AN INNOVATIVE INFRASTRUCTURE FOR INTER-WORKING BETWEEN DISSIMILAR EDM SOLUTIONS

An innovative infrastructure

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Abstract

The paper gives an overview of the European Esprit Condor project (ESPRIT 23105). The project aims at providing a large range of industrial areas, including the Construction industry, with an innovative infrastructure for distributing information and achieving co-operative work between heterogeneous Electronic Document Management (EDM) legacy systems, while ensuring document consistency throughout ongoing projects. The paper, first, presents the proposed technical solution, and gives a comprehensive description of the Application Programming Interface supporting the proposed inter-working and semantic linking services. The paper also includes a brief description of the modelling infrastructure supporting the proposed Condor system. Finally, a demonstrator involving the AutoCAD application, along with the Electronic Document Management systems used within the project, is presented. The latter demonstrates the Condor semantic-linking services. The project is ongoing and supported by a user interest group, which involves representatives from a variety of non-construction industry companies all over Europe.

Keywords: Electronic Document Management, Object Modelling, Object Inter-working, Computer Integrated Construction.

1 Introduction

The construction industry has always been characterized by its conservative culture. As indicated in (Anumba 1998) several factors have contributed to this, including poor investment in construction IT, poor dissemination of research results, poor marketing, inadequate user-interfaces of systems, mismatch between construction IT innovations and industry need, and poor uptake of promising research prototypes by software developers. The latter was, in fact, used as a driving criteria in the setting up of the Condor consortium. The challenge was at the time to bring together construction IT researchers (University of Salford, KTH, CSTB), industry practitioners (Kvaerner construction, JMBygg, Derbi), and software developers (Cap Gemini, Carasoft), to overcome this conservative culture barrier.

The nature of the construction industry is such that teams are set up for specific projects and then are broken apart on their completion. Organisations and individuals participating in a team bring their own unique skills and resources, which may include proprietary applications and data. The software applications used may vary from one construction project to another, depending on the nature and complexity (in terms of project type, size, number of actors involved, etc.) of the project. These applications include software for managing electronic and paper-based documents.

The overall analysis of the current document management practices within the three construction companies involved in the project revealed the following limitations, inherent to their current system and work methods (Rezgui et al. 1998a):

- Every partner within the project must use the same EDM system on a project to be able to access and share documents.
- The document's semantics and internal structuring is not controlled by the EDM system. Documents are handled as black-boxes.
- The EDM system does not support document cross-referencing or semantic linking.
- Security is always an issue. It is not easy to implement as with printed documents. EDM systems require improved user authentication and document protection.
- The EDM system is not integrated with proprietary and commercial applications used within the company (e.g. CAD applications and word processors).
- Most end-users in the construction industry are not computer literate. EDM systems lacking user-friendliness, or used in a maladapted environment (e.g. network communication problems) discourage the user from using the EDM system.

The Condor consortium is aware of the fact that it is not possible to develop a unique document management solution for all the project partners, because of their investment in proprietary systems. In fact, a strong demand from the project end-users, and also from the non-construction industry members of the UK Condor user interest group, was identified. This is summarized through the following question: *is it possible to have, at any time, knowledge of the existence of a potentially useful piece of information used in a given project? Is there any easy mechanism to access transparently this information, update it (if it is inconsistent), delete it (if it is no longer needed), and cross-reference it to another piece of information, while keeping the entire (fragmented and distributed) project information base consistent?*

We must also add that the end-users wish to use their favourite document management system. The above question can be complemented with the following one from the technical team, that expresses, in a sense, the Condor vision: *is it possible to develop a Virtual Universal Browser that accesses information regardless of its form, format, and location, and that can easily be plugged into any legacy document management system?*

The idea of a virtual universal browser plug-in makes certainly sense. This browser will have to access a variety of heterogeneous information as described in Figure 1. This is one of the conditions that any organization will have to face in order to remain competitive. Information is power, and the effective use and access to information will empower any modern organization (including construction organizations) that strives to gain more market places and remain competitive.

