WEB-Services as a Technology to Support Construction Processes

N. Riediger, K. Laube, W. Huhnt & B. Kochendörfer
Institute of Civil Engineering, Berlin University of Technology, Berlin, Germany

ABSTRACT: Construction projects are characterised by specific peculiarities so that the processes for the execution of construction projects need to be prepared and setup individually for each project. However, a lot of tasks are executed in similar ways in different projects. The knowledge of executing these tasks can be transferred from project to project whereas the context and the interaction between tasks may differ. The approach presented in this paper reflects the situation in dealing with construction processes and discusses WEB-services as a suitable technology to support the processes. The idea is to support specific tasks by WEB-services. These services are implemented once. The tasks that are supported by these WEB-services may occur in different projects. This is expressed in an individual process model for each project. Based on the relationships between tasks and WEB-services, an individual information system for each project can be customised on the basis of the process model.

1 INTRODUCTION

Construction projects need to be prepared individually. This is well known in practice and it is state of the art to develop work plans where rules for the project execution phases are documented. The work plan covers the specification of tasks and their sequence. Software systems are necessary to support the execution of tasks in distributed environments because project participants work at different locations.

This paper discusses an approach to support construction projects by an information system that considers the requirements of civil engineering projects. These requirements result from the specific peculiarities of construction processes. As an example, tasks in the area of managing defects are chosen to illustrate the use of the concept presented.

2 CONSTRUCTION PROCESSES

2.1 *Definition*

The term "process" has been defined in different disciplines. In business administration, a business process is defined as a sequence of performances belonging together for the purpose of goods and services (Scheer 1998).

Construction processes can be defined similar to business processes. Tasks are subdivided into subtasks. The sequence of tasks has to be developed. Additional elements like persons or technical equipment can be assigned to tasks so that different modelling techniques can be used to specify constructions processes.

2.2 *Complexity*

By this definition, "construction processes" are characterised not that precise accept of the fact that in these processes the influence of participants or different phases of the lifecycle respectively cause a high level of complexity. Therefore, the construction process has to be enlarged by these influences.

The physical life of a construction- or real estate project can be subdivided into different phases. It starts with the idea of the project and results in the deconstruction or demolition. Especially development, execution and utilisation are phases containing various principle tasks in the areas of project development, project management and facility management (Kochendörfer et al. 2004). Proceeding in these various phases does not differ eminently according to varying industrial sectors. However, the existence of diverse formalities such as HOAI (the German law on calculating fees for architects and engineers) or DVP (German Organisation of Project Management) leads to diverse variants of how to classify the phases.

The management of interfaces between the process phases in particular causes difficulties. The complexity of construction processes additionally increases by the high number of participants and the interdependence of the process phases. That makes the demonstration of all details within a process model exceedingly difficult.

Beside the owner and the architect, many other participants take part in construction projects. The bigger the project the higher the number of people involved. The management is responsible for the coordination. A main task is to find the right organisational structure in order to define the contract management. The most common constellations are individual enterprises, master planers, general contractors or main contractors and total contractors. The contract interfaces, the effort of coordination and the risk often decrease from high in individual enterprises to low in total contractors.

2.3 *Characteristics of construction processes*

Construction projects are characterised by specific peculiarities so that the processes for the execution of construction projects need to be setup individually for each project. However, many tasks are executed similar in different projects. The knowledge of executing these tasks can be transferred from project to project. The context and the interaction between tasks may differ.

Given the fact that the construction area changes and expands constantly it is obvious that the establishment of an all-embracing process model is considered as not possible. An all-embracing process model would have to include all aspects and variants of the construction area. Even though we could install such a model at present, it would have to be upgraded permanently. Any new form of contract, any new technical solution or new construction material would have to be included. To summarise all that, an all-embracing process model would never be completed.

The approach to set up construction processes based on optimised sub-processes does not work out. This fact is well known from mathematics. It is proved that the existence of local optimums does not inevitably mean that there is a global optimum. Figure 1 shows an example from the construction area. The sub-processes shown are optimised sub-processes that are valid in its discipline. To string these processes together does not lead to a global optimum because interdependences are not regarded (Fig. 2). A possible rightly connected optimum is shown in Figure 3. The sub-processes of the main-process are partly interrupted by subtasks of other sub-processes.

