Management of Small Construction Projects: Adding Metadata to Overcome some Electronic Messaging Limitations

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Abstract: This paper focuses on how the information technologies can improve the management of small construction projects. First, the specific situation of the construction industry is presented. Then, two particular issues are detailed: the role of metadata and the handling of the complete set of information flows that occur during a project. Those problems are not tackled in a satisfying manner by the current e-mail technology. Considering that e-mail is the most commonly used communication tool among the SMEs of the construction industry, it is worth trying to improve this tool to tackle the two above-mentioned issues. The paper describes thus a proof-of-concept prototype that implements some answers to these two questions in the context of small construction projects.

1 Introduction

According to official statistics [Ma00], the construction industry represents 6,8% of the total employment in the European Union (EU) and generates 5,4% of the total value added in the EU. This represents millions of people dealing with billions of EURO. The new Information and Communication Technologies have a great potential to improve the competitiveness of this sector. This industry is mainly composed of Small to Medium-sized Enterprises (SMEs) and it is well established that the management of administrative tasks is often sub-optimal in these companies. This paper focuses thus on the way that the e-mail technology, which is the most widely used electronic communication tool for managing small construction projects, can be enhanced by new features to improve the information management tasks.

2 Construction project management

2.1 State-of-the-art of the use of IT in the construction domain

From many points of view, the new Information and Communication Technologies have diffused for years within the construction industry. The most important Computer Aided

Design (CAD) software manufacturers (e.g. [Au04]; [Gr04]) offer extensions to publish information on the Internet. Several institutions (e.g. [Cs04], [In04]) have developed industry portals. The market also proposes tools to manage construction projects online (e.g. [Bi04], [Co04], [Bu04]). Others propose online catalogues (e.g. [Cb04], [La04]). Some international organizations, such as the International Alliance for Interoperability [Ia04], have agreed on standards in order to ease the exchanges between the players of the sector.

Unfortunately, it may be observed that few companies of the construction industry have already adopted those emerging solutions at a large scale ([Sa02], [ST02]). This observation reaches a critical level when the SMEs are concerned. Nevertheless, the basic trend evolves positively. On the basis of numerous scientific surveys, it appears that the e-mail technology has become a widely used communication tool in the construction sector (e.g. [Mu02], [Ot01], [Ri00], [Sa02], [SN03]). Therefore, if conceptual reflections lead to propose new features to improve the management of a (small) construction project, adding them to the most common tool (i.e. e-mail) is a promising way to facilitate their adoption. Indeed, such a strategy allows capitalizing on the existing knowledge of the users and on their positive attitude towards this tool. This approach is strengthened by the fact that non-technical issues often limit the acceptation of an ICT tool by the construction actors [So03]. Therefore, it might be important for new applications, whatever the underlying concepts and technologies, to mimic, as long as it makes sense, the appearance and the behavior of classic e-mail clients. Indeed, such a strategy allows testing innovative features while maintaining the users in a familiar environment.

2.2 The need to study the information flows

The effective management of information has a critical influence on the performance of a project. In the construction area, the steps of the production process are highly interrelated [KV00], which leads to a strong dependency among the companies engaged in the project. Suppliers commonly contribute 75-80% of the value of a construction contract, making their effective management and coordination essential to cost, quality and time objectives [Cl99]. In a few words, a lack of information flow management often leads to delays, additional costs and consequently bad relationships with the customers.