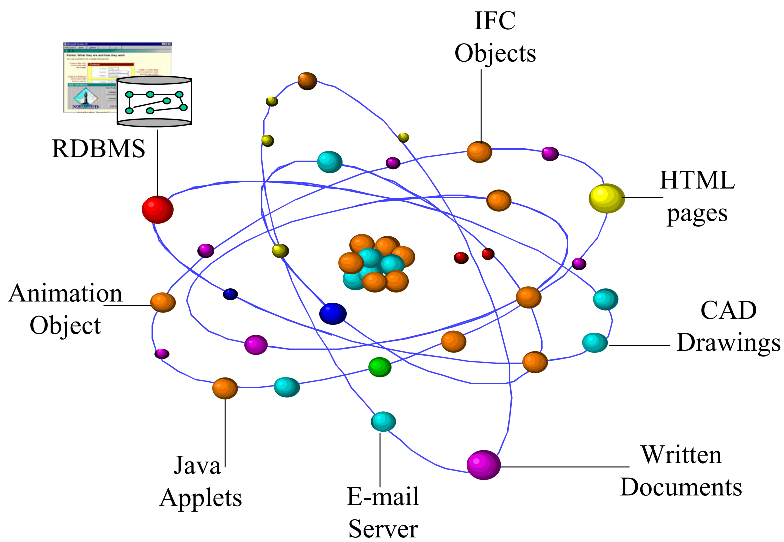

Fig.1: The Condor distributed information infrastructure

2 Proposed technical solution

A hybrid approach making use of the IDEF0 methodology and the Use Case approach (UML 1997) has been used to capture the requirements of the Condor system. It was found that both approaches were complementary and necessary for the understanding and specification of the proposed system. IDEF0 is used to define a high-level process activity model describing the document management practices taking place within the design and construction process. This is based on both the Infomate model (Bjork 1997), and the analysis and abstraction of the business processes and document management practices of the project end-users. A Use Case diagram, at a lower level, is proposed and detailed to describe the system in use. The proposed system architecture is presented in Figure 2. The major components of the architecture are described in detail in (Rezgui et al. 1998a), and include:

- the *CONDOR Integration Services* (implemented as a class library in the demonstrator);
- the *CONDOR API*, which defines the interface to the integration services. The main functions of the API are described below.

- the *Adaptors*, which provide the mapping between the CONDOR API and each of the document and object management systems to be integrated.

Before describing the Condor API, it is worth pointing out that the CONDOR references used by the API are globally unique. The format of these identifiers does not need to relate in any manner to the references used already by the differing EDM implementations. There will be functionality in each EDM adapter to map between CONDOR unique references and the EDM reference. An information object will have a globally unique (CONDOR) reference; parts of documents will have references also; this will be necessary for the semantic linking of documents. It is worth mentioning that the part references are assigned automatically as the document is written. The interface is provided between information providers and the CONDOR services (via the adapters and the API). The API includes the following functions:

- **Register() :** The purpose of the register() API method is to expose a document or other information element (object) to the CONDOR system so that it can be shared between EDM systems. The users can then examine the registered document in a manner that is familiar to them (i.e., as if the document were stored in their own EDM system*)*. There are several approaches which can be taken in the CONDOR system regarding the registration of objects; one is to use a centralised registry (the approach taken during the prototyping phases); another is to use a wholly distributed system. If the distributed system is used then the CONDOR system will support both passive and active registration mechanisms.
- **Retrieve() :** Once a document or object has been exposed to the CONDOR system, it is necessary for other EDM systems to be able to use the document. This is enabled by the Retrieve method. It is worth mentioning that in order for an EDM system to retrieve a document or object exposed by the CONDOR system; it must know its corresponding Condor unique reference.
- **Store() :** In some cases it will be necessary for an end user to be able to store documents or objects themselves in an EDM system which is not local to them. In order to do this the Condor system needs to be informed of the location that the document/object is to be stored. As a result of the invocation of the Store method, a status is returned by the Condor system to the originating EDM system to notify the success or failure of the store method invocation. A successful invocation will cause a Condor reference to be returned which can be used at any time to manipulate the documents or objects exposed by the CONDOR system.
- **Search() :** In order for an end user to ascertain which documents or objects are exposed by the Condor system, some kind of searching mechanism is required. This method supplies the searching capability for the EDM systems.
- **Unregister() :** If a previously exposed document or object needs to be hidden, the unregister mechanism will make the document or object no longer exposed, and therefore unavailable via the CONDOR system. The document or object with the Condor reference given will be removed from the database of shared or exposed documents.
- **Retrieve_meta()** : If a remote EDM system requires more information regarding an information element or object, it can invoke this method in order

to get the required information. This method allows the user to retrieve the meta data associated with a document. This makes it possible to perform statistical analysis on the meta data without having to retrieve the complete document.