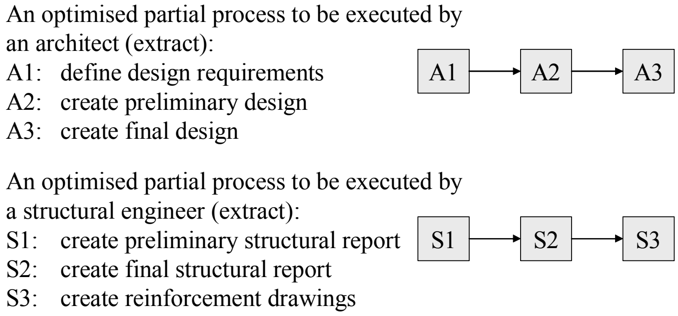

Figure 1. Optimised sub-processes (Huhnt 2004).

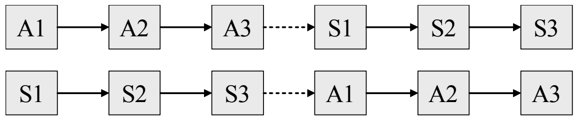

Figure 2. Non-optimal overall processes (Huhnt 2004).

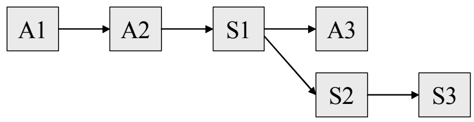

Figure 3. A possible optimal overall process (Huhnt 2004).

Another approach tries to deduce construction processes from roughly detailed and optimised processes. This approach does not provide the solution either. Figure 4 shows a roughly modelled construction process and the deduced processes in detail. Once dependencies between sub-processes are introduced a completely different structure of activities can be the result. That is shown in Figure 5. From rough to fine it is possible to bring processes in the right order but not the other way around. The result would never be explicit.

That underlines the fact that construction processes have to be set up newly from project to project. The only constants in this context are single tasks. They can be executed equally in different projects. The duration of the task has to be planned within the individual project.

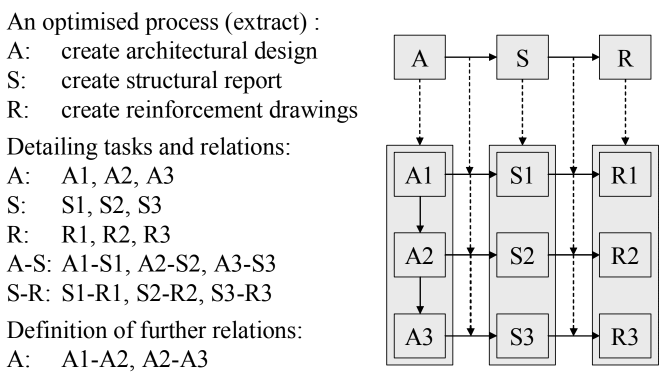

Figure 4. Introduction of dependencies within detailed processes (Huhnt 2004).

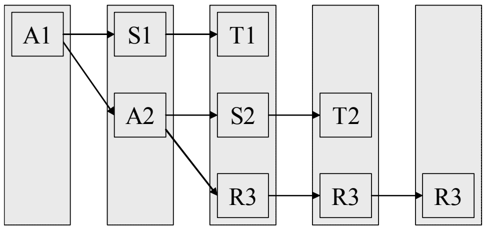

Figure 5. An optimal detailed process (Huhnt 2004).

All these approaches result in the displayed concept as follows.

3 SUPPORTING CONSTRUCTION PROCESSES IN DISTRIBUTED ENVIRONMENTS

The finding that construction processes need to be redesigned from project to project leads to the consideration that the reusability of processes is restricted. However, a lot of similar tasks need to be executed in several processes. Therefore, functionalities to support tasks can be reused. Supporting construction processes can be realised by providing one-time implemented functionality, which can be applied for each subtask calling for.

The process itself has to be modelled specifically for each project. In the process model it is now known which task has to be completed by whom. As a result of that the required functionalities of each process and person can be assembled. The principle of this concept is shown in Figure 6.

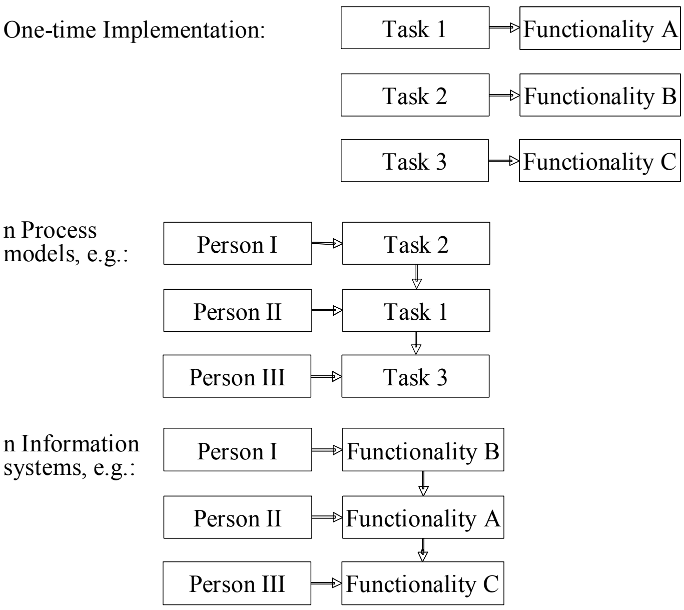

Figure 6. Concept of process support.