The focus on the relationships among the project partners slowly emerges in the literature as a worthwhile research theme and it appears to be a crucial issue. Several theories are candidates to investigate this area. For instance, the social network analysis theory [Sc00], which comes from the social sciences, has been recently used to study the communications within a project team ([TM01], [HP01]). Other researchers have proposed a relational model of the components of a collaborative architectural project that allows representing the interactions as a hypergraph [HH03]. The information exchanges have also been studied with the aim of finding out some parameters that could be monitored to detect current or future failures in the project [Fy02]. The construction and architecture sector could also benefit from research works on 'information flow management' carried out in other disciplines. For instance, some current research in the domain of discovering generic patterns in the graph interconnecting people, resources

and other real life objects could also be interesting to apply to the context of construction projects [CGM04]. These research works go in the same direction than the authors' reflections: a better knowledge of the information flows could help the project manager to carry out its supervision task more efficiently.
Unfortunately, there is a lack of tools giving a complete and easy-to-understand overview of the interactions between the project partners. Several reasons may explain this situation but the fact that the collection of primary data about the information exchanges is really challenging certainly plays a major role, even if one considers that mainly metadata (e.g. sender and receiver, sent date, type of communication media used…) are really useful for the analysis. This situation is due to the lack of integration of these information pieces that are disseminated among the numerous persons employed by the project partners. To sum up, this area really needs additional research before being able to offer some tools that might really be applied in practice.

2.3 The role of metadata

First of all, it must be reminded that a construction project has several specific features that make it different from a usual project in other industries. Most of the time, the construction projects differ very much from one to another, what has been called 'one-of-a-kindness' [KV00]. The operations are non-repetitive [BR93]. Control of design, procurement, and field operations are also typically organized in an ad-hoc manner, as appropriate for the needs of a specific project [Sc01]. Consequently, the elaboration of ontology for construction projects raises significant issues.
The Industry Foundation Classes (IFC) initiative is the most promising ontology in the construction domain but, due to its ambition to be exhaustive (it aims to include products, tasks, buildings, roles…), it appears quite complicated and heavy to implement. Despite the benefits of saving time and sharing common knowledge, large shared ontology is not commonly used yet in practice. In order to tackle this issue, some recent research works have proposed to use a very simple ontology that the project partners progressively complete during the project. Using such a small sized ontology is an element that may facilitate the communication among the people in a project in the design phase [Cr03]. In fact, from a pragmatic viewpoint, the challenge resides in the ability to propose the right level of granularity having a significant discrimination power and a sufficient conciseness.
In the context of small projects carried out by small companies (i.e. projects involving about five to ten partners), a set of simple and easy-to-understand metadata is probably preferable to a complex ontology. The authors argue that using such a limited set of meta-information may be helpful for the administrative management of the project. This set of metadata refers to some basic features of the project on the one hand, and to some fundamental characteristics of the information flows on the other hand (cf. Fig. 1). The main challenge, however, is to reach a semantics that is easy to understand, to remember and to communicate.
The Fig. 1 illustrates a proposition of structure for this set of metadata. Two subsets are distinguished: the first one concerns the project as a whole, the second one relates to the information flows occurring during this project.

For what concerns the project, two kinds of metadata are identified. The first one is used to identify the project. It includes information about the project name, the place, or the start date… The second type of metadata aims to qualify the project. It regroups some information about, for instance, the type of building (e.g. private house, commercial building, warehouse…), the participants, or the type of customer (e.g. public, private…). It has been previously discussed how a better knowledge of the information flows could be profitable. In order to collect such a useful knowledge that might eventually be automatically processed, some metadata are required at two levels. First, metadata are needed about the transmission process itself. This concerns, for instance, the direction of the flow, the date, the person involved, or the communication medium used. Second, the content of the information flow has to be qualified with standardized metadata, such as the project phase to which it relates (e.g. design, construction…), the category of the message content (e.g. technical, administrative, financial…), the opinion of the sender (e.g. positive, neutral…) or the requested action from the receiver (e.g. validate, correct, forward…).