- **Store_meta() :** As it is possible to store a document or object in a remote EDM system, it should also be possible to store meta information about that document or object remotely. This method allows this to be done.
- **Lock() :** If it is necessary to stop access to a shared document for a temporary time, then the document or object can be marked as locked. This could happen if, for example, the document/object owner updates the document/object.
- **Confirm_lock() :** This method enables users or EDM systems (or even the Condor system itself) to discover if a document or object is locked or not.
- **Unlock() :** This method is used to remove the lock marker from a document or object. Once unlocked, the document can be accessed as a shared object.
- **AddCrossReference() :** This method creates cross references between information elements that are semantically related. An example illustrating the use of this method is given in section 4.

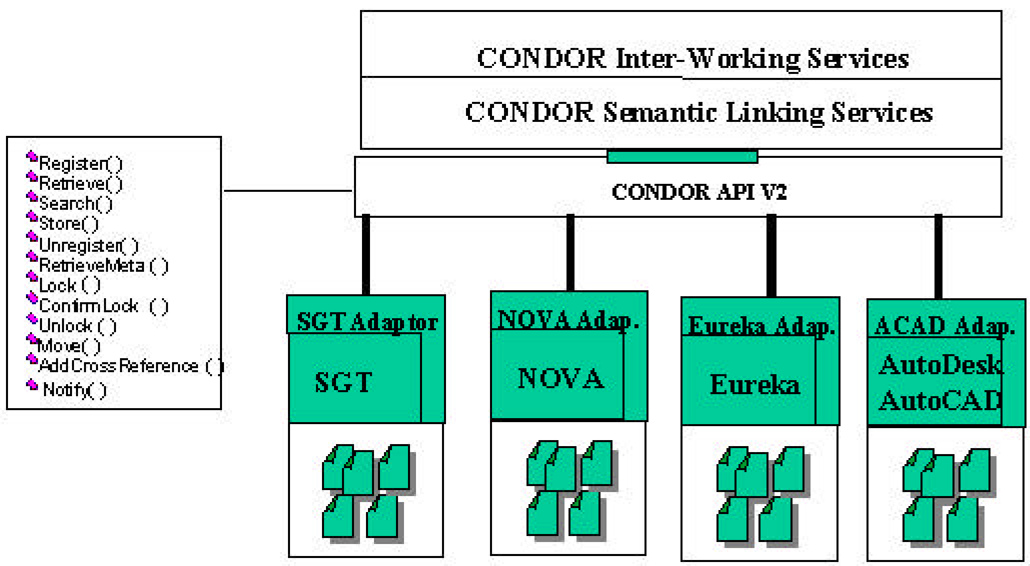

Fig.2: Proposed Condor system architecture

3 Modelling infrastructure

We have decided in Condor not to invest more in the Product modelling effort, but instead to concentrate on the development of an open object-based infrastructure that supports information sharing, cross-referencing, and inter-working between dissimilar legacy systems that are based on different data structures. We have, therefore, tried to make use as much as possible of existing work developed within companion projects funded by national (EPSRC) or European (including ESPRIT and JOULE) programs. A set of information models has been developed within the Condor project, as indicated in Figure 3. The Unified Modelling Language methodology (UML 1997) was chosen to specify, visualize, and document the underlying artefacts of the proposed system.

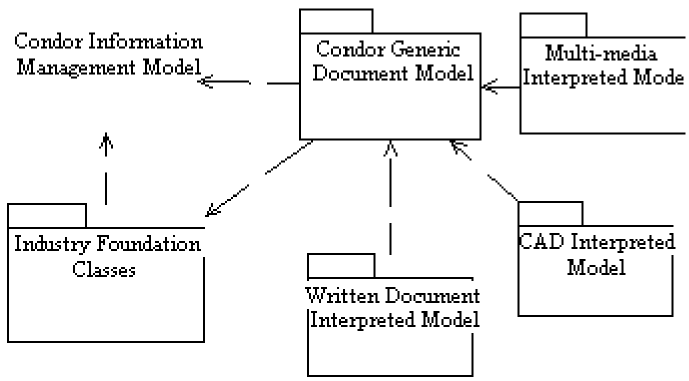

Fig.3: Condor modelling infrastructure

Figure 4 shows the basis for the handling of information versioning and right over Information Elements in the CIMM. The concept of Role is introduced, in the sense that all actors participate in a project by means of one or more roles. Thus it is the concept of a role rather than an actor that falls within the scope of the CIMM (Rezgui et al. 1998b). Through a role, an actor exercises authority over some parts of the project information, and each Authority is characterized by a number of responsibilities that relate to a particular object (Information Element). In order to discharge those responsibilities, the actor (through the role) needs to have certain rights to perform actions (or Operations) on the object in question.