The development of an information system consists therefore of three steps. In the first step, the functionalities are implemented once. The second step models the process. This is individual for each project. The third step provides the function specific for a project and the persons involved. The third step acts automatically.

The functionalities are provided with WEB-services via the Internet. Therefore, a distributed system for project processing is provided in which functionalities can be used by different participants working at different locations.

4 MANAGING DEFECTS

4.1 Defects

The motivation for a systematic prevention of defects is the high cost of defects in construction processes. It is considered as a typical construction process where usually 4%-12% of the overall construction costs are spend on rectifying faults and defects (Jungwirth 1996). There is a high capability of cost reduction by using information technology based upon process modelling. The management of defects fulfils the theoretical requirements: Different processes are necessary to be supported by an information system depending on the point in time when a defect is detected.

Defect prevention in particular is very important concerning the lifecycle of structural works. Most frequently defects appear during execution. However, defect prevention is a process attending the whole lifecycle of buildings from development to utilisation. The context and the interdependencies of tasks differ depending on the fact if a defect is detected before or after the final acceptance of a specific work. Although the tasks required are almost identical in different processes. Due to the process model supported by WEB-services the users of the system should be able to create their own specific information system by choosing the tasks in the desired order only with a “click”.

4.2 Detection of defects before acceptance

As described above, the process of defect prevention is suited for exemplified realisation of the R&D-project. Same tasks are assembled to different processes. It follows a precise description of the defect prevention process as well as the fundamentals it is based on.

In the process of defect management the legal claim of the client or the owner respectively changes at this moment of time when the client accepts the asset under construction or after completion (acceptance). The VOB part B (German Construction Contract Procedures, similar to British Fidic) strictly distinguishes the legal rights of the client regarding construction defects before and after acceptance. Before acceptance the legal rights of the client results from § 4 no. 6 and § 7 VOB/B. After acceptance

§ 13 VOB/B with a changed burden of proof to the disadvantage of the client is relevant.

Allocation of the burden of proof (before acceptance burden of proof is with the contractor, after acceptance shifting of the burden of proof to the principal), the possibility of substitutive execution and the beginning of limitation are depending on the basis for claim.

In the following the process of defect prevention will be described in more detail.

In case of defects before acceptance the construction supervision has to react as shown below.

As mentioned above before acceptance the legal rights of the client results from § 4 no. 7 VOB/B. If a defect is detected by the construction supervision it has to be taken up correctly. If the good or service is without defect after proof claims do not occur. In case of a defect the causer has to be found and the defect has to be associated with the causer. Right after declaration of a defect it has been proved beneficial to distinguish between contractor, subcontractor and assistant of the principal. As a result of that the taken up defect document can be handed out correctly.

1 If the principal or its assistant is responsible for the defect it has to be declared if concerns have been registered officially.

- If concerns have been registered claims of the principle to remove the defects are forfeited. This has to be communicated to the principle.
- If no concerns have been registered but the defect was hidden claims of the principle to remove the defects are forfeited. This has to be communicated to the principle as well.
- If the defects have been recognisable costs of defect removal are quoted based on proportion of causation. Often the contractor arranges the removal and gets paid referring to the proportion of causation.

2 If the reason of defect is on the side of the contractor it has to be declared who has caused it. However, with respect to proceeding responsibilities of the object the defect occurred, attention on potential re- or extra work of other participating groups has to be paid.

- If the defect of a good or service is due to the contractor or any other third party a notice of defect including an appointment of a date and demand for removal of defects has to be send.
- For accounting control belonging to construction supervision a notice has to be made for deduction of price in case of outstanding defect removal (up to three times of the expected cost of defect removal).
- If the defect removal took place within the appointment of date the following has to be proved.
- If the removal of defect has been successful the deduction of price has to be paid off or disregarded in the next account respectively.
- If the removal of defect is insufficient another notice of defect has to be made and send to the contractor.
- If the defect is not removed within the appointed date the construction supervision has to decide if the contractor gets another opportunity to remove or not.
- In case of providing another opportunity the contractor has to get a notice of delay including extension of time. Normally a second appointment of date should be provided.
- In case the contractor exceeds the second appointment or refuses the removal altogether the client has got the legal right of substitutive execution. That means he can order the execution some were else for the costs of the contractor. Therefore the contract with the contractor has to be cancelled in advance.

