other stakeholders of a construction project.
- Smaller South African construction companies in the Western Cape.

Data was collected through semi-structured interviews and detailed explanations on communication and information sharing practices were given by interviewees. More than 30 interviews were done, and interviewees ranged from contract managers, owners of smaller construction companies, site agents, an architect as well as a project manager.

The stakeholders involved in the construction process

General contractors in the South African construction were asked to list the main stakeholders to a construction project. As can be seen in figure 5, the architect, engineer, supplier, the various subcontractors and consultants are identified as the stakeholders commonly involved in a construction project and compares well with Tserng *et al.* (2005:245) list of stakeholders.

Figure 5 List of stakeholders to the construction project



There is also big focus on health and safety in the construction industry, and all construction projects must have health and safety officers, although such officers are not directly involved with the physical construction process. The client, although commissioning and paying for the construction works, has a much smaller role on the construction project than expected. This is because the majority of construction projects the principal agent is the link between the general contractor and the client. For example, all instructions regarding the project must be conveyed through the principal agent. It was found that either the architect or a quantity surveyor acts as the principal agent.

Stakeholders are not only linked together in terms of the information processes, but also in relation to the construction project. The construction project is in the centre, with the construction site and construction office managing and controlling the information processes, as can be seen in figure 6. The contract manager is ultimately responsible for the success or failure of the project, and acts as a buffer between stakeholders from other companies and the construction project, as highlighted by the following quotes from two contract mangers:

> *"Nothing happens if I do not know about is"* and
> *"(we) do not encourage direct communication from professional team to site or sub-contractors. There is some casual communication between all, but formal communication must go thru office."*

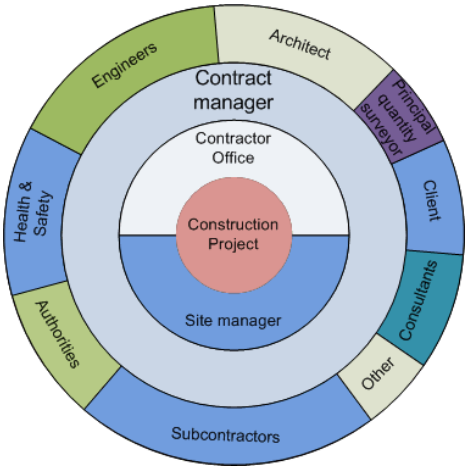
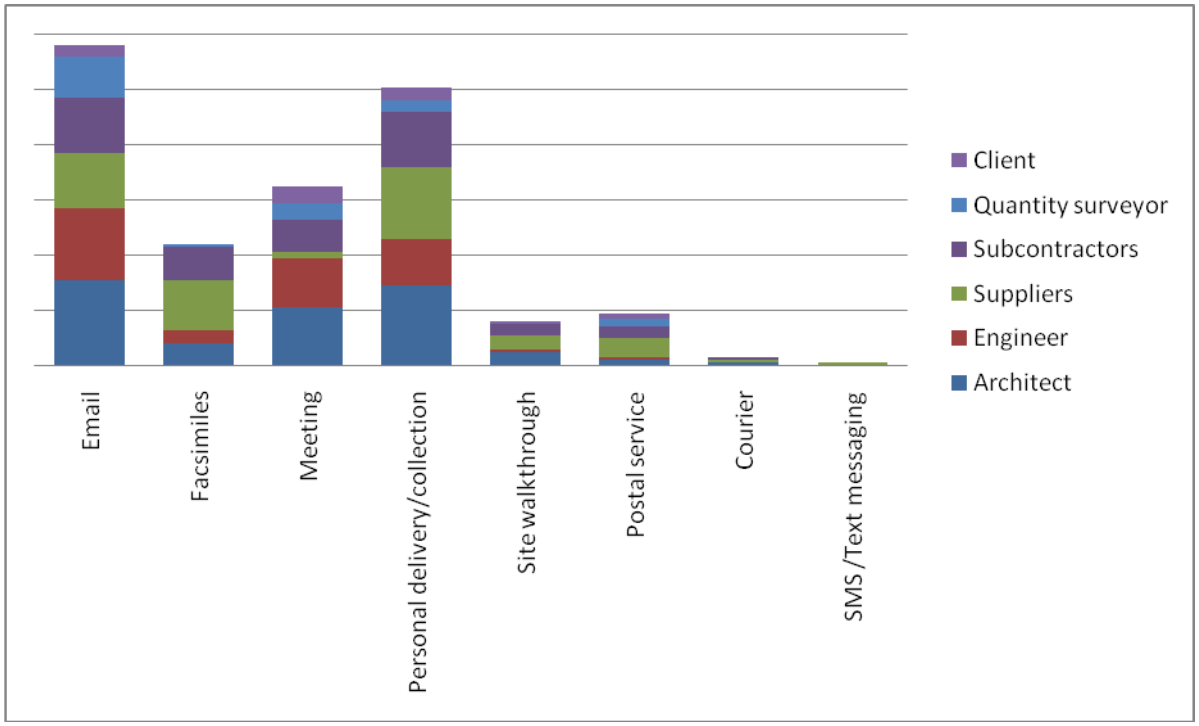