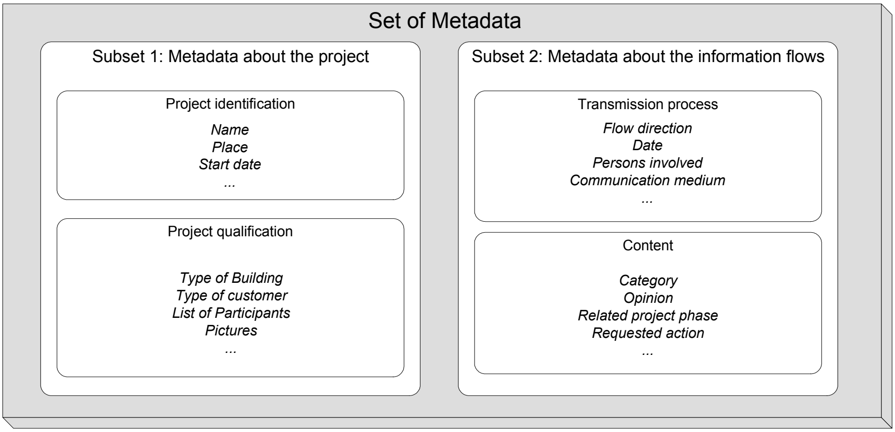


Fig. 1: Set of metadata used to describe the project and the information flows

3 Limitations of the e-mail technology

The e-mail technology has several advantages that made it very popular. Among others, it is easy to use, relies on standardized protocols, has a low cost and is widely diffused. It presents also, however, some limitations that bring some authors to argue that '*the opportunity exists for reinventing the email client, moving it from the current electronic analog of physical mail to a tool that allows to manage all of their digital communications.*' [Ro01] Among others, the current e-mail clients could be enhanced to what concerns the two above-mentioned issues: the management of all information flows and the usage of metadata.

3.1 Insufficient use of metadata

The first issue concerns the metadata attached to a message. In this context, it is important to discuss a critical factor influencing the value of metadata: whether or not it is well defined, structured or standardized. In this paper, metadata is called ‘normalized’ if its values belong to a limited list of predefined values (e.g. priority: high, medium, low) or if its value conforms to a standardized structure (e.g. e-mail address). In other words, this means that the field containing this metadata has a well-defined space of accepted values of which the semantics is clear and unique. Non-normalized metadata is information about the message that can be formulated in any manner (e.g. free text).
A classic e-mail message includes both normalized and non-normalized metadata. For instance, the ‘sent date’, ‘reply-to’ and ‘sender’ fields are considered as normalized metadata. This is not the case, for example, of the ‘subject’ field, which can include any kind of text, independently of its meaning or its relation with the effective content of the message. It is thus considered as a non-normalized metadata. Another important point is the context in which each kind of metadata is used. In the classic e-mail technology, the normalized metadata relates to the communication itself (e.g. sent date, sender…) or to the technological background (e.g. encoding type, MIME type of attached file, attachment size…). Neither the semantics of the message nor its organizational context is referred to by normalized metadata. This situation originates from the generic nature of the e-mail technology. Considering that e-mail was designed to be used in any context, it wasn’t possible to include metadata suited to specific usages (such as the construction industry). If such information were added to the messages, however, it would allow very interesting enhancements, such as process automation or intelligent filtering, which could significantly improve the administrative management of the messages.

3.2 Information flows management

The second issue deals with the capacity of an application to handle all kinds of information flows that occur during a project. It is obvious that the e-mails are only a small part of all information exchanges that the project partners have to handle. In order to get an effective overview of the current state of the project, the manager should thus have the opportunity to integrate into a single tool all information flows, whatever the media used (face-to-face meetings, telephone calls, fax, e-mails, postal mail…). In other words, providing him with a unique interface that shows in an appropriate manner all information flows related to his project would enhance its knowledge about the ongoing processes. It would naturally reduce the waste of time caused by the collection and re-assembly of all information pieces needed to produce a cognitive summary (i.e. a mental image within the manager mind) on the current state of the project.
The e-mail applications cannot fulfill this need because they can neither store nor display information about information flows that are transmitted by other communication media than electronic messaging. Indeed, an e-mail application is not designed for handling phone calls or postal mails, for example. The limitation mentioned in this section doesn’t originate thus from the e-mail technology itself but rather from its use in the context of

project management. Indeed, *'people use their email inboxes to manage their tasks'* [Ro01] but classic e-mail clients are designed to exchange messages.
In the context of its current use by the SMEs of the construction industry, these limitations, which are inherent to the initial purpose of the e-mail technology, could be interestingly overcome by including a simple mean to get a global view of the information exchanges.