The elimination of defect by the contractor has to be communicated in written form to the client. This paper is also used as a certificate of documentation and tracing of defect. The construction supervision has to assure itself on location if the announced defect has been corrected.

4.3 Detection of defects after acceptance

After acceptance the legal right comply with § 13 no. 5-7 VOB/B, the contractor is responsible for the guarantee.

In case of defect it has to be proved if:

- the defect has occurred effectively.
- the defect has been known while acceptance or if known the removal has been reserved.
- the claim of guarantee is not time-barred.

If the noticed defect does not feature one of the requirements no claims can be assert. In this case the principal has to be informed with justification accordingly.

In case the defect fulfils the requirements, the causer has to be detected for the following procedure.

1 If the defect is within the area of responsibility of the principal or one of its assistants, is has to be declared if the contractor has registered concerns.

- If the contractor has registered concerns the principal does not have any legal rights on defect removal. The principal has to be informed about this.
- If no concerns have been registered, but the defects does not have to be seen the principal does not have legal rights either. He has to be informed about this as well.
- If the defects were to be seen a quoting of costs of defect removal has to be done. The quoting has to comply with proportion of causation. Often the contractor arranges the removal and gets paid referring to the proportion of causation.

2 If the reason of defect is on the side of the contractor, it has to be declared which maintenance group has caused it and which contractor it has to be assigned to.

– It has to be analysed if a removal of defect is technically possible.
  - If removal of defects is technically impossible the contractor is allowed to refuse removal. In case of refusal reasons have to be proved. If the refusal was right the principal is allowed to reduce payment.
  - If the removal of defect is possible but out of scale, removal does not take place. The principal is allowed to reduce payment either.
– The extent of reduction has to be calculated and communicated to the principal and contractor. If no agreement of the extent of payment reduction can be done, the client or the owner respectively is allowed to employ an estimator.
  - If the removal is possible, not out of scale and the principal does not refuse it, removal of defects has to be done by the contractor.
– A notice of defect including an appointment of date has to be sent to the contractor.
– Does the removal of defects take place within the appointment of date, it has to be proved.
  - If removal has been successful the principal has to be informed.
  - If the defect has not been removed within the appointment of date or no reduction of payment has been agreed upon respectively, it has to be decided if the contractor gets another opportunity to remove defects. In case of another opportunity the contractor has to be admonished. If this is not the case, a substitutive execution at the expense of the contractor has to be suggested towards the principal. If this happens it is due to the principle to demand the costs of substitutive execution from the contractor. He also can receive the costs from the deduction for guarantees, the contractor has to make within the period of guarantee.

    The substitutive execution has to be proved after completion and to find fault if necessary.
  - If the defect has been removed the principal has to be informed. A letter should include a written confirmation of the contractor.

Basically, all detailed questions regarding conduct (judicial) should be answered by experts (jurisprudents in particular) to avoid methodological error.

5 IMPLEMENTING A DEFECT MANAGEMENT SYSTEM

5.1 State of the implementation

A pilot implementation is under development to demonstrate the use of the concept presented. The pilot implementation covers the development of WEB-services to support tasks in the area of managing defects. The processes are modelled using the existing modelling tool ARIS® Toolset by IDS Scheer AG. Based on an individual process model, the functionalities are available to support the execution of that process.

5.2 Implementing functionalities

A lot of research has been done in the area of implementing WEB-services. The WEB Services Description Language (WDSL) is available (WDSL 2001), and tools are available to generate the specifications of these services. The present pilot implementation uses the Unified Modelling Language (UML) to extract the information from the process models (Kochendörfer & Huhnt 2005). The WEB-services themselves need to be implemented.

5.3 Modelling a sequence of tasks

The processes are modelled as extended Event Process Chains (eEPC). Their central objects are functions that are used in this context to model the tasks to be executed. Beside the sequence of events and functions the eEPC includes additional rules and organisational units for modelling, e.g. the persons involved. Figure 7 shows the element types that are used in the present context to model construction processes. It consists of tasks (rectangle), operations (rectangle with two brackets in up right corner), application systems (rectangle with two additional lines in both sites plus the letters Ex), the entity type (simple rectangle) and the participants (oval with line in the left). The direction of arrows indicates data input or output. Figure 8 shows an extraction of a process model.