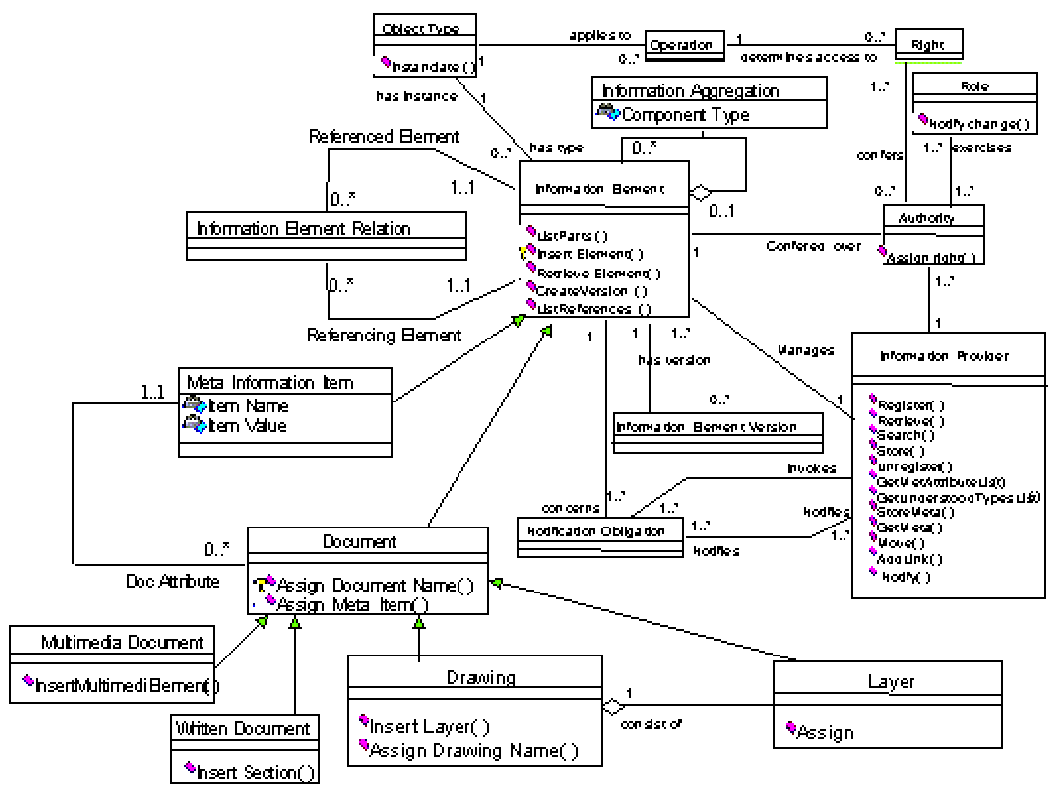

Fig.4: Overview of the Condor information management model

Figure 4 also describes the logical structuring and semantic linking between the various forms of information used in the industry. These include written documents, drawings and multi-media objects, and are all defined as being documents. An information element might reference, or be referenced, by any number of other information elements. The semantics of any association between information elements is defined within the Information Element Relation class, as indicated in Figure 4. An information element might also contain, or be part of, one or more information elements. For instance, a CAD layer might belong to more than one CAD drawing. The Information Aggregation class captures the semantic of this kind of aggregation between information elements. An information element is a versioned object that is specialized into a Document, and a Meta Information Item (that constitutes a set of attributes to the document). An information element might reference one or more Product Object(s) (this could represent an IAI / Industry Foundation Class).

4 Demonstration

The aim of the Condor prototype is to demonstrate the inter-working and semantic linking services of the Condor system. The demonstrator presented below made use of AutoCAD, along with the following legacy EDM systems:

- NOVA: it is a general purpose, Web based, EDM system developed by the Cap Gemini Group.
- SGT: it is a server of documents developed and used by Derbi. It is a conventional client-server application, running on both the Unix and NT platforms. The SGT NT version is used in the Condor project.
- Eureka!Filebase: it is a server of documents developed by Carasoft, and used by JM Byggnads AB. It bears similarities with the SGT EDM system.