4 Some answers to the e-mail limitations

Considering the above-mentioned limitations of the classic e-mail as well as the wide usage of this technology in the construction industry, it has been decided to design and develop a prototype, called BBeLink2, that integrates some answers to the two previously discussed limitations while mimicking the appearance of a classic e-mail client application.
The BBeLink2 prototype integrates in a single application a messaging system, an 'information flows' storage and visualization module and a light project management tool. The exhaustive description of BBeLink2 goes beyond the scope of this paper. Therefore, only the features related to metadata and information flow management will be discussed though the prototype includes several complementary features, such as a reliable dating system based on an external time server, an automatic, reliable and permanently active acknowledgment mechanism, or the capability to individually sign / encrypt attached files (see [OP02] and [OPF03] for additional details about some of its innovative aspects).
From a metadata viewpoint, the above-mentioned functional modules are harmonized, which means that they share the same set of metadata. The metadata that is relevant in the context of each module forms a subset of the global set. For instance, the same 'project phase' metadata applies to the messages and the information flows.

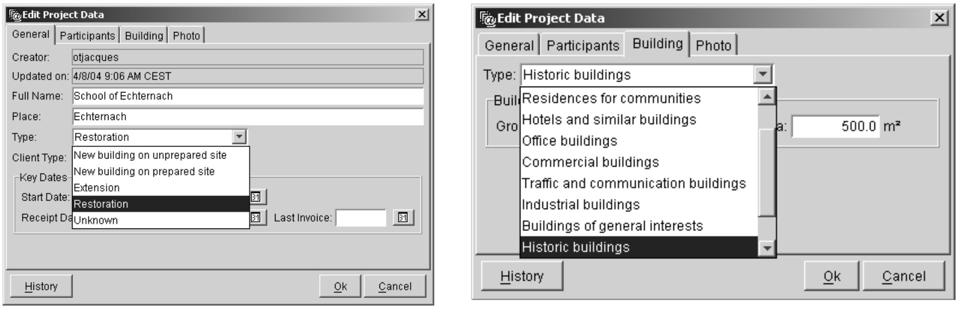
4.1 Use of metadata

This section explains how metadata fields are included in the project management module and in the messaging module.
The simple set of metadata proposed in a preceding section has been instantiated. In this context, grouping of the metadata in another way than in Fig. 1 better highlights the difficulties that have been encountered (cf. Table 1). Some metadata is applicable to all domains while other is specific to the construction industry.

Table 1: Classification of metadata

Metadata	applicable in all domains	specific to the construction industry
concerning the projects	*List of participants* *Start date…*	*Type of building* *Building area…*
concerning the information flows	*Sender* *Priority…*	*Construction phase…*

Considering the diversity of the construction project aspects, the elaboration of the list of values for the latter (normalized) metadata is a challenging task. Indeed, it isn't easy to agree on a limited list of project types or project phases. The preexisting works have thus been used to underpin the proposed lists each time that it was possible and relevant. For instance, the types of buildings have been identified on the basis of a Eurostat official classification [Eu97] and the four project phases that have been retained derive from academic works [Ka98]. The project management tool allows assigning metadata to the project. Some examples of normalized metadata (project type and building type) are illustrated in Fig. 2.



a. Project type

b. Building type

Fig. 2: Examples of project related metadata.

In the same way, the messaging module allows to set metadata values for the messages (cf. Fig. 3).