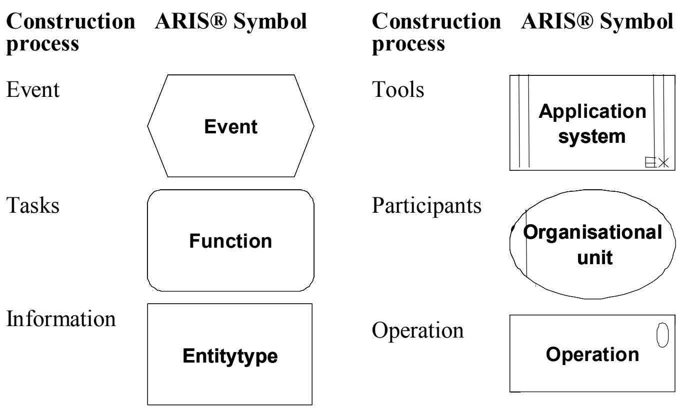

Figure 7. Methodology of modelling (IDS Scheer 2003a, b).

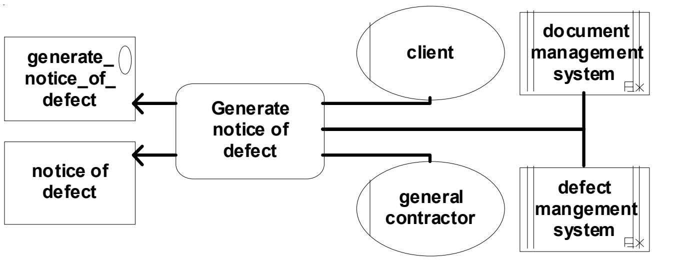

Figure 8. Extract from a process model.

5.4 Generating an information system

Based on the process model, all information is available to generate an information system for an individual process. The development of the functionalities required for managing defects is under progress so that for the processes described in section 4.2 and 4.3 information systems will be available in the near future.

6 CONCLUSION

This paper shows that process models can be used reasonably for specific provision of information systems in the construction area. The sequence of tasks in construction processes differ from project to project, whereas single tasks in various projects are alike. Therefore, the procedure of implementing functionalities of tasks has to be executed once whereas the functionalities can be used in different processes.

Construction processes take place in distributed environments where sometimes people work together from different continents and in different time zones. The use of the Internet is state of the art. WEB-services are a suitable technology to support construction processes. Therefore, this technology has been chosen to demonstrate the beneficial use of process models in supporting construction processes by information systems.

The research made has been shown in processes of defect removal exemplarily because they are representative for construction processes. They affect nearly all phases in construction processes and have to be operated in different phases at the same time. Defects are detected mostly at the joining of different phases. Its handling is a relevant assignment in the construction area and important for the efficient and effective processing of projects.

The tools used in the project as well as methods of information transfer are exemplary. Time will show which tools and languages are going to be appropriate in future. However, irrespective of technical progress, the analysed approach in principle is sustainable for supporting construction processes in distributed environments.

7 ACKNOWLEDGEMENTS

This paper is about results of the R&D project “interfun”. The project is supported by the Investitionsbank Berlin. It is partly financed by the European Union European Fond for regional development. Project partners of the authors of this paper are WeltWeitBau GmbH, Berlin, Germany and PiSA GmbH, Berlin, Germany.

REFERENCES

Huhnt, W. 2004. Progress Measurement in Planning Processes on the Base of Process Models. In Digital Proceedings of the Tenth International Conference on Computing in Civil and Building Engineering. Weimar.

IDS Scheer AG 2003a. ARIS 6 – Collaborative Suite Version 6.2 XML-Export und -Import. ftp://ftp.ids-scheer.de/pub/ARIS/HELPDESK/EXPORT/de_xmlexp62.pdf.

IDS Scheer A. 2003b. ARIS 6 – Collaborative Suite Version 6.2 Schnelleinstieg. quick_start_guide_aris_s.pdf.

Jungwirth, D. 1996. Qualitätsmanagement im Bauwesen. Volume 2. Duesseldorf: VDI Verlag.

Kochendörfer, B. & Huhnt, W. 2005. Zwischenbericht Verbundprojekt interfun. Teilprojekt profun. TU-Berlin.

Kochendörfer, B., Viering, M.G. & Liebchen, J. 2004. Bau-Projektmanagement. Volume 2. Stuttgart: Teubner Verlag.

Scheer, A.W. 1998. ARIS – Vom Geschäftsprozess zum Anwendungssystem. Volume 3. Berlin: Springer Verlag.

WSDL 2001. WEB Services Description Language 1.1. http://www.w3.org/TR/wsdl as found 11.5.2005.