Figure 6: Stakeholders in relation to the construction project

Communications methods used on a construction project

Communication methods ranged from phone calls, emails and, meetings and the postal services. Figure 7 depicts the communication methods used in relation to each stakeholder and the general contractor. Phone calls and informal meetings are not shown as it is used by all for various reasons.

Figure 7: Communication methods of the construction industry



Email is the most popular communication method, yet it is not used to communicate to every stakeholder. For example, although subcontractors are used on every project, only 64% of the general contractors used email to communicate with subcontractors. The same information is also received in more than one format, as illustrated by how construction drawings and contract instruction are distributed.

The management and control of contract information was highlighted by interviewees as difficult to control and keep track of. 63% of the drawings received by the general contractor are on paper as well as in an electronic format. Drawings are controlled from the contractor's office, yet used on the construction site. Drawings are regularly superseded by new drawings, increasing the management thereof. As one contract manger explained:

> "*Drawing control is a very complicated thing, and unless you have lots of juniors and it will not keep them busy the whole time, it is a nightmare. I end up doing it and I am never in top of it*".

Contract instructions emailed to the general contractor, written in the site instruction book or minuted during the site meeting. The general contractor must then also distribute this information again to the subcontractor. This highlights the complexity of the information management and distribution for the general contractor. The general contractor can only claim for additional cost to the original contract value if backed by an authorized contract instruction.

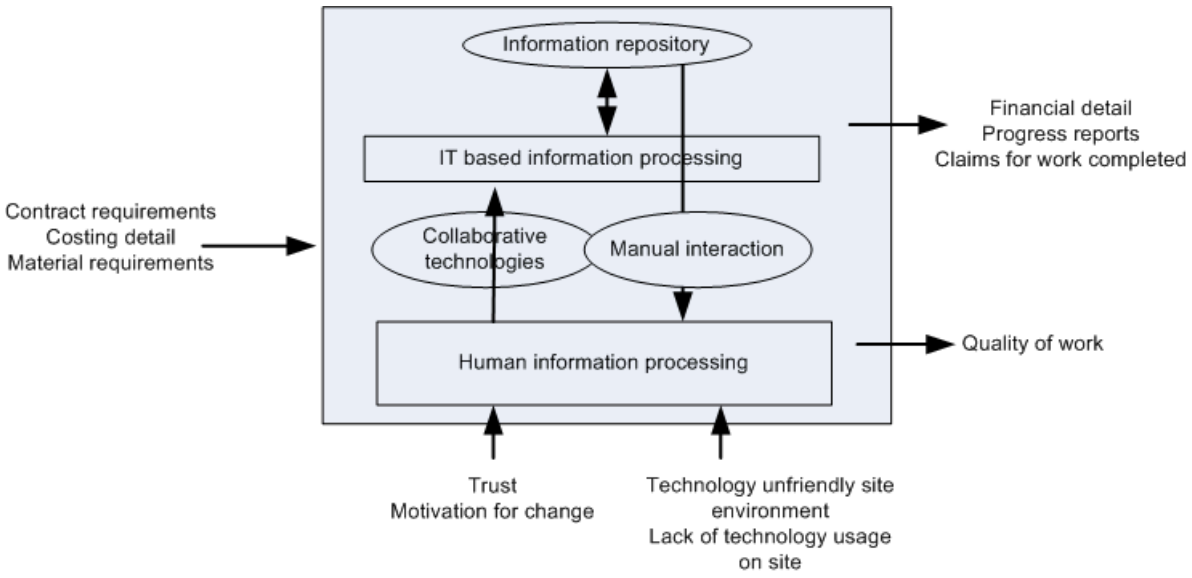
> *"Anything financial or change in specification will be recorded and we will make sure it is in the site instruction book"*

Information technology usage on construction sites was low. Only 44% of the companies interviewed had access to information technology on the construction site, and then only the management, contract managers, project managers and site agents, had access. Less than half of the companies used mobile access to the Internet while on the construction site. Mobile devices were mostly used for reading and responding to urgent emails.

Summary and next steps

Figure 8 is an enhancement of the Johnson and Tate model for a collaborative information system for the construction industry.

Figure 8 Enhancement of the Johnson and Tate model for a collaborative information system



This research only addressed the stakeholders involved and the communication processes used by the general contractor while busy with a construction project. The information requirements and information processes must be added to the model.

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