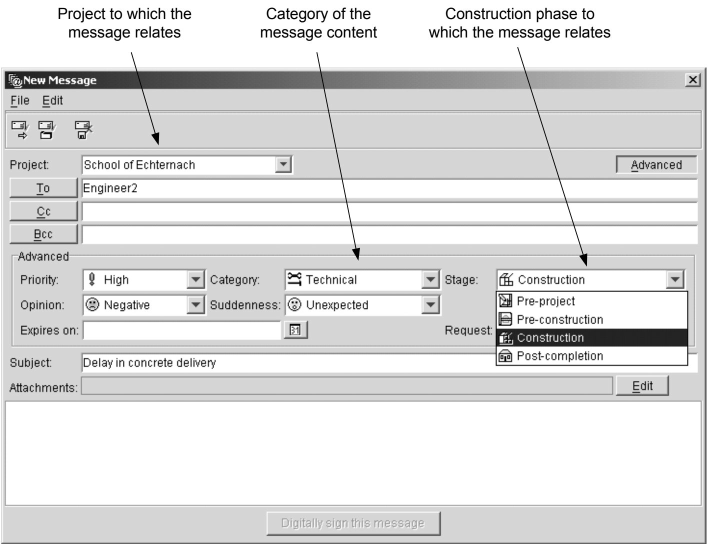


Fig. 3: Examples of message related metadata

The integration between those modules can be illustrated by the fact that a message can only be assigned to an existing project (in the example: ‘School of Echternach’) or to the default one (dedicated to store the messages that are not related to a specific project). Similarly, accepting the invitation message to join a project automatically creates in the storage hierarchy of the messaging module a correctly structured sub-tree that is associated to this project. Every message concerning the new project will then be automatically stored in the appropriate folder (e.g. inbox, sent…) of this new sub-tree. This integration heightens the level of global coherence of the data needed for the administrative management of the project and reduces the repetitive tasks with little added value (e.g. sorting messages). An advanced filtering tool based on the metadata has also been included in the prototype. It allows to build logical expressions with the metadata fields and to trigger a sequence of actions (e.g. ‘forward then move message’) if the expression is valuated as ‘true’ on incoming or outgoing messages. The predominant usage of normalized metadata significantly enhances the efficiency of the filters because it limits the comparison tasks between ‘free text’ fields and reference values.

4.2 Ability to handle all kinds of information flows

It has been previously discussed how useful could be a unique interface giving a global overview of the information flows within a project.