Two strategies have been considered for implementing the inter-working services between the above mentioned proprietary EDM systems. In the first strategy, called c*entralized registration*, any event (e.g. add, delete, modify) occurring on a Condor compliant EDM server is notified to a central database (*Registry*). The meta-data (e.g. title, abstract, author) describing the shared documents are looked up in this central database, while the documents themselves remain stored on the servers. The second strategy is called *distributed registration.* The central database is replaced by a *Brokerage* mechanism which has been implemented using CORBA (OMG 1996). Shared documents are looked up by broadcasting requests to the connected servers. The demonstration presented below makes use of the Centralized Registration Approach.

The AutoCAD package has been extended in order to support the main functionality of the Condor API. In the following scenario, the first step to using the AutoCAD extension is to start the Condor Browser. The latter is used to display the references of all the documents registered with the Condor system. The browser contacts the CONDOR-enabled EDM systems that it has been made aware of, and retrieves a list of documents. The user selects the document on which to work (in this instance, an AutoCAD drawing file) and opens the document from the browser's menu. The browser retrieves the document from the

EDM system on which it is stored, and displays the drawing in AutoCAD (as indicated in Figure 5). Next, the CORBA connexion between the CONDOR Browser software and the AutoCAD library must be made by invoking the “Start ORB” command from the CONDOR menu item in AutoCAD (Figure 5).

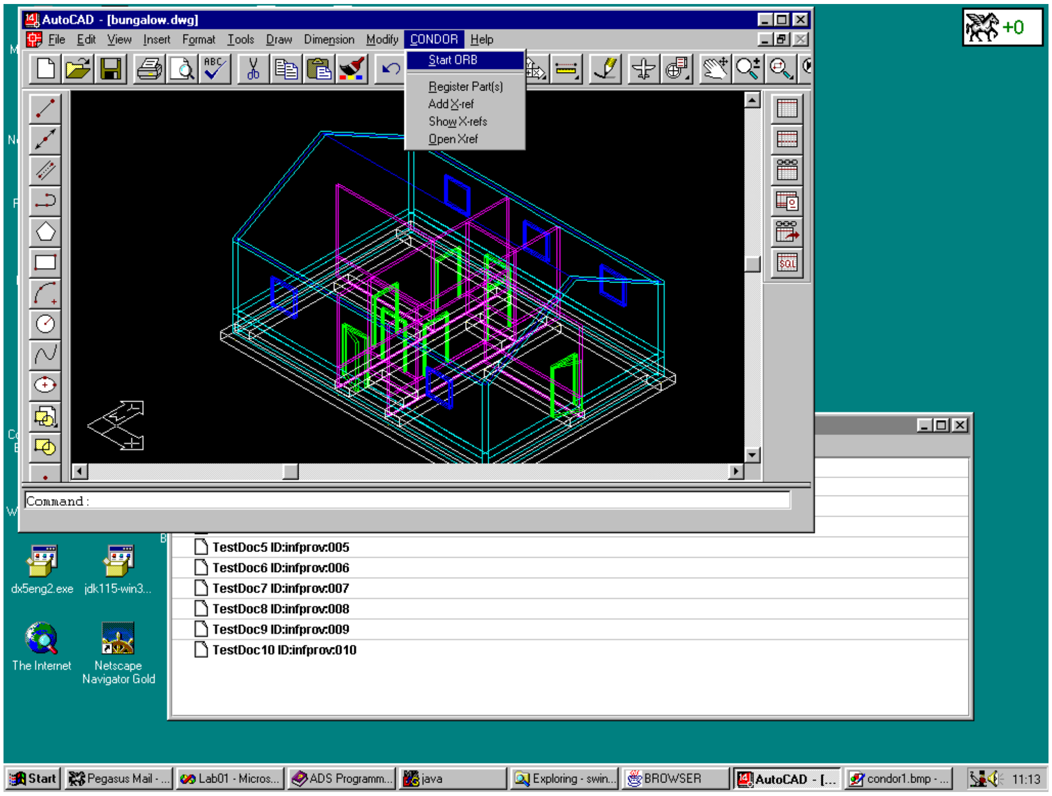

Fig.5: Condor compliant AutoCAD extension

Once the CORBA connexion has been made, it is possible to register parts of the drawing (for example, a door or a wall) with the CONDOR system. This method creates a unique Condor identifier for the drawing part which can then be cross referenced with other documents or document parts, which could be stored remotely. This is achieved by invoking the Register Part(s) command from the Condor menu of Figure 5. In order to add a cross-reference between a part of the AutoCAD drawing (e.g. door, window, or slab) and another document, the CONDOR Browser can be used to browse available documents which have been exposed through the CONDOR system. Once a document has been selected in the browser, the “Add Xref” menu command is chosen from within AutoCAD. This creates a reference between the chosen part from the AutoCAD drawing and the document which was selected in the browser.

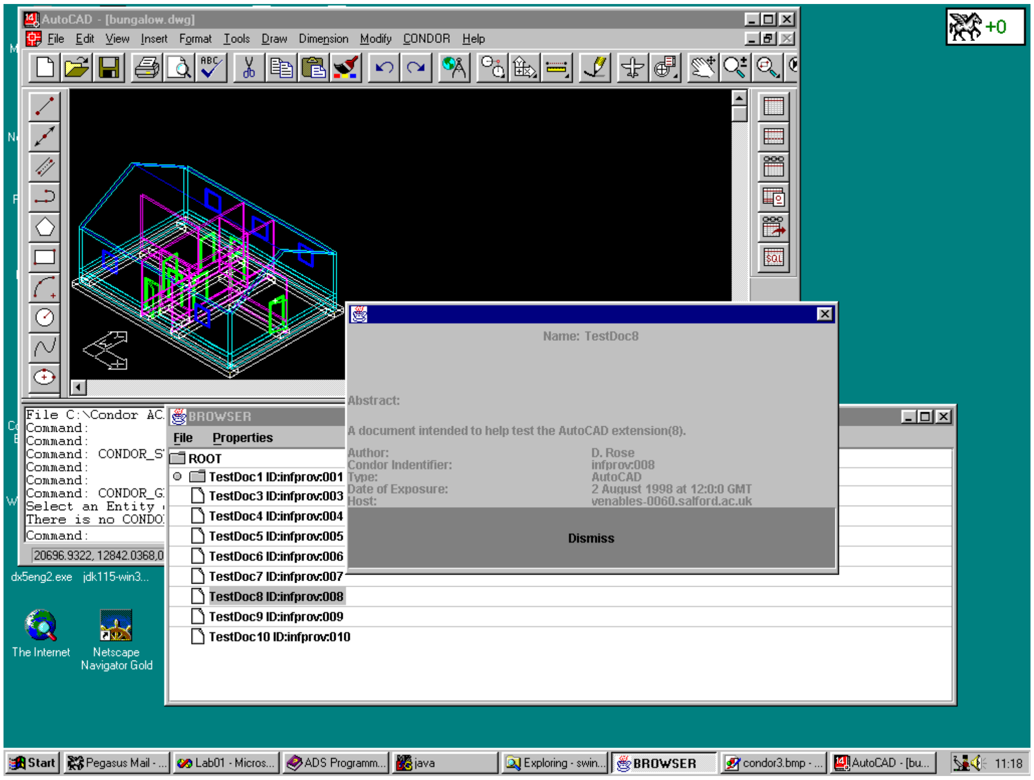

Fig.6: Cross Referencing a building part to a document

If existing cross references need to be checked, the “Show Xrefs” command from the AutoCAD menu can be used. This displays a dialogue box containing the cross referenced document identifiers. Lastly, a cross-referenced document can be opened on the machine running the AutoCAD and browser software. The requested document is retrieved by the browser from the EDM system, using the appropriate Condor API method invocation. The latter is displayed on the user’s screen.

5 Conclusion

This paper presented the European Esprit Condor project. A description of the technical solution along with its components (including the Condor API) is given. An overview of the modelling infrastructure supporting the system is also given. The models and API methods are still being refined in the light of experience from implementation work. Some functionality of the Condor prototype demonstrating the semantic linking and cross-referencing services (using the Corba technology) are illustrated in the paper. The consortium is now finalizing the last version of the prototype (V3) that will hopefully validate the overall approach taken in the project. The main problem that the consortium is now trying to overcome is the change of culture. The organisation and processes of construction projects must change in order to deliver the expected benefits. Therefore, the construction project lifecycle, from concept development to demolition and recycling, need to be examined and re-engineered. The Condor project includes an important BPR component. The Business Process Re-engineering research is still ongoing and aims at defining the appropriate process redesign strategy, within each company involved in the project, to implement effectively the proposed solution.

6 Acknowledgements

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