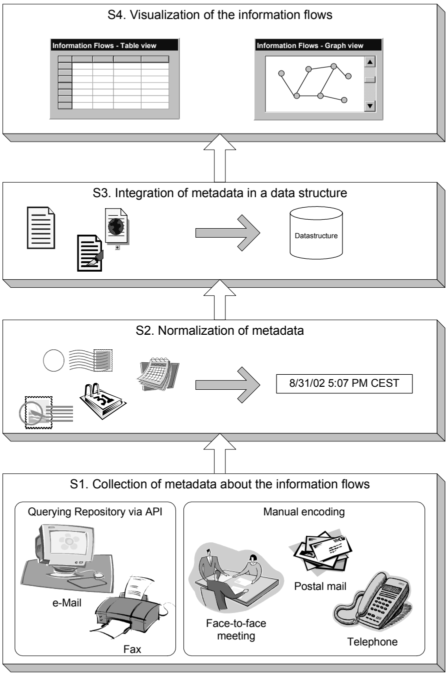


Fig. 4: Integration Process of Heterogeneous Information Flows

From a conceptual viewpoint, this can be achieved via a four-steps process (cf. Fig. 4). The first step (S1) consists in collecting information about all kinds of information flows. This can be achieved by automated process (e.g. queries in the repositories of the applications that handle these flows if some APIs are available) or by manual encoding. The second step (S2) aims to normalize metadata in order to be able to draw reliable relationships among them. The purpose of the third step (S3) is to integrate the metadata in a unique data structure. Finally, the fourth step (S4) is dedicated to the visualization of the information flows.
The BBeLink2 prototype proposes an instantiation of this process. The data collection step (S1) is automated for the messages exchanged by the BBeLink2 tool. The other information flows are manually encoded via an easy-to-use interface, which appears very similar to the one used to send messages. The normalization of the metadata (S2) is completely integrated within the data collection step because the encoding interface proposes to assign to each information flow only a limited set of attributes having a well-defined list of values (e.g. communication medium: telephone, fax, e-mail, face-to-face meeting, postal mail…). All the encoded information flows (either manually or automatically) are stored in a database (S3). They can be visualized as a list in the BBeLink2 tool (cf. Fig. 5) or exported to another visualization software (e.g. 'Ucinet' for visualization as a graph).

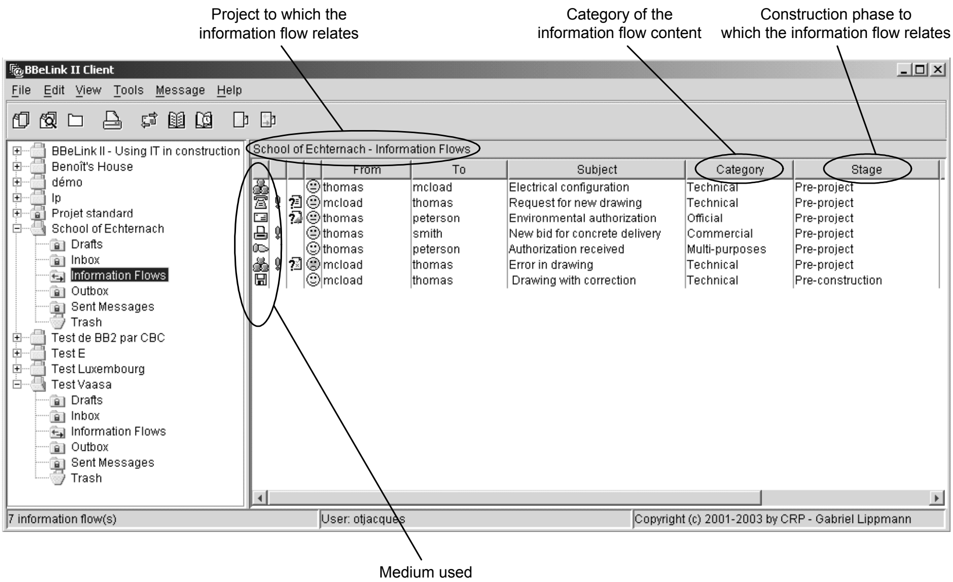


Fig. 5: Visualisation of all information flows occurred during a project.

The BBeLink2 prototype opens new ways to tackle the issue of project management. It must be considered, however, as a proof-of-concept tool that might be improved by complementary developments. Two of these further enhancements are especially worth being discussed. First, it is quite clear that the manual encoding of some information flows is a weakness that hinders the industrial deployment of the tool. A better integration with existing communication devices (e.g. telephone) would be a significant improvement. Second, the optimal visualization of information flows is a pending issue. Further research could focus on how to build a view of the information flows that optimizes the perception of the state of the project, the identification of problems and the comparison of similar projects.

5 Conclusions

The management of construction projects has still a great potential of optimization. In this context, the issue of information exchanges has been clearly identified as an important point. Therefore, many research works are currently carried out in the domain of technical information exchanges, in order to achieve an effective smooth integration of the numerous software tools present on the market. Beside this topic, the generic issue of information flows management is also worth being further studied. Indeed, the structure and the dynamic of information flows during a construction project are badly known. A better knowledge on this issue, however, requires assigning normalized metadata to those information flows. The proof-of-concept prototype that is described in this paper is a first step on the road to project management optimization through a better handling of information exchanges.

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